POLITEKNIK NEGERI BALI

Journal of Engineering Design and Technology

# logic

Vol. 22 No. 2 July 2022

LOGIC

Jurnal Rancang Bangun dan Teknologi

p-ISSN. 1412-114X

e-ISSN. 2580-5649

# LOGIC

**Jurnal Rancang Bangun dan Teknologi**

## Journal of Engineering Design and Technology

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Logic is a journal covering articles in the field of civil and mechanical engineering, design, and technology published 3 times a year in March, July, and November. Language used in this journal is English.

LOGIC. P-ISSN 1412-114X
LOGIC. E-ISSN 2580-5649
Indexing : GOOGLE SCHOLAR, DOAJ, EBSCO OPEN SCIENCE DIRECTORY, SINTA, GARUDA

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p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# MODE CHOICE PROBABILITY BETWEEN BUS AND RAILWAY CIANJUR-PADALARANG ROUTE

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***Abstract.*** Travel between cities in the Bogor, Sukabumi, and Cianjur areas is only accommodated by road-based public transportation that is interstate bus. The government issued a policy to reactivate railroads from Bogor to Padalarang, so that the southern region of West Java are connected to the rail network. This research intention to analyze characteristics of socio-economic users, characteristics of trip users, and analyze how much passengers move from the current bus to the Cianjur-Padalarang train. Data were collected by distributing questionnaires using stated preference techniques and analyzed using binary logit difference model with linear regression. The attributes to be analyzed are the difference between travel costs, travel time, and frequency of departure. The characteristic of users were analyzed with descriptive statictic method. The socio-economic characteristics of the passengers obtained were majority is male, aged 21-30 years old, education level senior high school, worked as entrepreneurship, income Rp2.000.001-Rp3.000.000, transportation costs for a month Rp100.001-Rp300.000. The characteristics of trip users are dominated by origin from Cianjur destination to Padalarang to work (economy), the frequency of trips is 1-2 times per week, the reason choosing the bus because of the bus have more easier mobility, the main travel time is 121-150 minutes. The results of the calculation of model sensitivity, the potential for passenger transfer from bus to train will increase if the difference in cost and travel time between trains and buses is getting smaller, and the difference in frequency is getting bigger.

*Keywords : Binary logit, Characteristic of trip users, Stated preference, Transportation mode choice*

## 1. INTRODUCTION

Cianjur Regency serves as a connection between Bandung, Sukabumi, and Bogor in the distribution of commodities and passengers [1]. This involves the implementation of a public transportation mode that is efficient, safe, pleasant, and environmentally friendly. The railway mode is a public transportation option alternative to the problem of inland transportation systems [2]. This is because railway travel time is more accurately guaranteed than highway-based modes of transportation, and the degree of road safety is significantly better. The train has a less fuel consumption value of 0.002 lt/km/org than the bus mode, which has a value of 0.0125 lt/km/org [3].

The government issued a policy on reactivating the Sukabumi–Cianjur–Padalarang railway [3]. With the reactivation of this route, the Bogor, Sukabumi, and Cianjur regions will be connected by train to the city of Bandung. As a result, there will be a competition between bus and train [4]. According to the study [5] there is an 80% chance of transferring modes of transportation to the Surabaya-Porong KRL route. This indicate the existence of intermodal competition, which affects mode selection. Based on the previous study review, it is also necessary to analyze the choices of bus and train modes of the Cianjur-Padalarang route to calculate the probability of passengers transferring from bus to train if it has been operating, as well as socio-economic and user trip characteristics.

Mode selection is a part of the travel demand modeling process, which is crucial in transportation policy [6]. This step calculates and predicts the number of people and/or commodities flows from the origin zone to the

destination zone [7]. In other words, mode selection aims to calculate the proportion of passangers who will use each mode of transportation.

The train is a low-cost mode of land transportation that uses locomotive-driven vehicles to draw gates with a high carrying capacity and cargo [8]. The quality of railway service is split into five categories: travel safety and dependability, timeliness, ease of service, comfort, and speed [9].

Improving the quality of bus services can be accomplished through better administration and operation of bus firms, as well as increased private sector engagement in the purchase of bus transportation services. In terms of service operations, public transportation buses require a consistent route and can be strictly patterned [10].

Stated preference is a data collection method for obtaining information on respondent preferences among several scenario hypothesis options [11]-[12]. Respondents were asked to select their preferred future sustainability strategies [13]-[14]. The respondents evaluation based on a 5-point scale (degree of preference) [15].

Consumers will be provided with two options. By comparing perceptions based on existing free variables, the mode selected has the highest utility value [6]-[16]-[17]. In determining the linear regression value, the train mode shift can be calculated using the formula:

$$\ln \frac{P_{KA}}{1-P_{KA}} = (U_{KA} - U_{BAK}) \quad (1)$$

$$(U_{KA} - U_{BAK}) = b_0 + b_n(\Delta Xn) \quad (2)$$

After getting the linear regression Eq. (1), the probability of selecting the mode with the binary logit difference can be calculated as follows [11]-[16].

$$P_{KA} = \frac{e^{(U_{KA}-U_{BAK})}}{1+e^{(U_{KA}-U_{BAK})}} \quad (3)$$

$$P_{BAK} = \frac{1}{1+e^{(U_{KA}-U_{BAK})}} = 1 - P_{KA} \quad (4)$$

$P_{BAK}$ = Probability of bus mode selected
$P_{KA}$ = Probability of train mode selected
$U_{BAK}$ = Utility value of bus mode
$U_{KA}$ = Utility value of train mode
$\Delta X_n$ = Attribute difference between train and bus

## 2. METHODS

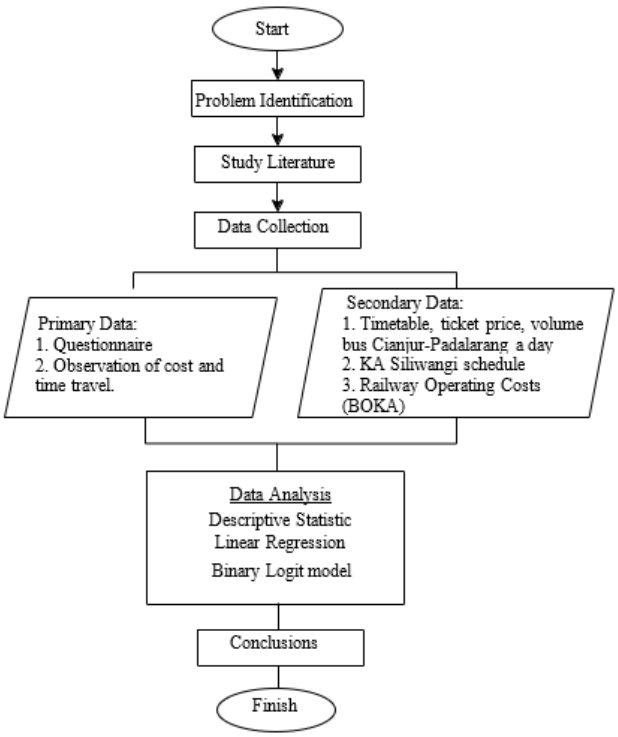



Figure. 1 Flowchart

Based on Figure 1, this research begins with problem identification and collecting literature studies. Furthermore, data collection obtained by direct observations, interviews, data from related company, questionnaire, and literature studies.

**Research Sample**

The Slovin formula is used to determine the number of research samples [5]-[18]-[16].

$$n = \frac{N}{1+N(\propto)^2} \quad (5)$$

The average number of passengers on the Cianjur-Padalarang bus is 240 passengers per day and the significant level is 95%, then:

$n = \frac{240}{1+240(0.05)^2}$ = 150 respondents

**Data Collection**

This study involves three independent variables, including the difference in travel time, travel costs, and travel frequency [13]-[19]. The dependent variable is a numerical scale value [20]. Secondary and primary data are required for this research. Primary data was collected by distributing questionnaires to bus passengers on the Cianjur-Padalarang route at Rawabango Station, Pasir Hayam Station, and the surrounding bus stop area. A preliminary survey was conducted prior to the distribution questionnaire to estimate travel time and costs [21].

The questionnaire consists of three sections: respondents socio-economic characteristics, trip user characteristics, and stated preference experiments [22]. The social and economic characteristics of respondents consisted of age, occupation, gender, education, income, and monthly transportation expenditures. The second part contains characteristics of trip users including origin and destination, purpose of travel, frequency, travel time, and rationale for selecting bus transportation, decent fares, and maximum train fares [2]-[23].

Respondents were asked a plan scheme question in the last section, which included attributes such as changes in ticket prices, travel time duration, and departure frequency. Secondary data was collected from UPTD Rawabango, Pasir Hayam Bus Station, and Bus Company in the form of bus departure schedule and daily bus volume. KA Siliwangi scheduled departure and railway operating cost (BOKA) from PT KAI Daop II Bandung [24]. The results of data collection are shown in Table 1.

Table 1. Assumptions of Existing Conditions Attributes (Economy Class)

| Attributes | Bus | Train |
|---|---|---|
| Cost Travel | Rp25.000,00 | Rp5.000,00 |
| Time Travel | 2 hours 20 minutes | 1 hour 35 minutes |
| Frequency | 15 times a day (03.40– 19.00 WIB) every 30 minutes | 3 times a day 07.16 WIB 13.16 WIB 19.16 WIB |

**Data Analysis**

The descriptive statistics approach with the Microsoft Excel program was used to determine the characteristics of bus passengers on the Cianjur-Padalarang route [16]. Individual responses are an option for rating points on a semantic scale [17], and primary data acquired from questionnaire results are qualitative data that must be transformed into quantitative data. This semantic scale is converted into a probability scale range from 0 to 0.9. The scale is transformed into a numerical scale using a binary logit model on Eq. (1). Table 2 shows the following changes in scale values as dependent variables.

The utility difference function equation in Eq. (2) then obtained by analyzing linear regression with SPSS v.25.0. Following that, an exponential value (e) is being acquired, which is used to calculate the probability value of the mode in Eq. (3) and Eq. (4) [19]-[20].

Table 2. Numerical Scale Transformation

| Option | Response | Probability Scale (P) | Numeric Scale $\ln \frac{P_{KA}}{1-P_{KA}}$ |
|---|---|---|---|
| 1 | Definitely choose the bus | 0,1 | -2,1972 |
| 2 | Maybe choose the bus | 0,3 | -0,8473 |
| 3 | Balanced options | 0,5 | 0,0000 |
| 4 | Maybe choose the bus | 0,7 | 0,8473 |
| 5 | Definitely choose the train | 0,9 | 2,1972 |

**Model Sensitivity Analysis**

The application of model sensitivity analysis in linear equations to determine the accuracy of future changes in one of the variables [25]. A modification in one attribute value is performe with the assumption that it has no impact on the other variable [26].

## 3. RESULTS AND DISCUSSION

A minimum sample size of 150 respondents is required for this research. During the survey, 186 respondents were obtained, but only 172 were suitable for analysis.

### 3.1 Analyze Characteristics of Socio-Economic Users

Based on the results of the gender distribution of respondents of Cianjur-Padalarang bus mode users dominated by men by 61%, while 39% were women. Because male passengers feel more safe and comfortable using bus transportation. The majority of respondents are aged 21-30 years with a percentage of 37%, the society of bus users to Padalarang is dominated by productive age. The education is dominated by high school graduates/equivalent by 45%. This can be because the level of equalization of education in the Cianjur area is relatively low so that the education is generally up to high school/equivalent.

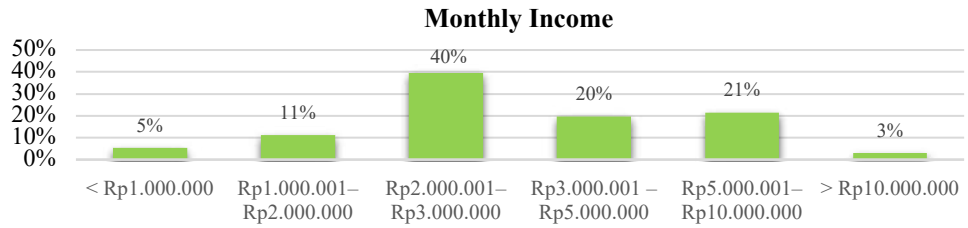



Figure 2. Respondents Income Characteristic Diagram

Figure 2 shows that respondents' monthly income of Rp2,000,001-Rp3,000,000 dominates with a percentage of 40%. This might be related to Cianjur's City Minimum Wage (UMK) of Rp2,500,000, whereas those with higher incomes include entrepreneurs and civil servants.

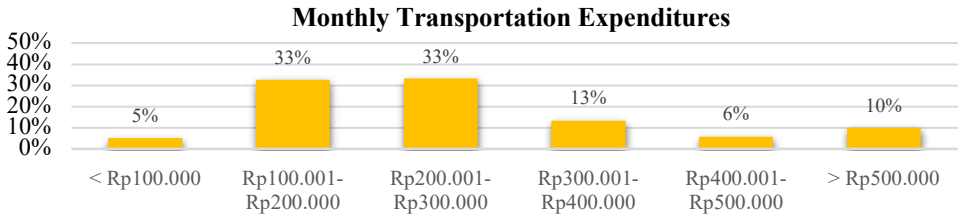



Figure 3. Respondents Montly Transportation Expenditures Diagram

Figure 3 shows that respondents transportation expenditures per month range from Rp100,001 to Rp200,000, with Rp200,001 to Rp300,000 approximately balanced at 33 percent. This is because the majority of people travel 1-2 times a week, therefore estimating bus tickets below Rp50,000 will result in expenditures closer to the nominal.

### 3.2 Analyze Characteristics of Trip Users

The origin of the trip is dominated by Cianjur with a proportion of 56%. This is because the distribution of questionnaires is intended for Cianjur citizens and surrounding areas who have traveled by bus to the Bandung area. The distribution of respondents with the purpose of travel to Padalarang dominant with 73%. This is because the target respondents are looking for is passengers on the Cianjur-Padalarang route. Respondents who used the bus on the grounds that there was no other mode option by 42%. Due to the fact of public transportation that goes to Padalarang is only a large and medium-sized bus. The majority of respondents aim to work (economy) at 50%. This is because many Cianjur citizens work and do business in Bandung.

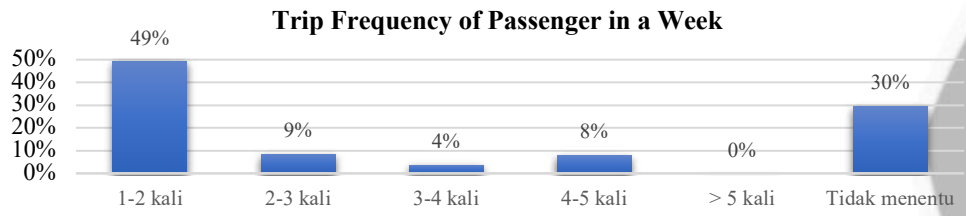



Figure 4. Respondents Trip Frequency Characteristic Diagram

As shown in Figure 4, 49% of respondents perfomed 1-2 trips per week by using the bus. This is because the majority of people who use bus mode are workers who go home and go in 1-2 times a week. The mode of transportation used to go to the station mostly uses motorcycles by 59%. This can be because the location of the bus station where passengers board the bus has easy access so that it is integrated with other public transportation.

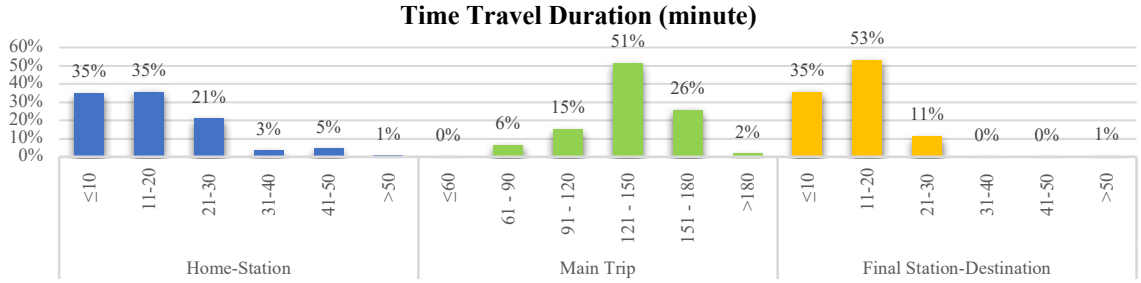



Figure 5. Respondents Time Travel Diagram

In Figure 5 the travel time from home to the bus station is about <20 minutes, which is with a percentage of ≤10 minutes respectively by 35% and 11-12 minutes by 35%. This is because the majority of passengers come from Cianjur City so it is quick to get to the bus station. According to responses, the average main travel time is 121-150 minutes, with a proportion of 51 percent. This might be because traffic conditions vary from trip to trip. The time from the bus station or bus stop to the respondents' destination was at most 11-20 minutes, with a proportion of 53 percent. This might be due to the location of the destination to a bus stop.


Figure 6. Acceptable and Maximum Train Tickets Fare Diagram

Figure 6 distribution of acceptable train tickets price according to respondents, which is Rp10.000 with a proportion of 48%. A price of Rp7.500 was chosen by 26% of respondents, while a ticket of Rp12.500 is selected by 23%. Respondents chose ticket prices less than Rp15.000, and no one chose Rp17.500 or Rp20.000. Because the majority of respondents income from Rp2.000.001-Rp3.000.000, as many as 49% respondents picked the maximum price of Rp15.000, so that respondents with a maximum price of Rp15.000 can compete with bus fares.

### 3.3 Alternative Equations of The Difference Function of Train and Bus Utility

Multiple linear regression analysis using independent variables travel cost difference ($\Delta X_1$), the travel time difference ($\Delta X_2$), and departure frequency difference ($\Delta X_3$), and dependent variables by a choice response on a numerical scale (Y). The three independent variables above can be used to create seven different equations. Based on the results of regression calculations, alternative equation 7 was chosen as the best utility difference function with parameters including the value of the smallest constant, the biggest F value, and the highest $R^2$ value. The result of linear regression shown in Table 3, all the variables considered had significant effect on the mode choice and significant value under 0.05.

Table 3. Result Linear Regression Analysis between Train and Bus

| Model | B | S.E. | t | Sig. |
|---|---|---|---|---|
| (Constant) | ,713 | ,035 | 9,890 | ,000 |
| Cost | -7,984E-5 | ,000 | -12,031 | ,000 |
| Time | -,0438 | ,001 | -11,699 | ,000 |
| Frequency | ,155 | ,004 | 10,238 | ,000 |

The following is an equation for the utility difference function between trains and buses.

$$U_{KA} - U_{BAK} = 0{,}713 - 0{,}00007984(\Delta X_1) - 0{,}0438(\Delta X_2) + 0{,}155(\Delta X_3) \quad (6)$$

**Moda Choice Model**

Furthermore, Eq. (6) is substituted into the binary logit model of difference in Eq. (3) and Eq. (4), so that obtaining the mode selection model equation between the train and the bus.

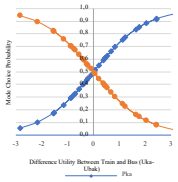
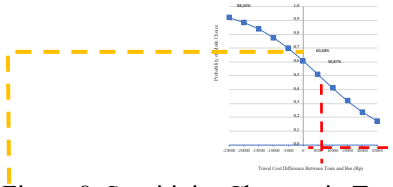


Figure 7. Graph Probability of Mode Choice between Train And Bus

From the model obtained the probability and difference in utility (benefit) between the train and bus as in the mode selection graph in Figure 7. The probability chart of the train moving in a positive direction. This indicates that if the utility or usefulness between the train and the Cianjur-Padalarang bus route increases, then the probability of the selection of the train will increase. Conversely, if the difference in utility value between the train and the Cianjur-Padalarang bus route decreases, then the probability of moving bus users to the train will reduce.

**Sensitivity of Model Analysis**

The sensitivity analysis of the model aims to determine the change in probability in case of a gradual change in the value of attributes between the selection of train and bus modes. Graphs of the sensitivity of this model are made based on reducing and increasing the portion of value assuming the other variables remain constant.



Condition:

Existing

Pka=Pbak=0,5

Figure 8. Sensitivity Changes in Travel Cost Difference

In Figure 8 the slope of the line on the sensitivity chart in negative direction, indicating that the higher the difference in travel costs between the train and bus routes Cianjur-Padalarang, the lower the probability of train selection. If you review the difference in costs on existing train and bus fares, then the probability of selecting train modes is at the difference in fares –Rp20.000 (train Rp5.000) is 88.4%, while the probability of buses is 11.6%. If the difference in travel costs between train and bus is equal to zero, then the probability of moving bus passengers to train is 60.68%. The probability of moving passengers to the train will be greater than the probability of choosing a bus when the difference in travel costs between the train and the Cianjur-Padalarang bus route is smaller than Rp5.000.

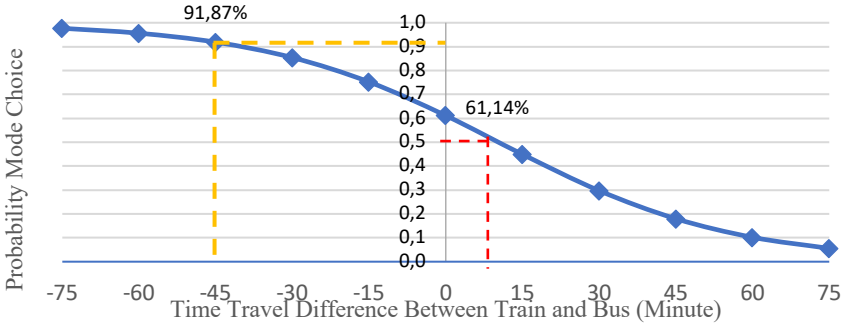



Figure 9. Sensitivity Changes in Time Travel Difference

Figure 9 shows that the slope of the sensitivity graph line is negative, indicating that the larger the value of the difference in travel time between the train and bus routes Cianjur-Padalarang, the less probable train selection. If compare the travel times of existing trains and buses, when trains 95 minutes and buses 140 minutes, the probability of choosing rail modes is 91.87% on the difference in travel time of -45 minutes, while the probability of buses is 8.13 %.

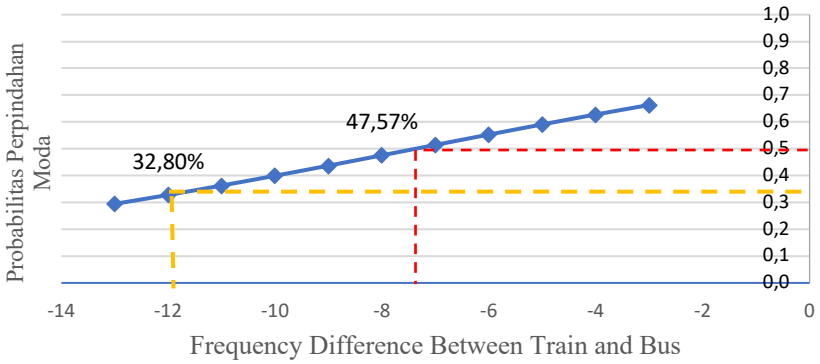



Figure 10. Sensitivity Changes in Frequency Difference

Figure 10 shows the slope of the sensitivity graph line in a positive direction, that indicate the higher the difference in frequency of travel between the train and bus routes Cianjur-Padalarang, the higher the probability of train selection. Consider the difference in frequency of existing train and bus travel, trains have 3 times and buses 15 times departure, the probability of choosing rail modes is 32.8% at a difference in departure frequency of -12 times, while the probability of buses is 67.2%. If the difference in train travel frequency is higher than -8, or as much as 7 times the trip, the probability of a train is higher than 50%.

### 3.3 Passenger Potential Analysis

If the train route is operational later, the estimated number of passenger movements can be calculated. This calculation used the probability value and the average daily number of passengers bus Cianjur-Padalarang route. Table 4 shows potential passenger transfer to bus.

Table 4. Projected Number of Passenger Transfers from Bus to Train

| Attributes | Value | Pka | Daily Potential |
|---|---|---|---|
| Cost | Rp5.000 | 88,4% | 212 |
| | Rp25.000 | 60,68% | 146 |
| Time | 150 minutes | 61,14% | 147 |
| Frequency | 7 trip a day | 47,57% | 114 |
| Existing | | 92% | 220 |

## 4. CONCLUSION

Based on the results of socio-economic characteristics dominated by men, aged 21-30 years, entrepreneurs, education high school graduate, monthly expenditure of transportation costs range from Rp200,000-Rp300,000, and has a monthly income at around Rp2,000,001-Rp3,000,000. The characteristics of passenger travel mostly come from Cianjur and aim to Padalarang, using a bus for easier mobility, the purpose of travel to economy with a frequency of 1-2 times per week, and mode of transportation to the station bus using a motorcycle. The trip from home to the bus station takes 11-20 minutes, the main trip takes 121-150 minutes, and from final bus station to the destination takes 11-20 minutes. Train fares start at Rp10,000 and go up to Rp15,000. The equation of utility difference function impacts 78.2%, with the difference in trip costs being the most influential attribute. The potential of rail passengers from the stated preference analysis on the model sensitivity, the probability of moving passengers to the train, will increase when the difference in cost and travel time attributes reduces and the difference in travel frequency attributes increases.

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p. 89 - 96

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# ANALYSIS OF IMPLEMENTATION SUPPLY CHAIN MANAGEMENT MATERIAL PROCUREMENT EFFECT ON CONSTRUCTION PROJECT PERFORMANCE

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***Abstract.*** The implementation of material procurement supply chain management is very much needed by the construction industry to improve project performance. Supply chains can contribute to reduced costs, improve efficiency and improve the delivery of a material's final results promptly on time. So that it is expected to achieve the project objectives in accordance with the cost, quality and time. that had been planned. This research aims to determine the influence of the implementation of supply chain management of material procurement to the performance of construction projects and the biggest challenges in implementing supply chain management of material procurement. The analysis methods used in this study are descriptive methods and regression methods with quantitative approaches. Data collection techniques using a questionnaire and using a Likert scale. The number of respondents as many as 28 people selected from project employees with purposive sampling method. The results showed that the application of material procurement supply chain management characteristics had a positive and significant effect on the performance of construction projects by 39%.The biggest factors that become challenges in implementing supply chain management of material procurement, namely the uncertainty of demand with an average of 2,797 and the smallest factor that becomes a challenge in implementing supply chain management of material procurement, namely internal uncertainty factor with an average of 2,202. Thus, from the results of the research, it is expected that the project can play a more active role in implementing supply chain management of material procurement to improve the performance of construction projects.

*Keywords : Supply chain management; Construction project performance; Deployment challenges.*

## 1. INTRODUCTION

Construction projects are complex because they combine a large number of diverse resources [1]. Materials are one of the most important parts of any construction project, because material resources can cost 50%-70% of the project cost [2]. In the event of a failure in the management system for construction materials will result in losses and the project may experience delays in work activities. Seven factors cause delays in the completion of the building project, one of which is the material availability factor of 15.14% [3]. To overcome problems such as delays in the completion of construction projects, the unavailability of materials when needed that result in losses and failures in the construction material management system, a good and appropriate management and control is needed by implementing supply chain management in the material procurement process.

Supply chain management is a cooperative relationship between suppliers that is related to the purpose of obtaining materials or materials needed from suppliers because of the demand for a material [4]. The parties

involved in the construction process will form the supply chain and will indirectly be interconnected and interdependent [5]. The concept of supply chain is applied to construction after seeing success in the manufacturing sector in applying the concept of supply chain and developing to date [4]. The purpose of implementing supply chain management is to reduce the amount of costs, increase the entire supply chain, reduce the time and delivery of materials promptly on time to satisfy customers [6]. The application of supply chain is strategy to improve project performance. Performance in the field of construction is one of the processes in the field of construction management by evaluating and comparing the plan with the results achieved, comparing deviations that occur and making improvements [7]. Project performance is limited by cost, time and quality [8]. Therefore, the application of a supply chain can reduce construction costs, increase efficiency, and improve the delivery of the result of a material accurately and precisely in time [9]. Supply chain management is contained in Presidential Regulation, Perpres No. 26/2012 on Print Blue Development of National Logistics System and Perpres No. 32/2011 on Masterplan for Acceleration and Expansion of Indonesia's Economic Development (MP3EI) in 2011 – 2025. With the main approach is to develop the concept of Supply Chain Management Construction to support the construction of reliable construction infrastructure [10]. In implementing supply chain management, In implementing supply chain management, several challenges must be faced, namely: the complexity of the supply chain structure and uncertainty [11]. Uncertainty is divided into three classifications: demand uncertainty, supply uncertainty and internal uncertainty [11].

Research on supply chain management on project performance has been conducted by researchers before [12]. The results showed that the influence of supply chain management on project performance was 68%. What distinguishes this research from previous research is the focus on the supply chain in the material procurement process where in previous studies the supply chain was described in general terms. And in this study using a questionnaire with purposive sampling method and data processing using statistics software. By using the purposive sampling method in sampling can facilitate the achievement of a research goal, because the sample used based on the necessary criteria and purposive sampling method is easy to do and more efficient. The purpose of this study is to determine the effect of the application of supply chain management characteristics of material procurement on the performance of construction projects on the "X" project and to determine the biggest factor that becomes a challenge in implementing supply chain management of material procurement on the project "X".

## 2. METHODS

The research began in May 2021 to June 2021. The research was conducted at the "X" Apartment Project located in East Jakarta. Data collection is carried out using questionnaires and project data. Sample selection is done by purposive sampling method based on predetermined criteria. The respondent criteria used as a sample are employees who have at least 2 years of work experience in the field of building construction and are appointed as competent staff in the field of material management.

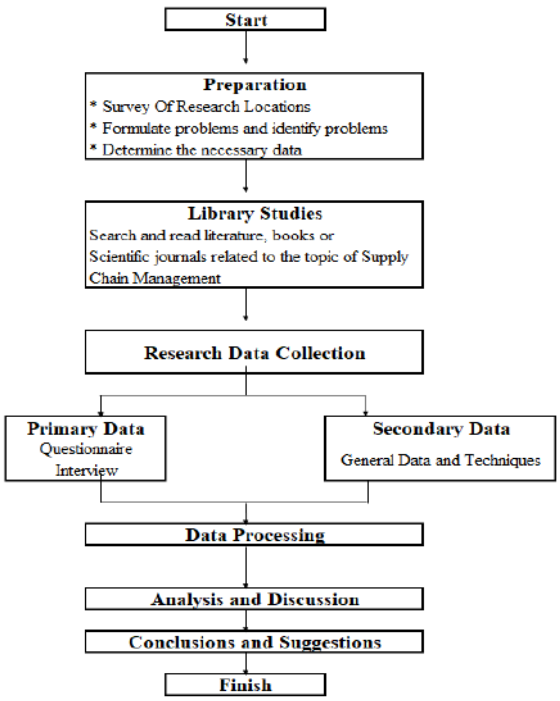


Figure 1. Research Flowchart

Figure 1 is a research flowchart. The research phase begins with the selection of research objects that will be reviewed with location observations. Then proceed with identifying and formulating the problems raised in the discussion of this research, then conduct a literature study, then data collection activities in the form of distributing questionnaires. After the data obtained is sufficient, then data using SPSS Statistics 25. The calculated value is used as a material for discussion and conclusions are drawn.

**Methods of Collecting Data with Questionnaires**

In this method, the author distributes questionnaires to respondents, namely related project parties who are competent in the field of material management by containing questions related to the implementation of supply chain management in material procurement, construction project performance and challenge factors in implementing supply chain management. Filling using a likert scale. This study uses descriptive research and causal associative research with a quantitative approach. Descriptive research aims to find the average, standard deviation, minimum and maximum [13]. Associative causal research to find out the effect or relationship between variables [14]. This research uses validity, reliability, normality, simple linear regression test, hypothesis testing and $R^2$ test [15].

## 3. RESULTS AND DISCUSSION

This result is obtained from data processing using SPPS Statistic 25, namely the effect of the application of supply chain management of material procurement to the performance of construction projects and challenges in implementing supply chain management of material procurement, the following results are obtained

### 3.1 Indicators on Research Variables

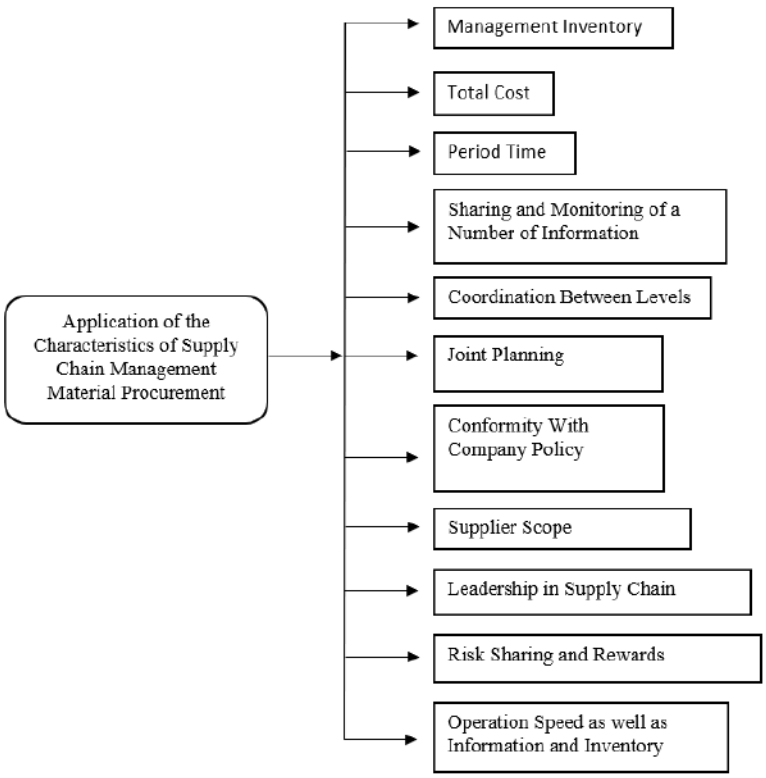


Figure 2. Indicators characteristics of Supply Chain Application Material Procurement

Figure 2 is an variable indicator of application characteristics of supply chain material procurement consisting of 11 indicators, namely management inventory, total cost, period time, sharing and monitoring of a number of information, coordination between levels, joint planning, conformity with company policy, supplier scope, leadership in supply chain, risk sharing and rewards, operation speed as well as information and inventory.

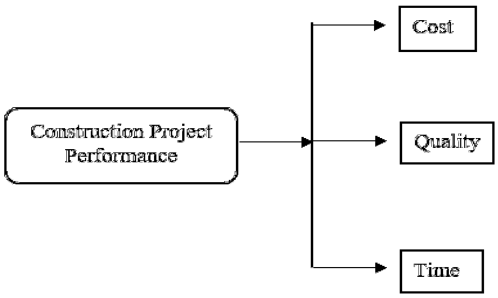


Figure 3. Indicator Construction Project Performance

Figure 3 is an indicator of construction projects performance variables consists of 3 indicators namely cost, quality and time

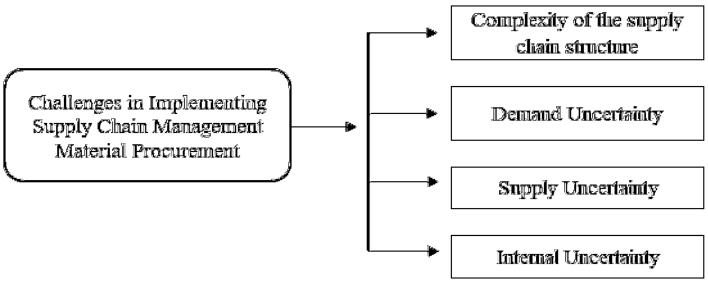


Figure 4. Indicator Challenges In Implementing Supply Chain Management Material Procurement

Figure 4 is an indicator of the challenge variables in implementing supply chain management for material procurement which consists of 4 indicators, namely the complexity of the supply chain structure, demand uncertainty, supply uncertainty and internal uncertainty.

### 3.2. The Effect of Material Procurement Supply Chain Management on Construction Project Performance

Table 1. Hypothesis Test Results (t test)

| **Model** | B | Std.Error | t | Sig. |
|---|---|---|---|---|
| (Constant) | 10.615 | 6.803 | 1.560 | .131 |
| Total X | .345 | .086 | 3.996 | .001 |

Table 1 is the result of hypothesis testing, the results of the study show that the application of supply chain management characteristics of material procurement has a significant effect on project performance. This is evidenced from the results of hypothesis analysis (t test) with $t_{count} \geq t_{table}$ (3.996 ≥ 2,056) significant level 5%, and the probability value of sig is 0.001 ≤ 0,05. If $t_{count} > t_{table}$ and value significance < 0,05, then Ha is accepted and Ho is rejected.

Table 2. Simple Linear Regression Test Results

| Model | B | Std.Error | t | Sig. |
|---|---|---|---|---|
| (Constant) | 10.615 | 6.803 | 1.560 | .131 |
| Total X | .345 | .086 | 3.996 | .001 |

Table 2 is the result of a simple linear.regression test, the regression equation is obtained Y = 10.615+ 0,345X. The constant value is 10,615, where project performance based on cost indicators, quality and time on construction is good and has a positive value. A positive value of 0.345 illustrates that, every one unit increase in the implementation of material procurement supply chain management variables will cause an increase in project performance of 0.345. Thus, the more implementation of material procurement supply chain management is implemented, the more construction project performance will increase. The t value is obtained from B divided by the standard error, the greater the t value, the smaller the significance value. Based on the value of simple linear regression test results, the standard error value is 0.086 and the t value is r 3.996 and produces a sig value of 0,001 < 0,05. So it can be concluded that Ha is accepted and Ho is rejected. Where there is a significant influence on the implementation of material procurement supply chain management on the performance of construction projects.

Table 3. Coefficient of Determination Test Results

| R | R Square | Adjust R Square | SEE |
|---|---|---|---|
| .624[a] | .390 | .365 | 4.370 |

Table 3 is the result of the coefficient of determination test, the value coefficient of determination or R square is 0.39 or equal to 39%. Standard Error of Estimate (SEE) is 4.370.

### 3.3 Challenges in Implementing Material Procurement Supply Chain Management

Table 4. Descriptive Statistics Variable Challenges in the Implementation of Supply Chain Management Material Procurement (Indicator of the Complexity of Supply Chain Structure)

| **Item** | Min | Max | Sum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Z1.1 | 2 | 5 | 102 | 3.642 | .780 |
| Z1.2 | 1 | 5 | 68 | 2.428 | 1.168 |
| Z1.3 | 1 | 5 | 79 | 2.821 | 1.123 |
| Z1.4 | 1 | 4 | 67 | 2.392 | 1.065 |
| Z1.5 | 1 | 5 | 74 | 2.642 | 1.095 |
| Average | | | | 2.785 | |

Table 4 is the result of the value of the indicator of the complexity of the supply chain structure, the most dominant item is shown in Z1.1, namely material suppliers are also partners of other parties with the highest number of 102 and an average of 3,642. The Supply Chain Structure Complexity indicator has a total average score of 2,785 answers which are in the category “Just Agree” [16]-[17].

Table 5. Descriptive Statistics Variable Challenges in the Implementation of Supply Chain Management Material Procurement (Indicator of Demand Uncertainty)

| Item | Min | Max | Sum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Z2.1 | 1 | 4 | 69 | 2.464 | .744 |
| Z2.2 | 2 | 5 | 91 | 3.250 | 1.142 |
| Z2.3 | 1 | 5 | 75 | 2.678 | .983 |
| Average | | | | 2.797 | |

Table 5 is the result of demand uncertainty indicator value, the most dominant item is shown in Z2.2, namely a change in demand with the largest number of 91 and an average of 3,250. The Demand Uncertainty Indicator has a total average score of 2,797 answers which are in the category “Just Agree” [16]-[17].

Table 6. Descriptive Statistics Variable Challenges in the Implementation of Supply Chain Management Material Procurement (Indicator of supply uncertainty).

| Item | Min | Max | Sum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Z3.1 | 1 | 5 | 70 | 2.500 | 1.138 |
| Z3.2 | 1 | 4 | 61 | 2.178 | .818 |
| Z3.3 | 1 | 5 | 73 | 2.607 | 1.314 |
| Average | | | | 2.428 | |

Table 6 is the result of supply uncertainty indicator value, the most dominant item is shown in Z3.3, namely the uncertainty of the quality and quantity of existing materials with the highest number of 73 and an average of 2,607. The supply uncertainty indicator has a total average score of 2,428 answers which are in the category "Do not agree" [16]-[17].

Table 7. Descriptive Statistics Variable Challenges in the Implementation of Supply Chain Management Material Procurement (Indicator of internal uncertainty)

| Item | Min | Max | Sum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Z4.1 | 1 | 4 | 62 | 2.214 | .686 |
| Z4.2 | 1 | 3 | 57 | 2.035 | .637 |
| Z4.3 | 1 | 4 | 66 | 2.357 | .911 |
| Average | | | | 2.202 | |

Table 7 is the result of internal uncertainty indicator value, the most dominant item is shown in Z4.3, namely the uncertainty of the quality of the parties (HR) in management with the highest number of 66 and an average of 2,357. The Internal Uncertainty Indicator has a total average score of 2,202 answers which are in the category "Do not agree" [16]-[17].

Table 8. Variable Challenges for Implementing Supply Chain Management Material Procurement

| **Indicator** | Code | Statement |
|---|---|---|
| Complexity of Supply Chain Structure | Z1.1 | Material suppliers are also partners of other parties |
| | Z1.2 | Frequent changes of members in a supply chain |
| | Z1.3 | Flow of information, goods and funds between supply chain members |
| | Z1.4 | Parties in the supply chain have their own interests |
| | Z1.5 | The number of parties involved increases the potential for conflict |
| Uncertainty of Demand | Z2.1 | Uncertainty about the type, timing or location of a project |
| | Z2.2 | There is a change in request |
| | Z2.3 | Uncertainty on the number of requests |
| Supply Uncertainty | Z3.1 | Delivery time uncertainty |
| | Z3.2 | Uncertainty in material prices |
| | Z3.3 | Uncertainty about the quality and quantity of materials available |
| Internal Uncertainty | Z4.1 | Information technology uncertainty |
| | Z4.2 | Uncertainty in the availability of working capital |
| | Z4.3 | Uncertainty in the quality of the parties (HR) in management |

Source: Siahaya (2013)

Table 8 is a statement of each indicator of the challenges in implementing supply chain management of material procurement. Each indicator has 3-5 statements.

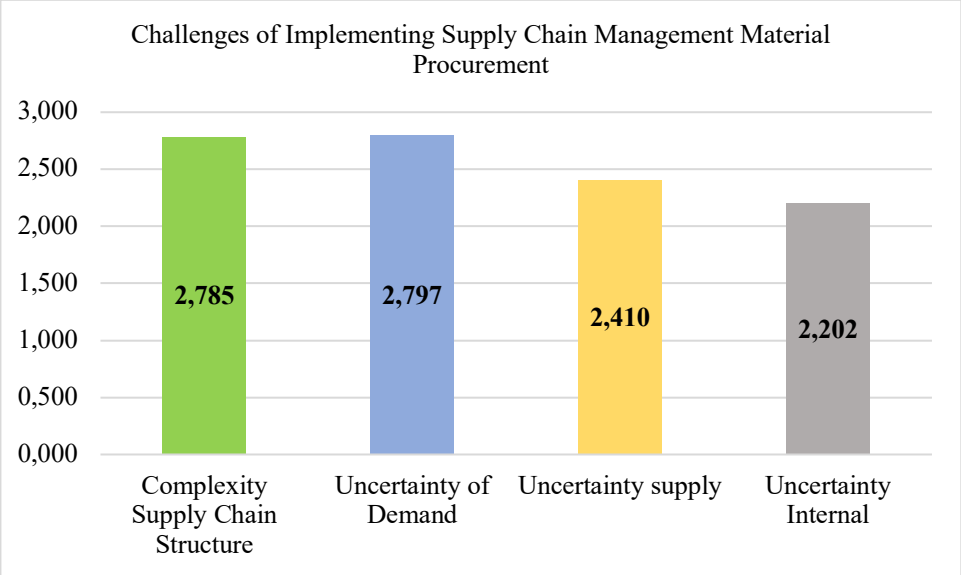


Figure 5. Graph of Challenges in implementing supply chain management in material procurement

Figure 5 is a graph of the challenges in implementing supply chain management of material procurement, of which the biggest factor is the uncertainty of demand and the smallest factor is the internal uncertainty obtained based on the average.

Based on the results of the analysis that has been done shows that by applying supply chain management characteristics to material procurement can improve project performance. Parties involved in a construction project are advised to further implement supply chain management of material procurement in a construction project to improve project performance by overcoming challenges in implementing supply chain management.

## 4. CONCLUSION

The conclusions from the research results are obtained as follows:

1) It is concluded that the application of supply chain management characteristics of material procurement has a positive and significant effect on the performance of construction projects. This is evidenced by the results of the hypothesis analysis (t test) and the sig probability value of 0.001 ≤ 0,05. The results also show that the value ($R^2$) is 0.39 where the application of the characteristics of the supply chain management of material procurement affects the performance of construction projects by 39% and the remaining 61% is influenced by other factors not examined and discussed in this research.
2) The biggest factor that becomes a challenge in the implementing of supply chain management for material procurement is the demand uncertainty factor with an average of 2,797 and the smallest factor that becomes a challenge in the implementing of supply chain management for material procurement is the internal uncertainty factor with an average of 2,202. The order of factors from the biggest to the smallest challenges in implementing supply chain management in material procurement are demand uncertainty, supply chain structure complexity, supply uncertainty and internal uncertainty.

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p.97 - 102

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# ANALYSIS OF TYPE L JOINT PRECAST BEAM CONCRETE

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***Abstract.*** Research precast beam type L shape has produced strength of flexure where it was jointed at middle of span with L shape. Problem was about strength and deflection with joint of Type L shape. Method of this research was applicated of load to two point of the beam. Data from data logger was noted. Aim of this research was determined strength of flexure such deflection and maximal load would be apllicated. Precsat beam type L shape consist of two beam P1 and P2 were tested at two point load was applicated. This research have produced of data of precast beam P1 and P2. Precast beam P1 has deflection 28,44 mm at maximum load 11,21 Ton. Precast beam P2 has deflection 26,71 at maximum load 11,76 Ton. Except that data, has produced also chart of load versus deflection where precast beam type L shape has behavior less for ductility approximately δu/δy 1,17, where deformation inelasticity was not seem. That occur because overlapping at joint of precast concrete at middle of span..

*Keywords : precast, flexure, concrete.*

## 1. INTRODUCTION

Development about building construction is so fast for decade eventually. Precast construction is a project building construction will be developed later. Innovation precast concrete construction will be needed for development at construction industry. For that reason, therefor research about precast element has developed with observation to element precast beam L shape joint. Many research of precast beam were investigated by expert for many years ago. Investigation of closure-strip details for connecting prefabricated deck systems by Alexander Au, Clifford Lam, Bala Tharmabala at 2011. This research was described about joint of two part element precast slab concrete. To connected between two element slab precast was required lap splices rebar of two element precast slab. Between two element of precast slab has void. Void will be filled by grouting material non shrinkage. Research Seismic behavior of a type of welded precast beam concrete-column connection by Mario E. Rodríguez, Miguel Torres-Matos at 2013 was described about connecting of two element precast beam at joint of beam column. Connecting between two element was required plat and reinforcement with welded to connecting of two element precast beam and void of top beam will be filled by topping concrete. Research precast concrete deck to girder mechanical connection by George Morcous and Raed Tawadrous at 2020, describe about connecting between half slab precast and girder.

Research of joint type L shape was required plat type L and connected by Sika grout 215 for filled section with void at middle of precast beam. L shape that is mean, joint of element precast have shape such as word of L and easier to adjusting. For connecting between element of precast has welded and used Sika grout 215 to cover its void. Sika grout 215 was material for grouting between element concrete has welded and casted. Specification of material sika grout have compressive strength for 3 days approximately 40 N/mm2 and for 7 days approximately 52 N/mm2. This joint was needed plat with thick 5 mm and welded was needed for connect of two of plat from respectively element. For this research have compressive strength 42,13 N/mm2. This joint was needed plat with thick 5 mm and welded was needed for connect of two of plat from respectively element.

The question for this research is how about strength of flexural precast beam concrete type L joint if any load were applicated and how about deflection occur.

Aim of this research was determined of strength of flexural precast beam concrete type L joint beam P1,P2

and deflection occur.

Result of research, It is evidence that result all of specimen indicate have equal performance for ultimate strength so for behavior of pattern of failure, precast beam concrete type L joint was behavior less for ductility. Ductility of precast beam P1 and P2 was has less behavior ductility δu/δy at least approximately 1,17. Strength of flexural precast beam concrete type L joint P1 at ultimate was value 11,21 Ton at deflection 28,44 mm. Strength of flexural precast beam concrete type L joint P2 at ultimate was value 11,76 Ton at deflection 26,71 mm.

Because of that result of tested precast beam concrete type L joint which good performance then joint of beam by type L joint was needed to applicated and needed sustainable research to be perfect performance.

## 2. METHODS

Location for testing element precast beam was at Laboratory Bina Teknik Permukiman dan Perumahan Direktorat Jenderal Cipta Karya Kementerian PUPR Jl. Panyaungan, Cileunyi Wetan Kab. Bandung. Material was used for manufacture precast beam consist of concrete, reinforcement D13 and d8. This Research was required Universal Testing Machine to loading precast beam. Method of loading was applicated two of load P to respectively point at top of beam. To control and note a deflection and load applicated, used LVDT which it connected by Data Logger. Two support have applicated for support loading of two load at precast beam while loading. For furher information could be see figure 1 at below.

Figure 1: UTM machine

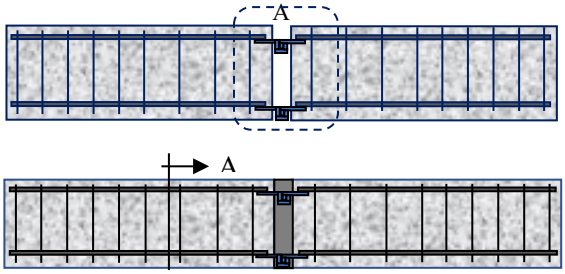


Figure 2. Prototype element precast type L Joint concrete beam

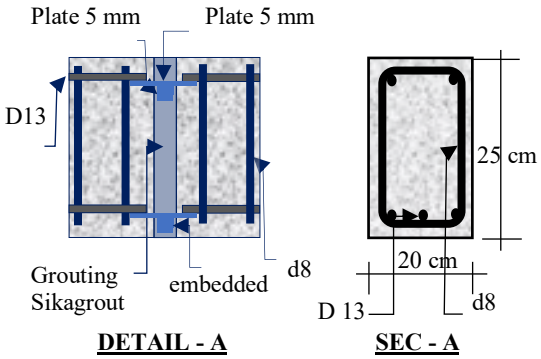


Figure 3. Detail and Section of element precast type L Joint concrete beam

Figure 2 describe of prototype of precast beam concrete type L joint. Figure 3 describe of detail and section of element precast type L Joint concrete beam. Method or step to get the data was describe at bellow.By Ultimate Testing Machine (UTM) at figure 1 was tested the specimen of beam with reinforcing or framework at figure 2 and figure 3. The Load was applicated at two point of the beam. UTM was tested the beam until rupture or collapse and datalogger was noted a result of that loading. Output data from data lodger was computed and take some conclusion.

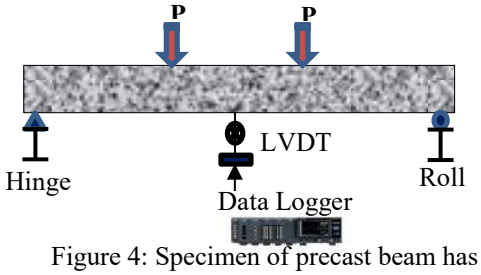


Figure 4: Specimen of precast beam has

## 3. RESULTS AND DISCUSSION

Research of precast beam concrete type L joint for all specimens were indicated that precast beam concrete type L joint was capable for resistance under loading until at least more than 11 T, accordingly all specimens were indicated that strength of flexural and deflection was not different respectively between specimens and will be explained at below. For pattern of crack, all of specimens have pattern of crack were equal crack due to moment, indicate that all specimen have not different behavior. Specimen precast type L joint have embedded with long width enough at the below then concrete was extruded of embedded at below (figure 4). Average of compression strength of specimens were 311,89 kg/cm2 and 421,33 kg/m2 for sika grout 215 at 9 days.

Results of strength of flexural precast beam P1 at ultimate was achieved 11,21 T at deflection 28,44 mm. Strength of flexural precast beam P2 at ultimate was achieved 11,76 T at deflection 26,71 mm.That indicate, specimens precast type L have strength ultimate was good enough nevertheless have behavior less for ductility. Table 1 showing result of flexural test of loading test.

Figure 5: Specimen of precast beam has

Table 1: Result of Flexural

| No | Element | Load | Deflection. |
|---|---|---|---|
| | | Ton | mm |
| 1 | P1 | 0,00-2,62 | 0,00-0,90 |
| | | 2,77-3,92 | 0,94-1,71 |
| | | 3,93-4,96 | 1,75-3,43 |
| | | 5,01-5,76 | 3,66-6,04 |
| | | 5,75-6,65 | 6,30-9,13 |
| | | 6,83-8,93 | 9,47-17,39 |
| | | 9,66-11,21 | 18,52-28,44 |
| 2 | P2 | 0,00-2,13 | 0,00-1,2 |
| | | 2,23-3,72 | 1,27-2,83 |
| | | 3,87-5,46 | 2,92-6,42 |
| | | 5,55-7,53 | 6,58-12,23 |
| | | 7,71-19,55 | 12,48-17,73 |
| | | 9,60-11,65 | 17,81-15,14 |
| | | 11,70-11,76 | 25,40-26,71 |

Figure 6 showing chart of result of loading versus deflection of specimen beam P1. Figure 7 showing chart of result of loading versus deflection of specimen beam P2. It is evidence that result all of specimen indicate have equal performance for ultimate strength and not different for behavior of pattern of failure, precast beam concrete type L joint was behavior less for ductility. For further information could be see chart at below.

For figure 8 showing of result of loading versus deflection of specimen entirely beam P. If refer to figure 8, showing indeed behavior of precast beam P1 and P2 was has less behavior ductility δu/δy at least approximately 1,17. The benefit of precast beam concrete type L joint is more effective for construction than conventional beam (cast in site) and minimize cost of construction, cost of all element will be cheaper and can be applicated at location with difficult to rotate and difficult for availability of materials for mixing concrete.

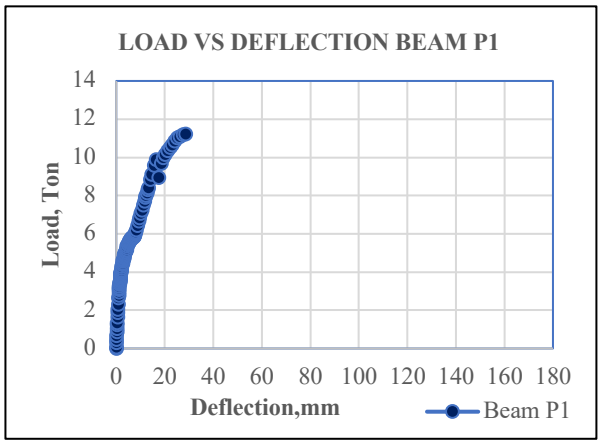


Figure 6. Chart of Result Beam P1

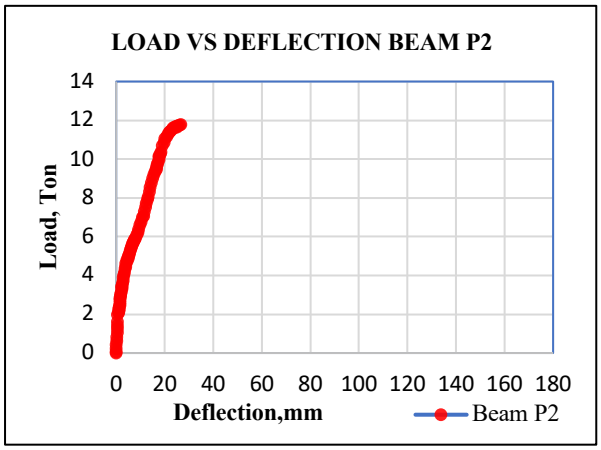


Figure 7. Chart of Result Beam P2

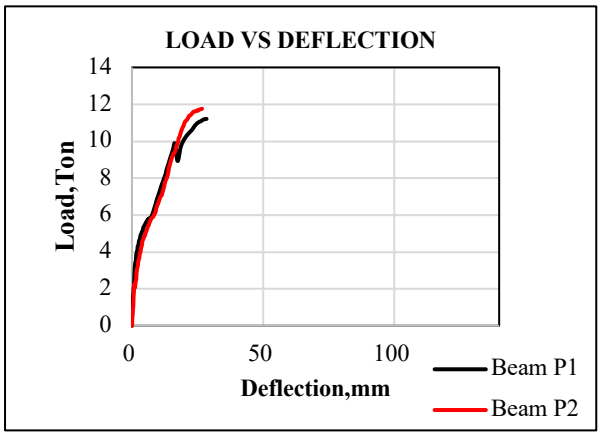


Figure 8. Chart of Result Beam P1, P2

Mario E. Rodríguez and Miguel Torres-Matos was researched of seismic behavior of type of welded precast beam concrete beam-column connection. The beam-column connections with welded longitudinal reinforcement showed local embrittlement of the steel, resulting in brittle failure of the connection.

That research was given that joint with welded system was showed local embrittlement of the steel, resulting in brittle failure of the connection and equally with this research (figure 5).

Recommendation from this research is precast beam concrete with type L joint can be applicated at constructions of building or other construction was needed joint at moment maximum.

## 4. CONCLUSION

Result of precast beam concrete type L joint (P, P2) were strength of flexural beam at ultimate and deflection of beam at ultimate. Strength of flexural precast beam concrete type L joint P1 at ultimate was value 11,21 T at deflection 28,44 mm. Strength of flexural precast beam concrete type L joint P2 at ultimate was value 11,76 T at deflection 26,71 mm. Result all of specimen indicate have equal performance for ultimate strength and not different for behavior of pattern of failure, precast beam concrete type L joint was behavior less for ductility $\delta u/\delta y$ at least approximately 1,17 and result all of specimen indicate have same as performance.

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p.103 - 109

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# APPLICATION OF COMMON DATA ENVIRONMENT (CDE) AS A METHOD OF DESIGN REVIEW IN CONSTRUCTION PROJECT

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***Abstract.*** The development of technology in construction projects produces a method known as Building Information Modelling (BIM). Common Data Environment (CDE) is one of the cloud technology adoption systems that can effectively convey various data information from several BIM softwares without having to download the softwares. Searching for accurate project information according to the latest version takes a long time if the document or information is not well structured. This study aims to analyze the application of CDE to the project in the design review and to determine the criteria that affect the success of the implementation of CDE in the design review and the biggest obstacles in the use of CDE. This research was conducted using a survey method which was distributed to representative respondents. The results showed that the implementation of CDE as a design review on the project was in accordance with CDE standards with an average respondent's level of achievement of 83.28%. The most influential criterion on the success of CDE implementation in the design review is data security. The biggest obstacles are in the form of lack of cooperation between CDE users, undisciplined use, and data that is not always updated.

*Keywords : common data environment (CDE); BIM 360; CDE implementation; review design.*

## 1. INTRODUCTION

CDE platform as the management of all BIM data both in collecting, managing, storing, and disseminating data and information for the entire project team [1]. Problems in project management that often occur in conventional construction are poor communication and coordination between project teams. Timeliness, accuracy, and completeness of information are causes of successful project completion on time and within budget [2]. There are several versions of the documents on the projectand status required for the aquracy of the project documents to be used. Searching for accurate project information according to the latest version takes a long time if the document or information is not well organized. The many versions of documents and the spread of documents in various storages are some of the causes to take time to search the right documents. To find data on common companies takes about 13% of time uses [3]. In the construction industry the situation is worse, it takes about 30% for the Project Manager to find the information needed [3]. If this happens frequently, other processes such as approval, signing, ratification, and information distribution will be delayed.

Common Data Environment (CDE) is a collaborative platform that connects various project data with cloud technologies [4]. By using CDE, everyone involved in the project can take part in handling problems on the project and collaboratively digitally [5]. CDE is an opportunity to increase collaboration and efficiency in the construction industry [4]. BIM 360 is one of the CDE platforms from Autodesk that can be used for communication and coordination with construction actors in review design.

The implementation of the Common Data Environment (CDE) with a survey method has been carried out by Aska to determine the implementation of CDE in the project and the influencing factors and obstacles in its implementation. The results of his research indicate that the factors that influence the implementation of CDE are the readiness of its implementation and the obstacles in the use of CDE are socialization, gadgets and internet

connections, cooperation between users, and the absence of applicable regulations [1].

This research used a survey method [6] to find out the success criteria that affect the implementation of CDE and the obstacles based on survey results from representative respondents. CDE is used for the project life cycle, start from design, delivery, and management until its maintenance. The CDE platform implements the exchange of information between various systems. CDE can be used to monitor work progress, validate incoming data, record all activities carried out by various team members, improve collaboration, and avoid errors such as duplication of data or documents [7].

## 2. METHODS

The method used in this study is a descriptive survey. Descriptive surveys are used to explain current conditions or attitudes [8]. The instrument in this study is a questionnaire which is a set of questions to obtain information from respondents based on their personal perceptions and other matters related to the research material [9]. The questionnaire in this study was divided into 2 parts, part 1 questionnaire contains the criteria for success in implementing CDE and part 2 questionnaire contains obstacles in the use of CDE. This research questionnaire uses a Likert scale of 1-5 [1],[10]. Before the questionnaires are distributed to respondents, the indicators or statements that have been prepared by researchers based on CDE standards and CDE E-books have been validated by experts first [11].

Primary data were obtained from respondents with a sample of 20 people. The respondents of this study are people who have implemented CDE in projects but it has not been proven that the respondents understand the CDE platform as a whole and have certificates. The sampling technique used in this study was purposive random sampling by considering the representation of the total project employees [12]. The data were processed and analyzed using SPSS Version 26 software. The data must be valid and reliable to be used in this study. So the researchers tested the validity and reliability as a research instrument test [13].

Descriptive statistic analysis was used to find out the description of the Y variable (the application of CDE in the review design) by the value of the respondent's level of achievement (TCR) using a Likert scale [14][15]. The Likert scale according to Sugiyono (2015) is a tool used to measure the perception or opinion of a person or group of people on the potential and problems of an object. Multiple linear regression analysis is used to test the relationship between two or more independent variables that affect the dependent variable [16]. To find out the success criteria that affect the implementation of CDE in X Project, multiple linear regression analysis is used [11]. This analysis was carried out after the regression model met the requirements of the classical assumption test (normality, linearity, heteroscedasticity, and multicollinearity) [17]. To find out the biggest obstacle in using CDE, a descriptive analysis was carried out by looking for the mean value of the research data [14].

## 3. RESULTS AND DISCUSSION

### 3.1 Validity Test

The validity test was carried out using SPSS Statistics 26 by comparing the Pearson Correlation value from the SPSS output results. The instrument was tested by involving 20 respondents (n=20) and an error tolerance value used 5% so the r-value from the table is 0.444. Each statement is declared valid if the Pearson Correlation value of the SPSS output is greater than 0.444. The results of the validity test on the questionnaire part 1 all variables in this study are valid. The results of the validity test in the questionnaire part 2 contained 1 invalid statement so that statement was not used in this study. The data is re-tested to ensure all statements are valid.

### 3.2 Reliability Test

The reliability test was carried out using SPSS Statistics 26 by seeing Cronbach's Alpha value from SPSS output. Tthe value from Cronbach's Alpha must be greater than 0.6, so this instrument is reliable.

Table 1. The Result of Reliability Test

| Questionnaire Part 1 | | |
|---|---|---|
| **Variable** | *Cronbach's Alpha* | Description |
| Team ($X_1$) | 0,765 | high level of reliability |
| Roles and Responsibilities ($X_2$) | 0.669 | moderate level of reliability |
| Approval Workflow ($X_3$) | 0.608 | moderate level of reliability |
| Common language and data availability ($X_4$) | 0.698 | moderate level of reliability |
| Data Security ($X_5$) | 0.627 | moderate level of reliability |
| BIM ($X_6$) | 0.670 | moderate level of reliability |
| CDE Implementation in Review Design (Y) | 0.840 | high level of reliability |
| Questionnaire Part 2 | | |
| Variabel | *Cronbach's Alpha* | Description |
| CDE Usage Obstacle | 0,750 | high level of reliability |

Table 1 is the reliable test results of each variable in the questionnaire. Part 1 of the questionnaire contains the criteria for the successful implementation of CDE and the implementation of CDE as a design review. part 2 of the questionnaire contains the obstacles in implementing CDE.

**3.3 Respondent's Level of Achievement (TCR) Analysis**

Based on the questionnaire data part 1, the data was processed using a Likert scale for each statement. The steps to analyze the TCR value are as follows:

1. Calculate the rating index

$$I = \frac{100}{Jumlah\ Skala\ Likert} \quad (1)$$

Refer to Eq. (1), the evaluation of Calculation of the index value that will be used as a category determination

$$I = \frac{100}{5}$$

$$I = 20$$

Based on the results of the calculation of rating index (I) it was obtained for the percent category for each scale is 20% with the following intervals:

0-20% : Strongly disagree
21-40% : disagree
41-60% : Neutral
61-80% : Agree
81-100% : Strongly Agree

2. Calculate maximum value (Y).

$$Y = Skor\ Maksimum \times n \quad (2)$$

Refer to Eq. (2), the evaluation of maximum value calculation

$$Y = 5 \times 20$$

$$Y = 100$$

Calculate the total score for each statement and calculate the Respondent's Level of Achievement (TCR) value to get the percentage score per statement.

$$TCR = \frac{Total\ Skor}{Y} \times 100\% \quad (3)$$

Refer to Eq. (3), the evaluation of respondent's level of achievement (TCR) value.

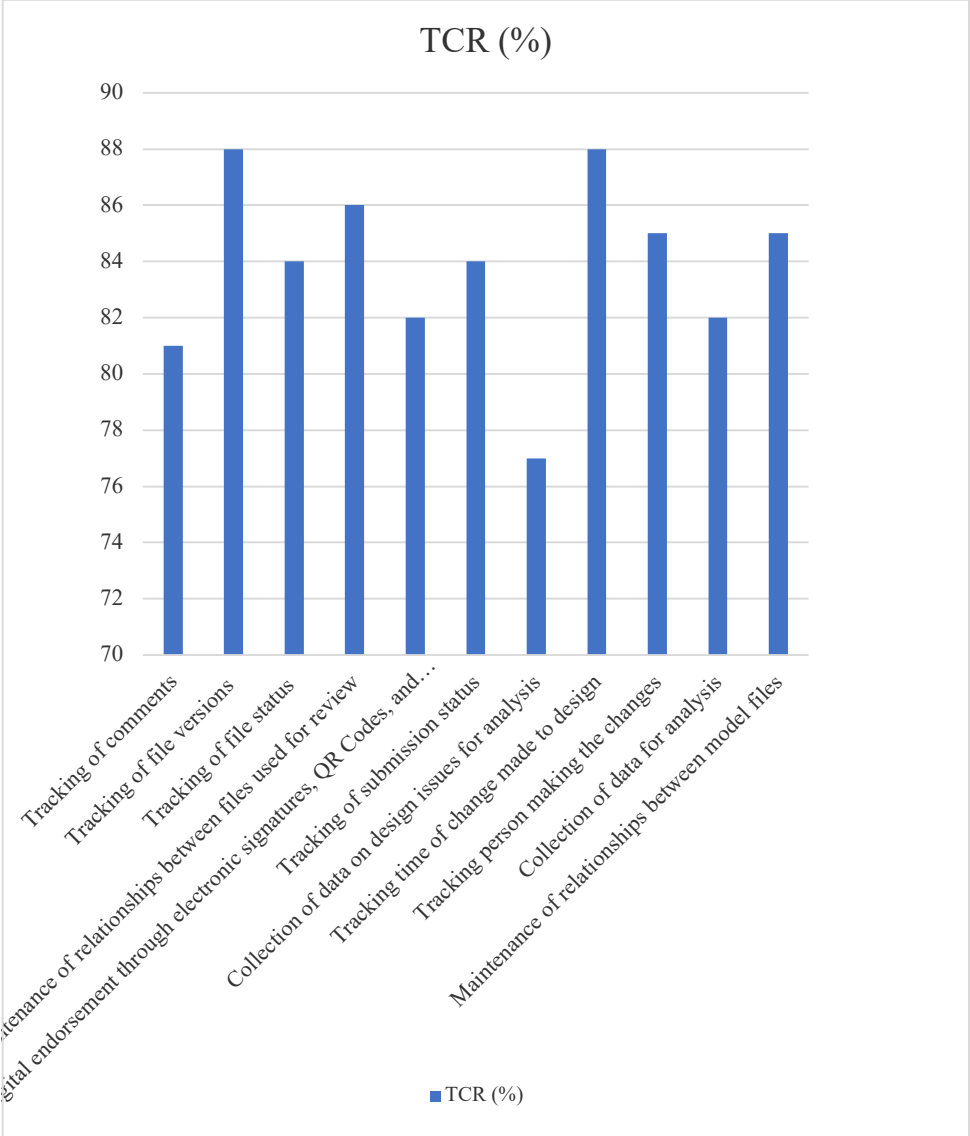


Figure 1 Recapitulation results of Respondent Achievement Level (TCR)

Figure 1 is a recapitulation results of the Respondent Achievement Level (TCR) value on variable Y in the questionnaire part 1 which contains statements regarding the application of CDE as a design review. Based on the recapitulation of the TCR value in the questionnaire part 1 on project X, an average value is 83.82%, this means that most respondents agree that the implementation of CDE on the project is in the design review. Is in accordance with the CDE standard.

The application of CDE in design reviews that is most applied to projects based on the level of achievement of respondents is to track the version of the drawing and track the time team members make changes to the design. The application of CDE in design reviews, especially to track versions of drawings and the time team members make design changes, can minimize the field team from being too late to notice changes in the design [18].

**3.4 Analysis of Criteria Affecting the Success of CDE Implementation**

Questionnaire data in part 1 regarding the application of CDE in the review design was analyzed by multiple linear regression to determine the criteria that significantly affect the implementation of CDE (Y), namely Team (X1), roles and responsibilities of team members (X2), Workflow approval (X3), Common Language and data availability (X4), Data security (X5), and BIM (X6). The data to be analyzed by multiple linear regression must meet the requirements of the instrument test and the classical assumption test. If the value of sig. Less than 0.05, it can be interpreted that there is a significant influence between the independent variable and the dependent variable.

Table 2 Multiple Linear Regression Test Results

| Variabel | *Unstandardized Coefficients* B | *Sig.* |
|---|---|---|
| *Costant* | 15.309 | 0.005 |
| Team ($X_1$) | -0.625 | 0.049 |
| Roles and Responsibilities ($X_2$) | 0.138 | 0.663 |
| Approval Workflow ($X_3$) | 0.620 | 0.044 |
| Common language and data availability ($X_4$) | -0.329 | 0.207 |
| Data Security ($X_5$) | 2.887 | 0.000 |
| BIM ($X_6$) | 0.720 | 0.030 |

Table 2 is the result of multiple linear regression test from the SPSS application. these results can be arranged as follows:

$$\hat{Y} = 15.309 - 0.625\ X1 + 0.138\ X2 + 0.620\ X3 - 0.329\ X4 + 2.887\ X5 + 0.720\ X6 \quad (4)$$

Refer to Eq. (4), the evaluation of multiple linear regression equation

Based on the equation above, it can be concluded that there is a negative value in the team criteria and common language and availability, this states that the X1 variable has no influence on the implementation of CDE as stated in the study entitled "Implementation of the Use of the Common Data Environment in Project X" states that the more the higher the quality of the existing human resources on the project, does not mean the higher the success of its implementation [1].

The T test was conducted to determine whether or not there was a significant effect of the independent variable (X) on the dependent variable (Y) partially with the research hypothesis:

Ho : Variable Xi does not have a significant effect on variable Y partially

Ha : Variable Xi has a significant effect on variable Y partially

The level of significance (α) in this study is 0.05, if the significance value is less than 0.05 and the t value is greater than the t value based on table (2.132), it means Xi variable has a significant effect on the Y variable partially.

Table 3 T Test Results

| Variabel | t | *Sig.* |
|---|---|---|
| Team (X1) | -2.171 | 0.049 |
| Roles and Responsibilities (X2) | 0.445 | 0.663 |
| Approval Workflow (X3) | 2.229 | 0.044 |
| Common language and data availability (X4) | -1.328 | 0.207 |
| Data Security (X5) | 7.718 | 0.000 |
| BIM (X6) | 2.428 | 0.030 |

Table 3 is the result of the t-test or test conducted to determine whether or not significant effect on each independent variable. The results of the t-test can be seen from the t value obtained compared to t in the table (2.132). Based on the table above, the variables that have a t value greater than 2.132 are the team variable, approval workflow, data security, and BIM with a significance value of less than 0.05. Thus, team criteria, approval workflow, data security, and BIM are criteria that have a partially significant influence on the success of implementing CDE in the design review. The negative sign in t value means that it has the opposite effect on the success of the CDE implementation.

The F test was conducted to determine whether or not there was a significant effect of the independent variable (X) on the dependent variable (Y) simultaneously (together) with the research hypothesis:

Ho : Variable Independent (X1, X2, X3, X4, X5, dan X6) does not have a significant effect on the Y variable

simultaneously

Ha : Variable Independent (X1, X2, X3, X4, X5, dan X6) have a significant effect on the Y variable simultaneously.

If the value of F is greater than F value based on table (3.24), then the variable X has a significant effect on the variable Y simultaneously.

Table 4 F Test Results

| | |
|---|---|
| F | 30.061 |
| *Sig.* | 0.000 |

Table 4 is the result of the F test to determine is there a significant effect on the independent variables simultaneously. F test results can be seen from the F value obtained compared to F in the table (3.24). F has a value of 30,061 more than 3.24 and a significance value is 0.000 less than 0.05 so it can be concluded that Ha is accepted and Ho is rejected. In other words, it is concluded that team criteria, roles and responsibilities of team members, approval workflow, general terms and data availability, data security, and BIM simultaneously have a significant influence on the implementation of CDE in the design review.

Determination test is carried out to determine the percentage of the influence of the independent variable (X1, X2, X3, X4, X5, dan X6) on the dependent variable (Y) by using the coefficient of determination (R Square). The coefficient of determination (R Square) obtained in this study is 0.933 or 93.3% which means that team criteria, roles and responsibilities of team members, approval workflow, general terms and data availability, data security, and BIM have an effect of 93.3% on the implementation CDE in design review. While the remaining 6.7% is influenced by other factors that are not in this study.

### 3.5 Analysis of the Biggest Obstacle in the Use of CDE

The biggest obstacle in using CDE was analyzed based on the mean value in the questionnaire part 2.

Table 5 Recapitulation of Mean Values from Questionnaire 2

| Rank | Statement | Mean |
|---|---|---|
| 1 | Lack of cooperation between CDE users | 4.25 |
| 2 | Undisciplined in the use of CDE | 4.15 |
| 3 | Difficult to adjust to new technology | 4.15 |
| 4 | Data on the CDE platform is not always updated | 4.10 |
| 5 | Users are still confused about the features available on CDE | 3.15 |
| 6 | Lack of training | 3.10 |
| 7 | Server is often down when using CDE | 2.90 |
| 8 | There is no regular monitoring from experts | 2.75 |
| 9 | There are no official regulations or Standard Operational Procedure regarding the use of CDE | 2.35 |

Table 5 is a recapitulation of the average value in the questionnaire part 2. The average value can be used to find out the obstacles experienced by the user. The biggest obstacles in the use of CDE in Project X are the lack of cooperation between CDE users (4.25), undisciplined in the use of CDE (4.15), difficult to adapt to new technologies (4.15), and data on the CDE platform that is not always updated ( 4.10) [19]. The journal entitled "Factors of Effective BIM Governance" states that the obstacles in the adoption of BIM are human, cost, technical, and legal resources [20].

## 4. CONCLUSION

The implementation of CDE in the design review on project X is in accordance with the standards for implementing CDE, as can be seen from the calculation of the Respondent Achievement Level (TCR) of 83.82%. The criteria that have a significant influence on the partial implementation of CDE are team, approval workflow, data security, and BIM. Team criteria, roles and responsibilities of team members, approval workflow, common terms and data availability, data security, and simultaneous (shared) BIM have a significant impact on the implementation of CDE. The most influential criterion on the implementation of CDE in the design review is data security. The biggest obstacle in using CDE in project X is the lack of cooperation between users, undisciplined

in the use of CDE, and data on the CDE platform that is not updated. Research related to the implementation of further CDE in a project is recommended to test in other fields such as monitoring in the field and reviewing project management variables, especially the competence of the team and the roles and responsibilities of its members.

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No.2 July 2022; p.110 - 118

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# INFLUENCE OF SALINITY LEVELS ANALYSIS ON SETTLING VELOCITY OF FINE SEDIMENT GRAINS IN CILIWUNG ESTUARY

## Salinity Levels on Settling Velocity of Fine Sediment Grains

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***Abstract.*** estuarine sediment transportation hold a very complex method, which is the combined impact result of periodically shuttle flow, ocean waves, and the electrochemical property of sea water. Settling velocity (SV) is such a parameter fundamental for sediment researchers so that its accurate resolution has been regarded as a top priority in correcting modelling numerical and conceptual understanding of fine sediment dynamics. This experimental study to have goal to analyze the effect of salinity levels on the settling velocity of fine sediment grains in the Ciliwung estuary, Jakarta. The method used is direct measurement using the hydrometer analysis method. The result of experiment shows salinity levels affect the settling velocity of fine sediment grains in the Ciliwung estuary. The higher salinity, faster the settling velocity of fine sediment grains. The average settling velocity at distilled water salinity 0 ppt is 1.083 mm/minute, sea water with salinity 0.3 ppt is 1.537 mm/minute, and sea water with salinity of 0.6 ppt of 1.561 mm/minute. So, salinity have affects to the SV, if the salinity is high then SV is also high and if the salinity is low then the SV is also low.

***Keywords*** *: settling velocity; salinity; fine sediment; estuary*

## 1. INTRODUCTION

Natural rivers around the world have winding channel characteristics with different sizes of bottom sediment grains and different flows [1]. Transport of estuarine sediment have a highly complex method, which is the combined effects result of periodically reciprocating flow, ocean waves, and the electrochemical characteristic of sea water[2] [3]. There is a growing interest in the suspended sediments transport in estuaries due to both the high dredging costs associated with problems of siltation in harbors and channels of navigation, and environmental problems[4][5]. One of the major parameters required for successful numerical simulations of suspended sediment distributions and the estuarine turbidity maximum is settling velocity (SV)[6]. SV or also known as falling velocity in sedimentology and morpho coastal dynamics, especially for those fine sediment estuaries is a critical parameter in the sediment under-standing behavior and dynamics. The SV directly determines of vertical distribution of Suspended Sediment Concentration (SSC) and flux of near-bed deposition, and its accurate determination has been regarded as a priority in characterizing fine sediment transport[7]. The height affects the SV, the larger particles that will occur, the greater the SV [8]. The goal of this study is to analyze the effect of salinity levels on the settling velocity of fine sediment grains in the Ciliwung estuary, Jakarta. Salinity and settling velocity have engagement, and those should be concerned related with sedimentation due to settling velocity is affected by salinity level.

SV is such a parameter fundamental for sediment researchers so that its accurate determination has been regarded as a top priority in improving correcting numerical and conceptual understanding of fine sediment

dynamics[9]. Salinity has also been documented by Burt in 1986 as having the ability to alter fine sediment SV in some bracket is hand saline waters. Higher salinity may induce greater SV over the entire SSC range according to Burt (1986). Positive ions of contained in natural sea waters, carry positive electric charges which benefit for the growth of flocs. However, higher saline content does not always favor SV; SV reaches a maximum value at a salinity of 10–15 practical salinity units (PSU) for Tamar Estuary mud by Al Ani et al in 1991[7]. The natural distribution of salinity is influenced by several factors, including rainfall, the flow of fresh water into the sea directly or through rivers and glaciers, evaporation, ocean currents, mixing turbulence, and wave action. In addition, salinity also affects the speed of sediment deposition. If the salinity is high then the sediment deposition rate is also low[8].

Fall or settling velocity studies started by Stokes and was subsequently followed by different researchers resulting in a variety of equations with two common assumptions[4]. The settling velocity in the previous research of a particle in a quiescent fluid was derived by equating the effective weight force to the drag force with respect to the particle shape. In case of very fine sediments (silt) or a large depth, the settling process can continue during the slack water period[10]. Other previous research shows the SM12 method is well-suited to application in computational models of estuarine dynamics with high-level closures and also in simpler cases[11]. Research that has been carried out by A.J. Manning et al. presents the findings of the depositional velocity of recent laboratory studies investigating flocculation dynamics for three different mud/sand mixtures at concentration (0.2–5 g.l−1) and turbulent shear stress (0.06-0.9 Pa) in a mini-annular flume [12] .

And other previous research the estuarine hydrodynamics was characterized as well-stratified[13]. In freshwater, the sediments suspended existed mainly in a dispersed state[14][15], and fine sediment is anticipated to form floc as soon as it meets saline water[16]. In estuarine waters, the suspended sediment occurred largely as coagulated flocs with their behavior significantly affected by the salinity gradient and vertical stratification[7][17]. In the upper diluted water, the in situ median diameter of suspended sediments was closely related to salinity, but in situ SV and apparent density varied less with salinity[7]. Common problem occurred on downstream rivers and estuaries is sedimentation. Salinity and settling velocity have engagement, and those should be concerned related with sedimentation due to settling velocity is affected by salinity level. Such is the case with the problem that occurs in the Ciliwung estuary. A sedimentation process can result in silting, rising water levels, and obstruct river flow from the middle to downstream. Based on description and previous research above, this study has purpose to analyze the effect of salinity levels on the settling velocity of fine sediment grains in the Ciliwung estuary, Jakarta.

## 2. METHODS

This study is direct measurement research uses the hydrometer analysis method which can also be called the sedimentation test, which is a method to calculate the grain size distribution of soil based on soil sedimentation in water. The sample location in the old Ciliwung estuary, Jakarta and there are 2 sampling points showed in Figure 1, namely

1. approx. 50 meters before the floodgate, and the depth when sampling is 1.8 m,
2. right at the floodgate with a depth of 2.4 m.


Figure 1 : Google earth of research location

The testing time started there are 14 times experiment, from the time in minutes, are 1,2,3,4,8,15,30,60,120,180,240,300,360, and 420. And the samples tested had a mass of 50 grams. The water used in the test is distilled water with salinity 0 ppt, sea water with a salinity of 0.3 ppt which is taken before the floodgate, and sea water with a salinity of 0.6 ppt which is taken right at the floodgate. The steps of the research carried out at the Civil Engineering Laboratory of the Politeknik Negeri Jakarta are as follows:

1. Prepare tools and samples as shown in Figure 2
2. Weighting the sample with a mass of 50 grams as shown in Figure 3
3. The sample is allowed to stand for approximately 24 hours as shown in Figure 4a
4. Samples are blended as shown in Figure 4b
5. Conduct a settling velocity test by putting the mashed sample into a measuring cup as shown in Figure 4c

Figure 2 : Sample of mud and water from Ciliwung estuary

Figure 3 : Weighting samples

Figure 4a

Figure 4b

Figure 4c

Figure 4a : The sample is allowed to stand for approximately 24 hours
Figure 4b : Samples are blended
Figure 4c : Conduct a settling velocity test by putting the mashed sample into a measuring cup

## 3. RESULTS AND DISCUSSION

Table 1 below is the experimental data on the settling height of the fine sediment and the settling velocity got when the sample was tested by adding distilled water, where 0 of the pH and salinity. Obtained when the sample was tested by adding water with salinity 0.3 ppt and 0.6 ppt. For the settling height shown in table 1 and figure 11, the longer the testing time, the lower the settling height of the grains. This also happened to the settling velocity, the longer the testing time the slower the settling velocity as shown in table 1 and figure 12. With a relatively long settling height, the researchers also tested using a mixture of samples with salinity 0.3 ppt and 0 ,6 ppt.

Table 1: Experimental data of grain - settling height and velocity of sample with different salinity

| Time ($t$ (minute)) | Settling height of Sample + water salinity 0 ppt r ($h$ (mm)) | Settling height of Sample + sea water salinity 0,3 ppt ($h$ (mm)) | Settling height of Sample + sea water salinity 0,6 ppt ($h$ (mm)) | SV with sea water salinity 0 ppt $v$(mm/minute) | SV with sea water salinity 0,3 ppt $v$(mm/minute) | SV with sea water salinity 0,6 ppt $v$(mm/minute) |
|---|---|---|---|---|---|---|
| 1 | 45 | 30 | 31 | 3 | 2 | 3 |
| 2 | 42 | 28 | 28 | 2 | 5 | 3 |
| 3 | 40 | 23 | 25 | 2 | 4 | 4 |
| 4 | 38 | 19 | 21 | 0,75 | 2,25 | 3,75 |
| 8 | 35 | 10 | 6 | 1,428571429 | 0,428571 | 0,285714286 |
| 15 | 25 | 7 | 4 | 0,333333333 | 0 | 0 |
| 30 | 20 | 7 | 4 | 0,133333333 | 0,13333333 | 0 |
| 60 | 16 | 3 | 4 | 0,066666667 | 0,01666666 | 0,016666667 |
| 120 | 12 | 2 | 3 | 0,033333333 | 0 | 0 |
| 180 | 10 | 2 | 3 | 0,03333333 | 0 | 0 |
| 240 | 8 | 2 | 3 | 0 | 0 | 0 |
| 300 | 8 | 2 | 3 | 0,03333333 | 0 | 0 |
| 360 | 6 | 2 | 3 | 0 | 0 | 0,01666666 |
| 420 | 6 | 2 | 2 | -0,01428571 | -0,0047619 | -0,0047619 |

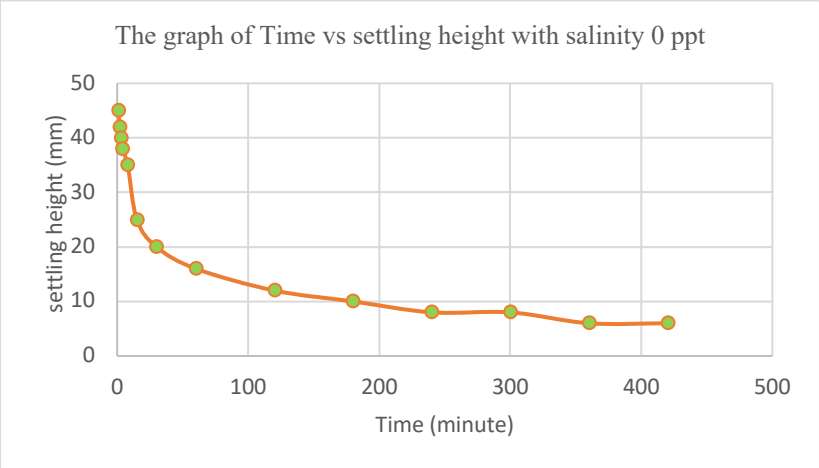


Figure 5: The graph of Time vs settling height with salinity 0 ppt

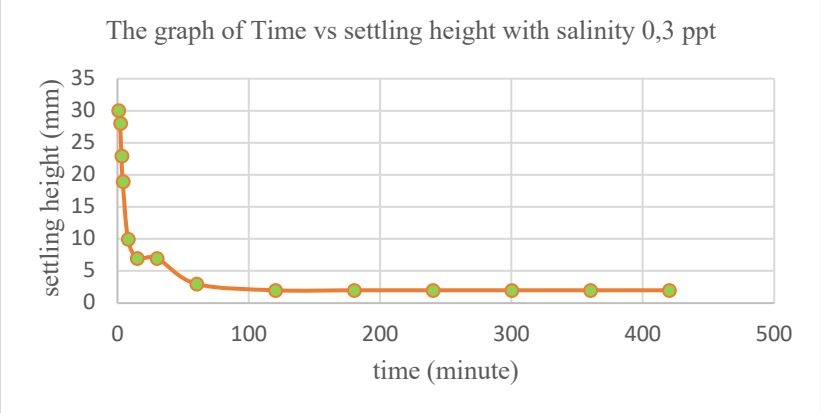


Figure 6 : The graph of Time vs settling height with salinity 0,3 ppt

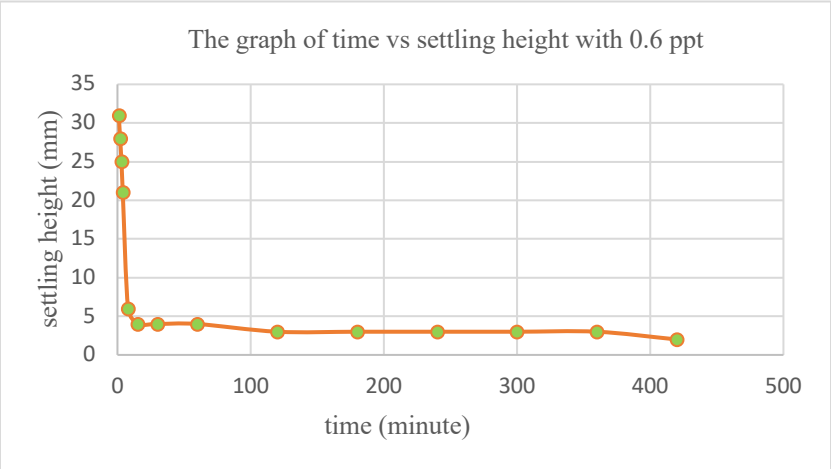


Figure 7: The graph of time vs settling height high with 0.6 ppt

Figure 8 shows the experimental results of the fine grain drop height in the sample added with distilled water that has a salinity of 0 ppt in each time interval. There are using 14 times interval, namely the range from the 1st minute to the 450th minute. The maximum drop height of fine grains is found in the first interval, namely the 1st to 4th minute, with a settling height value ranging from 38 to 45 mm. Figure 9 is the drop height of the fine grains in the sample added with seawater which has a salinity of 0.3 ppt. It can be seen that the maximum drop height of fine grains is also found in the first interval, namely the 1st to 4th minute, with the settling height value ranging from 19 to 28 mm. There is a difference in the height of settling to be shorter with the height of settling in the sample mixture added with water that has a salinity of 0 ppt. Figure 10 is the result of an experimental result of the fine grain drop height in the sample added with seawater which has a salinity of 0.6 ppt. It can be seen that the height of the fine-grained fall reaches its maximum at interval 1. Followed by the second interval, which is between the 8th – 60th minute, and the minimum settling height is at the 3rd interval, which is the 120th – 420th minute. The experimental results on the graph are linear with experiment at salinity 0 ppt and 0.3 ppt.

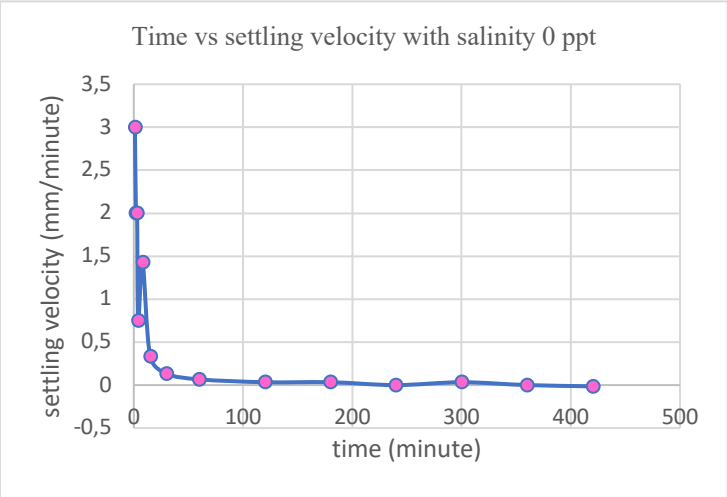


Figure 8 : The graph of time vs settling velocity with distilled water salinity 0 ppt

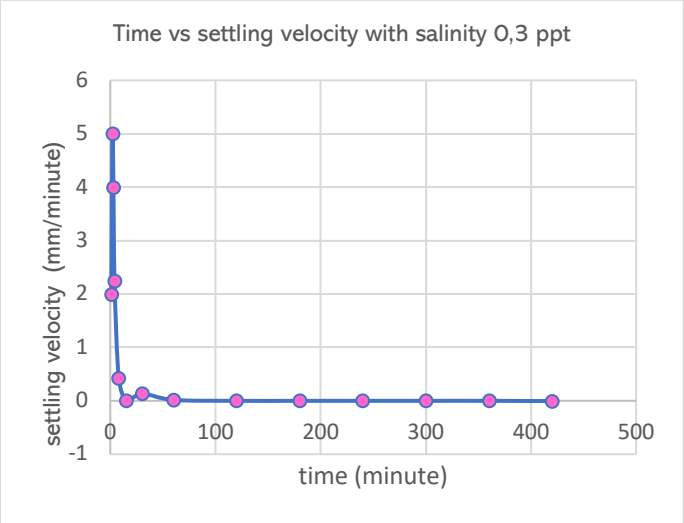


Figure 9 : The graph time – settling velocity with sea water salinity 0.3 ppt

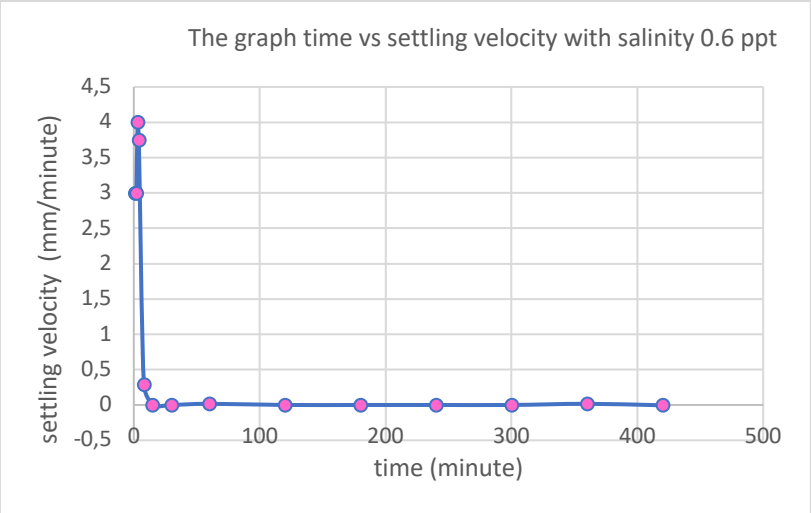


Figure 10: The graph time vs settling velocity with sea water salinity 0.6 ppt

Figure 11 shows the experimental results of the settling velocity of fine grains at each time interval on the sample added with distilled water which has a salinity of 0 ppt. It is calculated using the average velocity equation, namely the height of the fall divided by the change in time. The SV of fall is presented in a graph as a function of time vs. settling velocity of fall. The relationship that is seen is that the longer the experiment time the slower the grain SV, so that it takes a long time to get the sedimentation results until the deposition process stops[18]. The maximum SV calculated is in the first interval, which is between the 1st to 4th minute time span with a large settling velocity ranging from 0.75 mm/minute – 3 mm/minute. The results of the analysis in the 8th minute the SV of settling fine grains rose again at a value of 1.5 mm/minute. Figure 9 shows the experimental results of the SV of fine grains at each time interval on the sample added with seawater which has a salinity of 0.3 ppt. The results of the analysis show that the settling velocity of fine grains is inversely proportional to the time interval. However, there are some data that are not uniform, namely between the 1st and 2nd minute, and the 15th – 60th minute. The maximum settling velocity is in the 2nd minute, which is 5 mm/minute. Figure 12 shows the experimental results of the SV of fine grains at each time interval on the sample added with seawater which has a salinity of 0.6 ppt. The results of the analysis show that the SV of fine grains is inversely proportional to the time interval. However, there are some data that are not uniform, namely between the 1st and 3rd minutes, namely in the 1-2 minute it has a SV of 4 mm/minute but in the 3rd minute it rises to 4 mm/minute. However, even so, the overall settling velocity of settling velocity fine grains is inversely proportional to the time interval determined in the experiment. The maximum settling velocity is in the 3rd minute, which is 4 mm/minute.

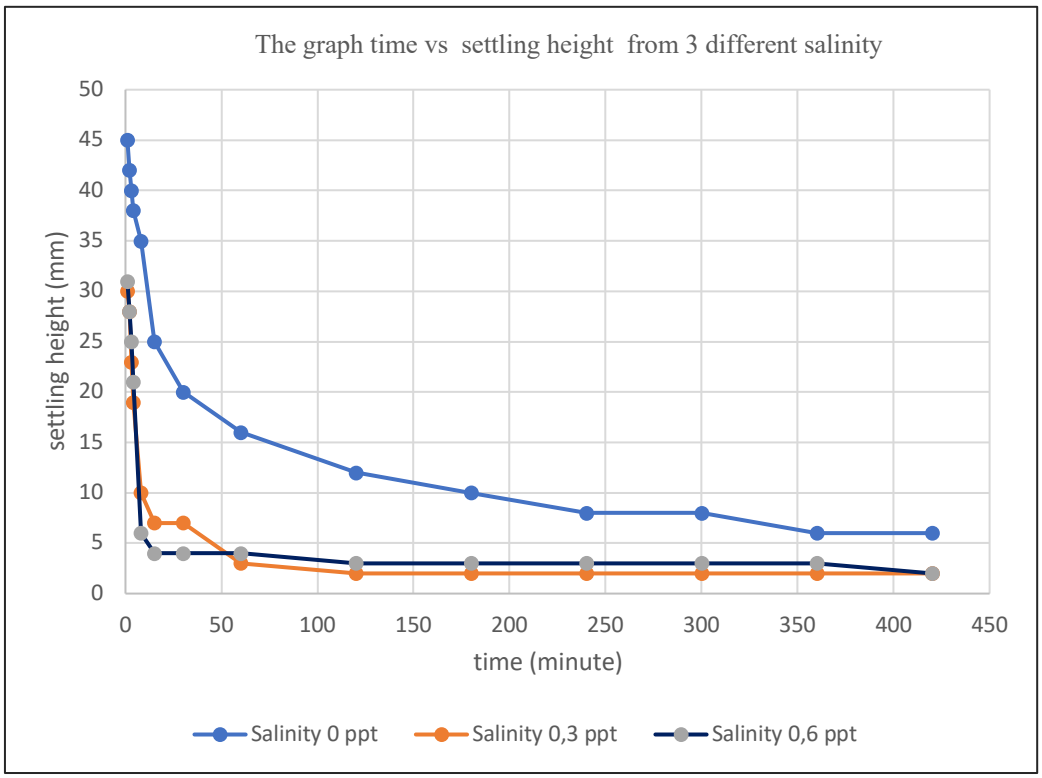


Figure 11: The graph of comparison time vs settling height from 3 different salinity

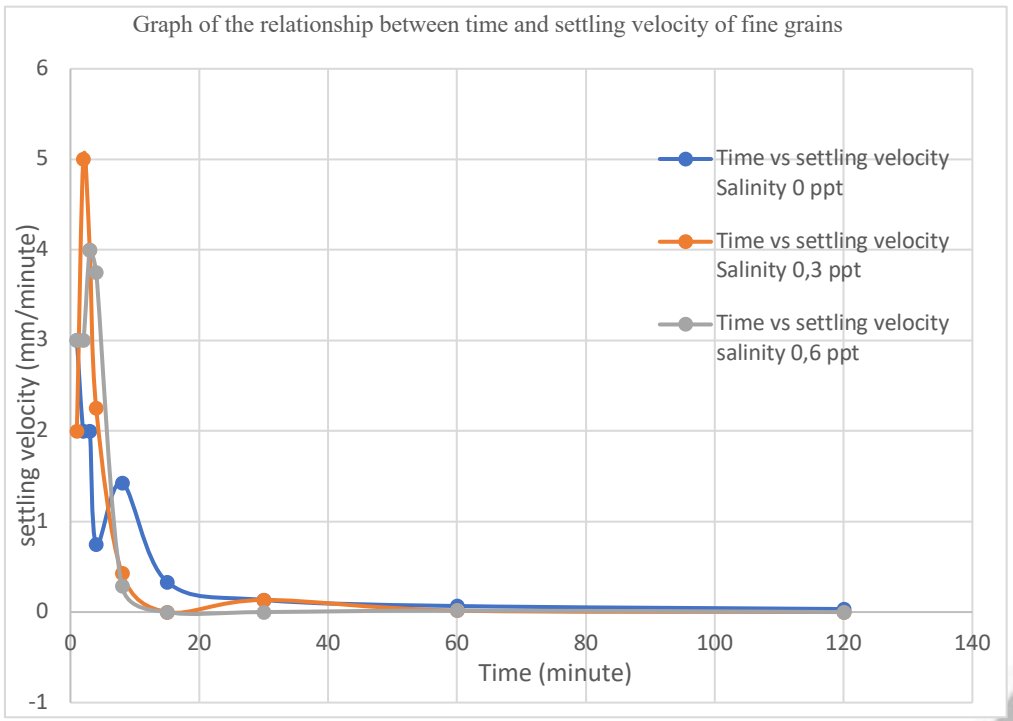


Figure 12: Comparisons of settling velocity of fine sediment in three different salinity

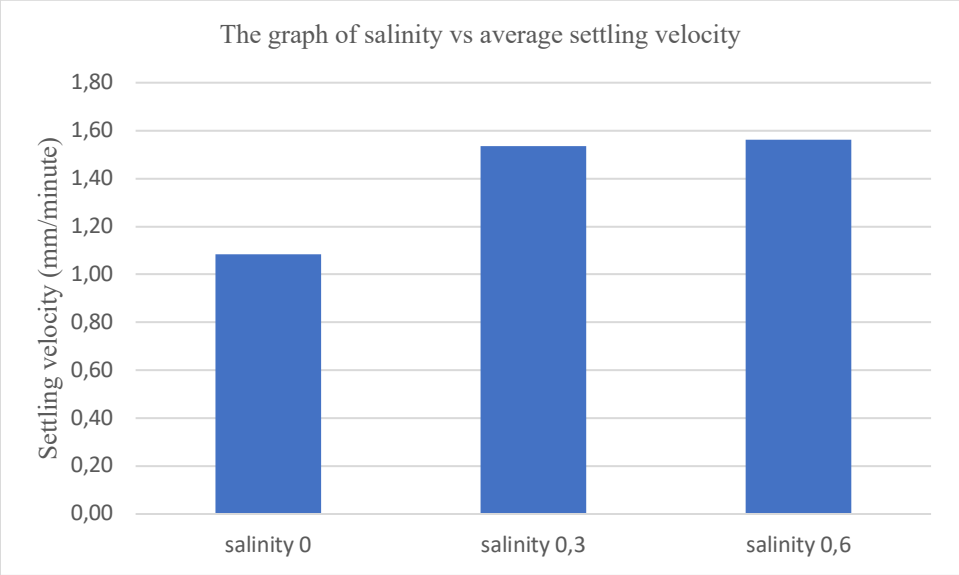


Figure 13: Average settling velocity of fine sediment in three different salinities

The model of hydrodynamic calculates the vertical velocity and the turbulent overspread [11]. The settling velocity of sediments in varies of estuary in space and time; it's in one estuary may not be comparable with that in another. Density and concentration of sediments in the water column have the same size, the settling velocity may be different under different conditions of hydrodynamic[19]. Determine the settling velocity of muddy sediments is much more complex than sand, because of its dependence on the state of flocculation, which in turn of depends on the concentration of sediment, the characteristics of turbulence, the water and sediment properties, and the time/space-history of all of these. In a laboratory study conducted by Mignot, 1968 has shown a clear effect of salinity on the rate of deposition of cohesive materials[20]. The results of the research that have been carried out by the current researcher are in accordance with previous laboratory studies which show that salinity is indeed a relevant factor as shown in Figure 11 and Figure 12. Figure 11 shows a graph of time to drop height of soil grains, from the figure it can be seen that the more the longer the observation time, the shorter the drop height of the soil grains. The maximum drop height of soil grains is in the sample using a salinity of 0 ppt, which is about 5 – 45 mm. Samples mixed using 0.3 ppt salinity, overall have a higher fine grain drop than using samples mixed using 0.6 ppt salinity. However, the difference between salinity 0.3 ppt and 0.6 ppt is not that significant but can still be observed.

Figure 12 shows a graph of the results of the study between the time and SV of settling fine grains at the study site. The results showed unstable data, there were some parts that suddenly rose and tended to fall. However, if we take the average fall settling velocity of 3 different salinities, it can be seen that the settling velocity of the fine grains with the addition of salinity will accelerate the settling velocity. Specific finding from this research is relationship between salinity level and settling velocity on Ciliwung estuary as shown in figure 13, namely the average settling velocity at 0 ppt salinity is 1.083 mm/minute, 0.3 ppt salinity is 1.537 mm/minute, and salinity 0.6 ppt is 1.561 mm/minute. So, salinity have affects to the SV, if the salinity is high then SV is also high and if the salinity is low then the SV is also low. From the results of this study, the recommendations that the author can give to the community and local governments are information on sediment characteristics that can provide solutions for adding appropriate facilities/infrastructure in sedimentation control activities, especially rivers that empties into Jakarta Bay and are influenced by tides.

## 4. CONCLUSION

Salinity affects the settling velocity of fine sediment in the Ciliwung Estuary, the higher salinity, faster the settling velocity of fine sediment, the average settling velocity at distilled water with 0 ppt salinity is 1.083 mm/minute, sea water with salinity 0.3 ppt is 1.537 mm/minute, and sea water with salinity of 0.6 ppt of 1.561 mm/minute. So, salinity have affects to the SV, if the salinity is high then SV is also high and if the salinity is low then the SV is also low.

## 5. ACKNOWLEDGEMENT

Thank you very much for UP2M Politeknik Negeri Jakarta for the sponsorship this article submitted to Logic.

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p.119 - 126

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# WEB-BASED GEOGRAPHIC INFORMATION SYSTEM OF BANTEN PIODALAN STORES MAPPING IN DENPASAR CITY

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***Abstract.*** Banten is a medium used in Hindu religious ceremonies and also as a medium of prayer in getting closer to Ida Sang Hyang Widhi Wasa or God Almighty. Hindus are required to be able to know the meaning and method of making a banten, but along with the development of an increasingly modern era resulting in a high level of activity in big cities, one of which is Denpasar City, this underlies the tendency of people to prefer buying banten rather than making it. because of the limited time they have. This also underlies the development of a web-based mapping information system for banten piodalan stores in the city of Denpasar. The public will find it easy to find out the mapping of the locations of Banten shops in the city of Denpasar through the system. The system is also equipped with a marketplace feature that makes it easy for the public to make transactions to buy banten piodalan they want and those who want to make transactions in selling banten piodalan.

*Keywords : banten, geographic information system, marketplace, transactions, mapping*

## 1. INTRODUCTION

Bali, where the majority of its citizens are Hindus, where traditions, culture and religion are very close, interrelated and complement each other. Especially in Bali, there is such a thing as Banten. Banten is an tribute and a medium for Hindus to get closer to Ida Sang Hyang Widhi Wasa or God Almighty [1]. Hindus are required to be able to understand things related to the banten, starting from the meaning and also the production technique, especially the supporting materials in it [2], Not a few Hindus in Bali also take advantage of their abilities in making a piodalan banten as a source of income for them, but not all Hindus in Bali understand about the complementary medium of banten. This could be because many people prefer to buy banten at banten store rather than making them themselves according to [2].

One of the solutions that can be done for this is to create a system that can display the locations of banten piodalan stores in certain areas. Technology combined with geographic information which certainly has a very positive impact, especially in terms of location knowledge. The purpose of making this system is to make it easier for users to access information from the location of the nearest banten piodalan stores, in addition to easy access to information, this system is also a marketplace between sellers and buyers. Sellers can directly promote their banten piodalan and buyers can compare the prices of banten at each seller on the system, buyers can also directly buy banten on the system and make payments via transfer to the banten merchant in the system. There are several previous studies that were used as a reference, among others; the banten management information system which discusses the web-based banten data management system displays data management from the content so that it can be displayed in an android-based banten information system [3]. Bebayuhan oton information system by applying a tree diagram that discusses the bebayuhan information system and displays procession data, banten and facilities as a complement to the ceremony [4].

Based on some of these studies, This research is a Geographic Information System (GIS) was developed

that was able to manage and display information on the location of banten stores in the Bali area, especially the Denpasar area, and a marketplace that assists users in buying and selling banten piodalan. This Geographic Information System will be built based on the web where the information is equipped with dynamic maps. This system is expected to overcome some of the limitations of manual maps, with dynamic map development, it is hoped that a geographic information system for mapping banten stores in the Denpasar area will be realized. This geographic information system is also expected to have the ability to update data quickly and easily equipped with complete information. Complete data about a banten shop in this application will later be managed by the merchant, namely the banten seller from the banten shop itself.

## 2. METHODS

### 2.1 Research Method

The research methodology used is the Design Scientific Research Methodology (DSRM) [15]. This methodology has 6 stages which can be seen in Figure 1.

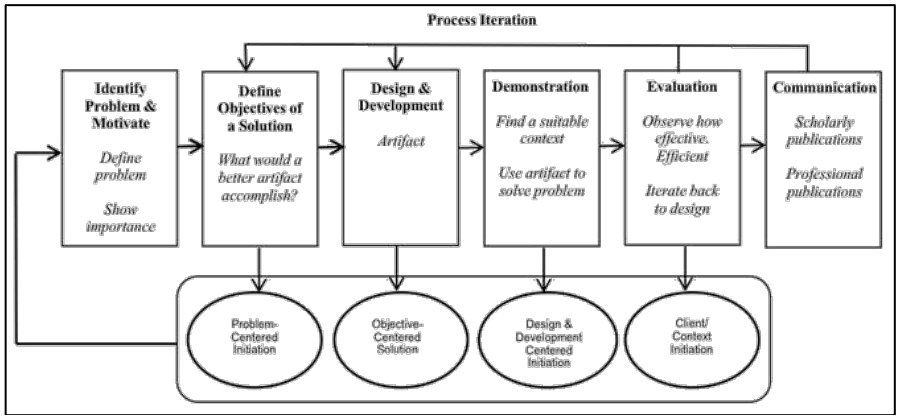


Figure 1. Design Scientific Research Methodology (DSRM)

a. Identify problem and motivate, This stage is carried out to find out the problem that not all Hindus in Bali understand about the complementary medium of banten. This could be because many people prefer to buy banten from the sellers of banten rather than making them themselves.
b. Define Objectives of a solution, carry out research analysis related to literature studies from previously collected and understood solutions, so that research objectives or research directions to be made can be determined by determining new solutions.
c. Design and development, carried out to make a temporary modeling of the system to be designed. The design consists of an overview of the system. System design consists of context diagrams, data flow diagrams, database design, and interface design.
d. Demonstration, This stage is carried out by conducting a demo of the system results that have been made to the supervisor to get advice in developing the system.
e. Evaluation, This stage is carried out with the aim of knowing the extent to which the system developed can run well according to its functionality.
f. Communication, In this method, it means documenting the results of research that has been completed by making reports or publishing them in journals.

### 2.2 System Overview

An overview of web-based geographic information system of banten piodalan stores mapping in denpasar city can be seen in Figure 2.

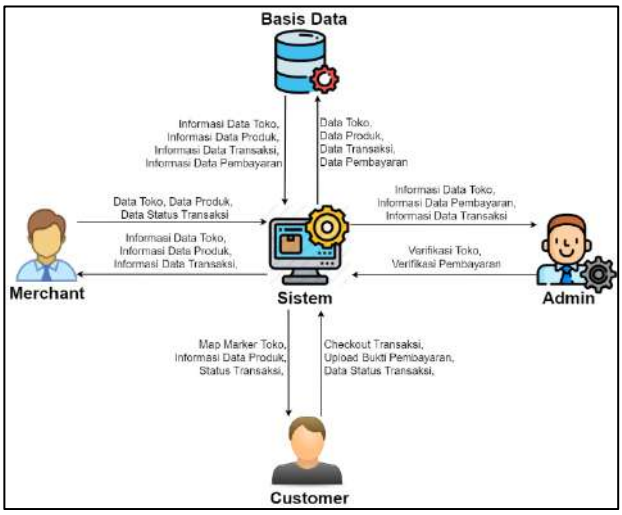


Figure 2. Geographic Information System Mapping of Banten Piodalan Stores System Overview.

Figure 2 is an overview of geographic information system mapping of banten piodalan stores which consists of 3 types of users, namely, merchant, customer, admin. Merchants can add new stores and products to the system. Admin can verify stores added by merchants, accept and approve payments for transactions that occur in the system. Customers can see the mapping of stores registered in the system, customers can make transactions directly from the system.

### 2.3 System Tree Diagram

The tree diagram is a hierarchy of a process in a system. The hierarchy of web-based geographic information system of banten piodalan stores mapping in denpasar city can be seen in Figure 3.

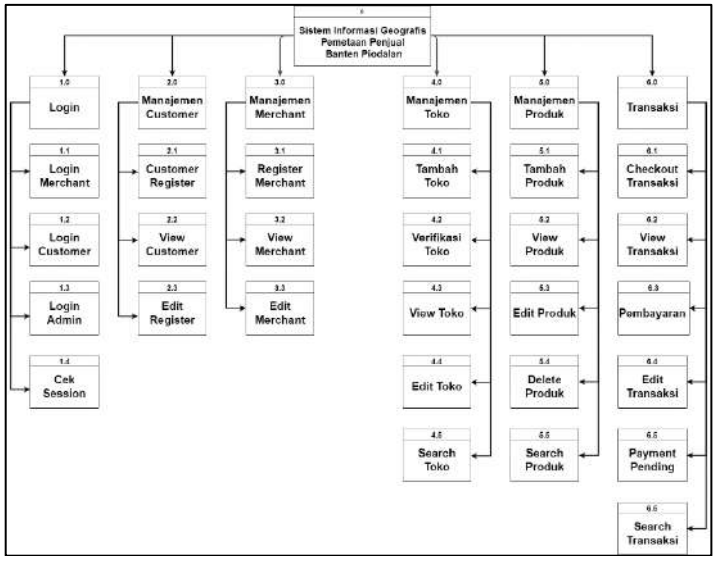


Figure 3. Tree Diagram of Geographic Information System Mapping of Banten Piodalan Stores.

Figure 3 is a tree diagram of geographic information system mapping of banten piodalan stores consisting of 2 levels, namely Level 0 and Level 1. Level 0 consists of 6 processes, namely Login, Customer Management, Merchant Management, Store Management, Product Management, and Transactions. Level 1 consists of sub-processes of each process at level 0.

## 3. RESULTS AND DISCUSSION

web-based geographic information system of banten piodalan stores mapping in denpasar city produces system results that can be implemented based on a previously established design. The following are the results of the system implementation consisting of the results of the customer display system, the results of the merchant display system and the results of the admin display system.

### 3.1 Customer Web Page Display

The system results from web-based geographic information system of banten piodalan stores mapping in denpasar city explain and display the system results for all the features contained in the system with access as customers.

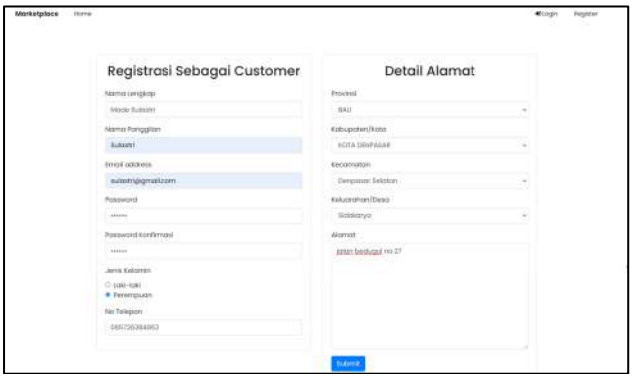


Figure 4. Customer Sign up Display

Figure 4 is a display of the registration page as a customer on the system. Customers need to register an account if they want to make a purchase transaction for banten piodalan.


Figure 5. Customer Sign in Display

Figure 5 is a display of the sign in process page as a customer on the system which functions to check username and password in order to sign in to the system. Figure 6 is the display when the customer has logged in.

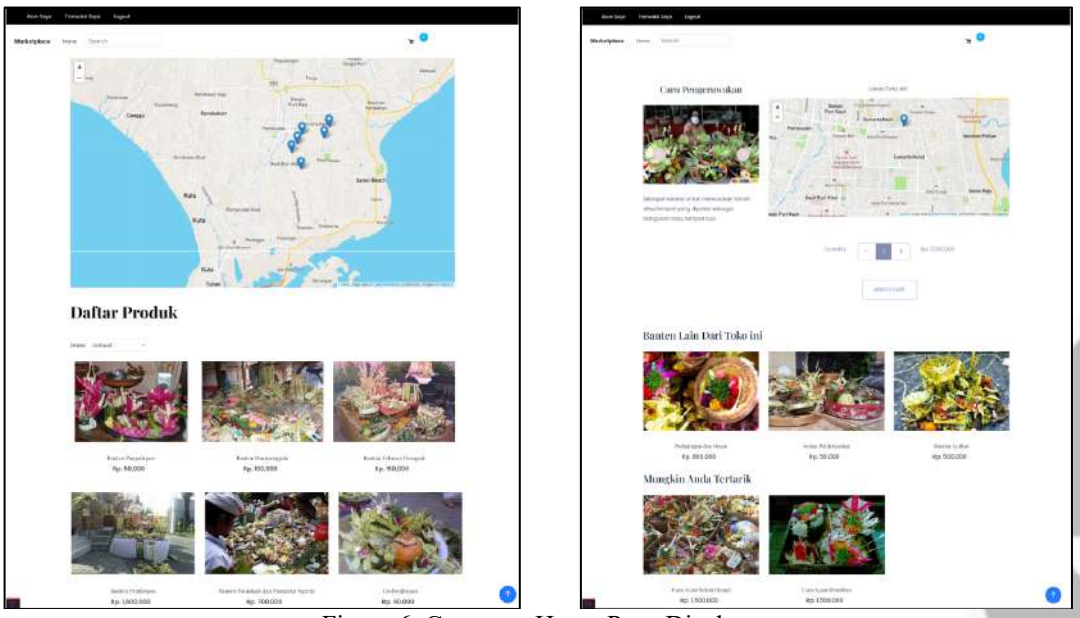


Figure 6. Customer Home Page Display

Figure 6 is a display from the customer's home page which displays a mapping of the location of the Banten stores, all banten products in the system and the display of the banten product page which displays photos of the banten product, the name of the banten product, a description of the banten product, recommendations for other banten products and the location of the banten product. the store that sells the banten product on maps, as well as the quantity accompanied by the price if you want to add the Banten product to the cart or shopping cart.

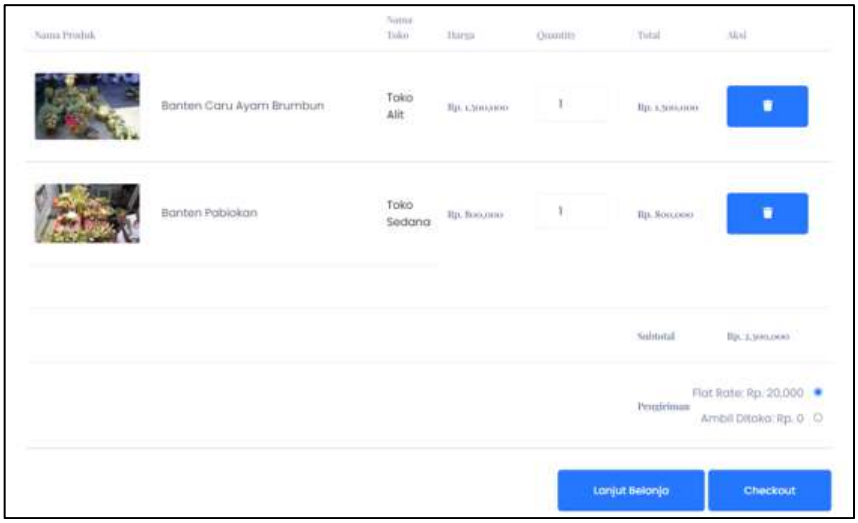


Figure 7. Customer Cart Display

Figure 7 is a display to see a list of Banten products that have been added to the customer's shopping cart on the system. Customers can see information about any banten product that have been added to the shopping cart. Figure 8 is a display of uploading payment confirmation receipt if the customer has made a transaction checkout and made a payment.

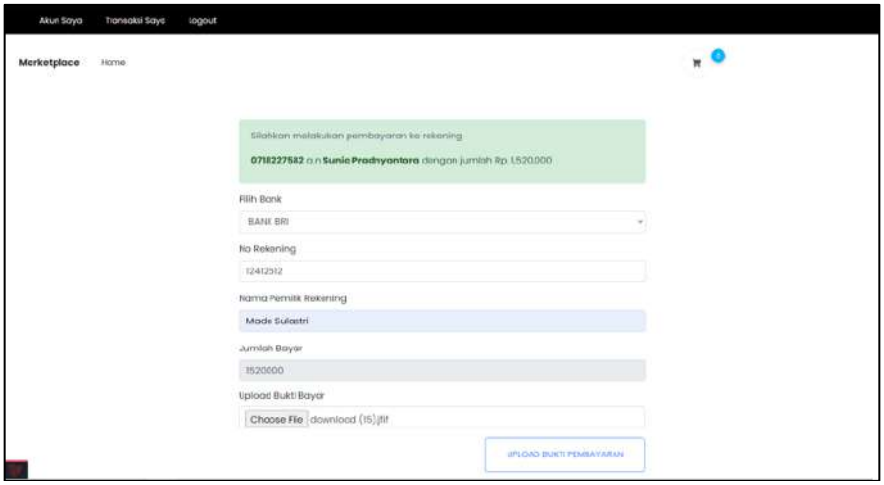


Figure 8. Payment Confirmation Receipt Upload

Figure 8 is the display of the payment confirmation receipt upload process page by the customer on the system, if the customer has made a payment via bank transfer to the admin account, then the customer needs to upload payment confirmation receipt to the system.

### 3.2 Merchant Web Page Display

The system results from web-based geographic information system of banten piodalan stores mapping in denpasar city explain and display the system results for all the features contained in the system with access as merchant.

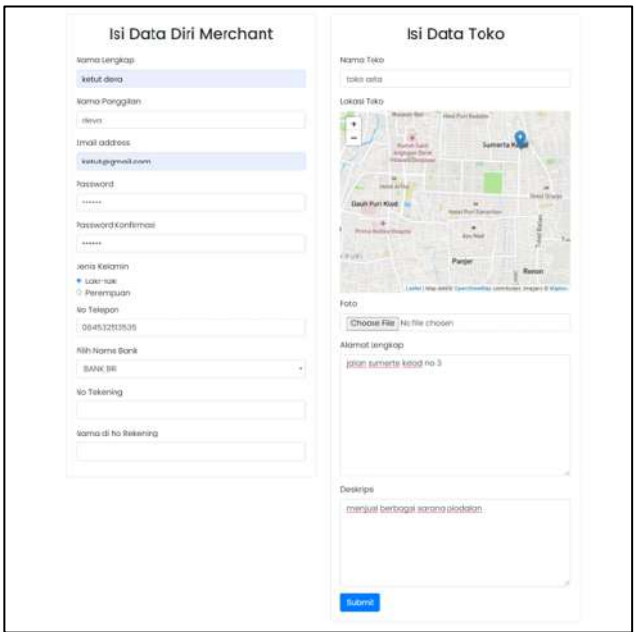


Figure 9. Merchant Sign up Display

Figure 9 is a display of the registration page as a merchant on the system. Merchants need to register an account if they want to sell banten piodalan on the system. Figure 10 is merchant store display when the customer has registered and logged in as a merchant.

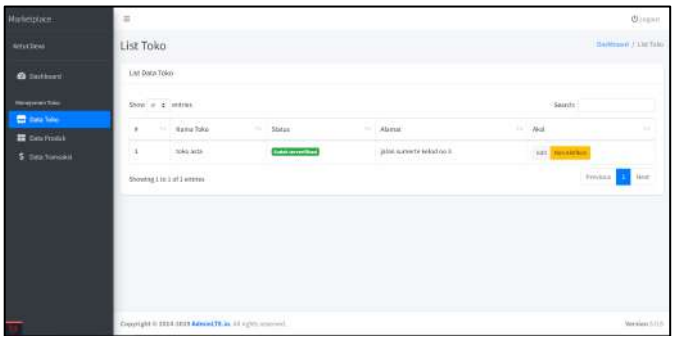


Figure 10. Merchant Store Display

Figure 10 is the page of the banten piodalan store owned by the merchant on the system. Merchants can see all the information related to their banten piodalan store.

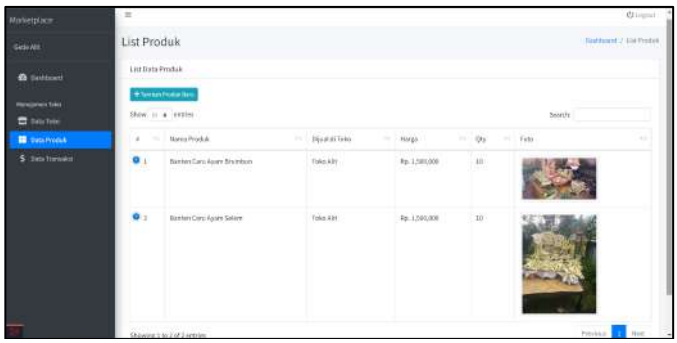


Figure 11. Banten Product Display

Figure 11 is a list page for banten products owned by merchants in the system. Merchants can see all information related to the Banten store that has been added, merchants can also delete and edit their Banten

products.

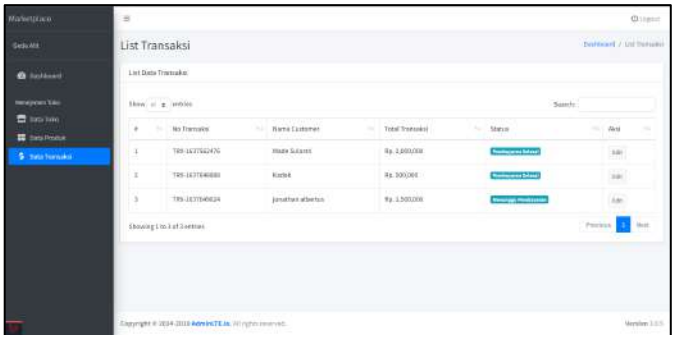


Figure 12. Merchant Transaction Display

Figure 12 is a transaction list page owned by merchants on the system. Merchants can see all information related to transactions that occur, merchants must also make changes to transaction status on the system according to the status of transactions that occur.

### 3.3 Admin Web Page Display

The system results from web-based geographic information system of banten piodalan stores mapping in denpasar city explain and display the system results for all the features contained in the system with access as admin.

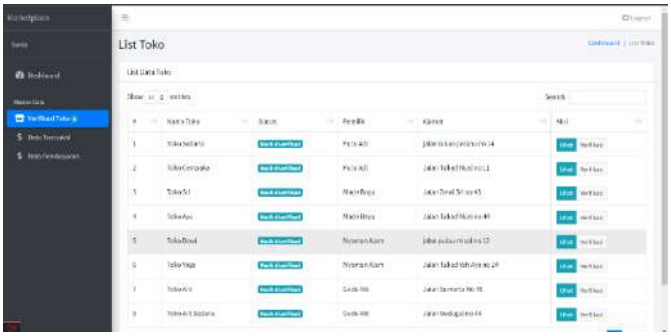


Figure 13. Store Verification Display

Figure 13 is a shop verification list page on the admin dashboard. the admin can see all the information related to the store that needs to be verified, the admin also has to verify the store that has just been registered in the system

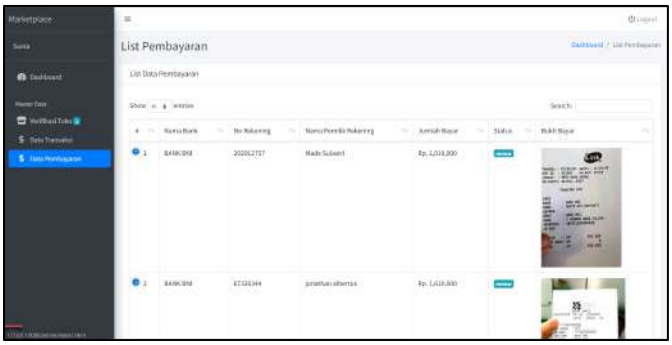


Figure 14. Payment Confirmation Receipt Validation Display

Figure 14 is a payment validation list page on the admin dashboard. admin can see all information related to new payment confirmation receipt that enter the system, admins also have to validate to accept or reject payment confirmation receipt that have been uploaded by customers.

## 4. CONCLUSION

Based on the results of the discussion of geographic information system mapping of banten piodalan stores, conclusions can be drawn, namely:

a. Web-based geographic information system of banten piodalan stores mapping in denpasar city is a system that allows users to mapping banten stores in Denpasar City, and is equipped with a marketplace feature that allows direct buying and selling interactions in the system between sellers and buyers.
b. The results of the web-based geographic information system of banten piodalan stores mapping in denpasar city are in the form of a website-based application with three types of users, namely. Merchants or banten sellers can add store locations to the system and sell banten products on the system. customers or buyers who can make purchases of banten products on the system. admin to validate the store added by the merchant and validate the payment made by the customer

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p.127 - 131

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# INNOVATION OF ADAPTIF TECHNOLOGY BASED ON INTERNET OF THINGS FOR INCLUSIVE STUDENT

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***Abstract.*** This paper discusses the learning system of inclusive students by adapting adaptive technology. The learning process is carried out by adjusting the curriculum and educational infrastructure. Students at the PGRI Argopuro Jember University College have 45-50 inclusion students with each batch of 2018-2020. Inclusive students (blind, deaf) experience negative stigma, mentality, difficulty understanding lessons, task completion, and communication. Inastec adaptive technology innovation based on internet of things is proposed to improve the inclusive student learning system. Learning utilizes application algorithms and hardware design schemes for the Respberry Pi 3 B+. The results of applying Inastec's adaptive technology based on the internet of things can help inclusive students in understanding theory, completing assignments, and communicating with the Inastec platform tool with text output and voice feedback on sound speakers.

*Keywords : adaptive technology, internet of things, in aztec, raspberry pi.*

## 1. INTRODUCTION

The education of inclusive student makes adjustments to the curriculum, infrastructure, and education system that can help the needs of students [1]. Inclusive education such as elementary, junior high, high school, vocational school called Special School (SLB) with slow disabilities and learning difficulties [2],[3]. The colleges for inclusive students have special needs in physical, intellectual, social, emotional, linguistic, and learning processes [4]. The success factor of the inclusive education learning process is to provide tutoring [5].

The teaching and learning process of inclusive education can be supported by appropriate technology in solving problems. The technological advances are accompanied by an effective and efficient learning system [6]. However, the process of inclusive student education is still a problem with the negative stigma and mentality of the community [7]. This is influenced by four factors namely. First, the learning system is not right in higher education. Second, students cannot receive environmental treatment. Third, technological innovation cannot match the needs of students. Fourth, the implementation of teaching staff cannot adapt to adaptive technological innovations to facilitate inclusive student learning [8].

The application of adaptive technology as a learning medium can help the learning process by paying attention to students to evaluate the shortcomings of the teaching and learning system. Adaptive technology provides easy access for inclusive students (blind and deaf) Special Education Study Program at PGRI Argopuro Jember University with computer media. So that lecturers can provide a more effective and efficient learning process with methods that are easily understood by students.

Therefore, inastec adaptive technology innovation (inclusive assistive technology) based on the internet of things is proposed in the learning system for inclusive students. [9],[10]. Inastec adaptive technology utilizes structured programming language algorithms. Each argument will result in interaction without the help of human labor in doing its work. The working principle of inastec adaptive technology uses an internet network that is connected to a hardware system. Teaching staff can monitor students in the learning process, assigning assignments, and completing assignments.

## 2. METHODS

The method used in Inastec's adaptive technology innovation based on the internet of things using Google's cloud platform and Respberry Pi 3 B+ [11]. Technological design is divided into two, namely, the application of algorithms and hardware schemes [12]. The application algorithm is similar to the google cloud platform which is used as a storage for communication services with the internet network as a Respberry Pi server [13]. Raspberry Pi provides google text to speech API, core, SQL, and owncloud database services [14]. Voice input in the form of google text to speech API is stored as a database, and RPI Monitor is a monitoring server on a rest-full API. The stored database is sent via a fronted interface with the Respberry IP Address web browser, then the text is converted into sound that is displayed on the Inastec platform.

Hardware schematic is designed with microphone and audio splitter as voice input on google assistant [15], [16]. The Raspberry Pi B+ is equipped with a sound card to store sound, then a small computer is connected to keep the operating system safe while running [17]. Voice input displayed on the monitor screen in the form of text connected to a computer and LED Projector as a learning medium for deaf students [18]. The monitor speakers are controlled using a power amplifier for feedback as sound for blind students [19]. Inastec's adaptive technology method based on internet of things is described in Figure 1.

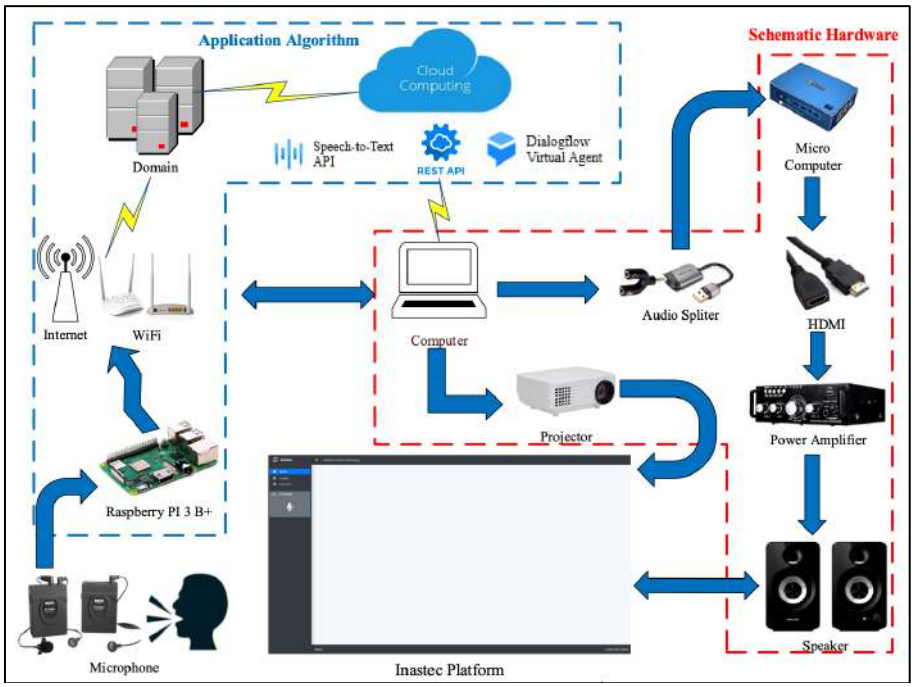


Figure 1. Inastec Platform

The purpose of the Inastec assistive technology model is as a tool for inclusion of blind and deaf students. The microphone voice input will be used as network communication that is connected to wireless using a static IP and client server. The static IP and client server take advantage of the dynamic domain name system (DDNS) to provide port forwarding on the Raspberry Pi with internet network access. Then the Raspberry Pi is connected to the Inastec interface to display sound output in the form of text, and feedback text as output on the sound speaker. Inastec products function as a platform for technology-based learning media. So that inclusive students can learn effectively by adapting internet of things-based technology. The benefits of inastec products are that students can easily understand the material, complete assignments and communicate.

## 3. RESULTS AND DISCUSSION

### 3.1 The Learning of Monitoring Using Inastec

An inastec assistive technology is internet of things based with Raspberry Pi and bluetooth integration. So that Inastec assistive technology can be controlled remotely using a smartphone or laptop. Users of this technology are not only used as learning media, but can monitor student learning systems effectively with one device. The Raspberry Pi can be connected to various sensors, then the data obtained by the sensor is then forwarded back to the Raspberry Pi via the internet. The Raspberry Pi will continue the message to give orders to control and monitor blind and deaf students at PGRI Agropuro University Jember. Learning Monitoring Using Inastec is described in Figure 2.

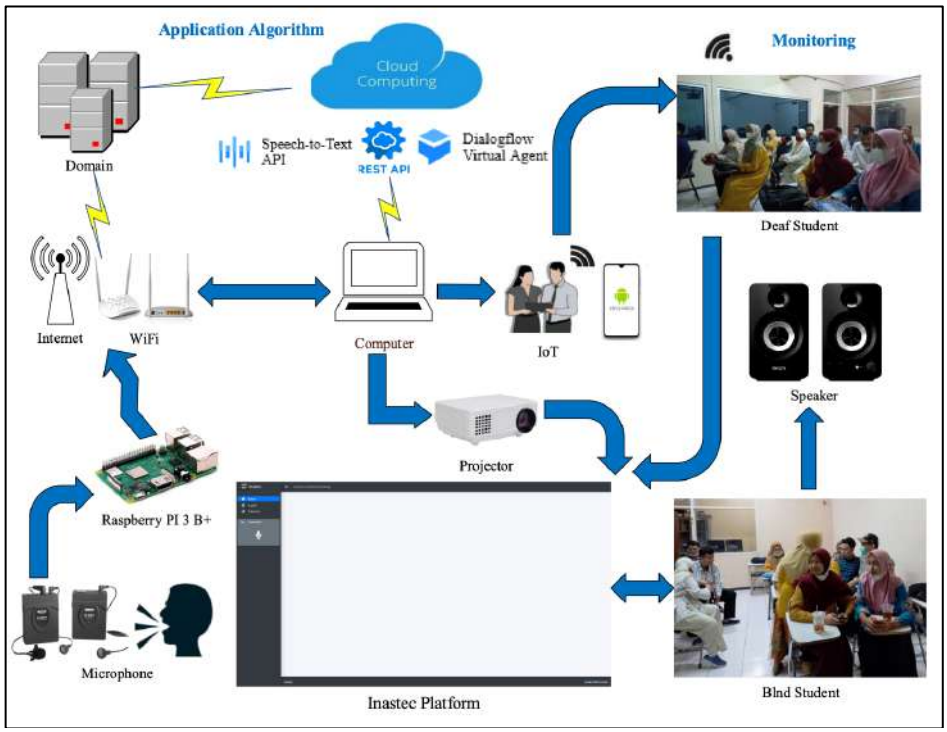


Figure 2. The Learning of Monitoring Using Inastec

### 3.2. Inastec Programs

The Inastec program consists of inv, bower, htts, index, and packages programs. Each program provides arguments on the Respberry Pi B+. RESTful API uses the PHP programming language and the phpMQTT library found on the Server [20]. This RESTful API is a service that serves to bridge the gap between IFTTT and MQTT Broker. phpMQTT is a simple php class used to connect, subscribe and publish to MQTT Broker [21]. The HTTP RESTful API source code uses PHP programming and the phpMQTT library.

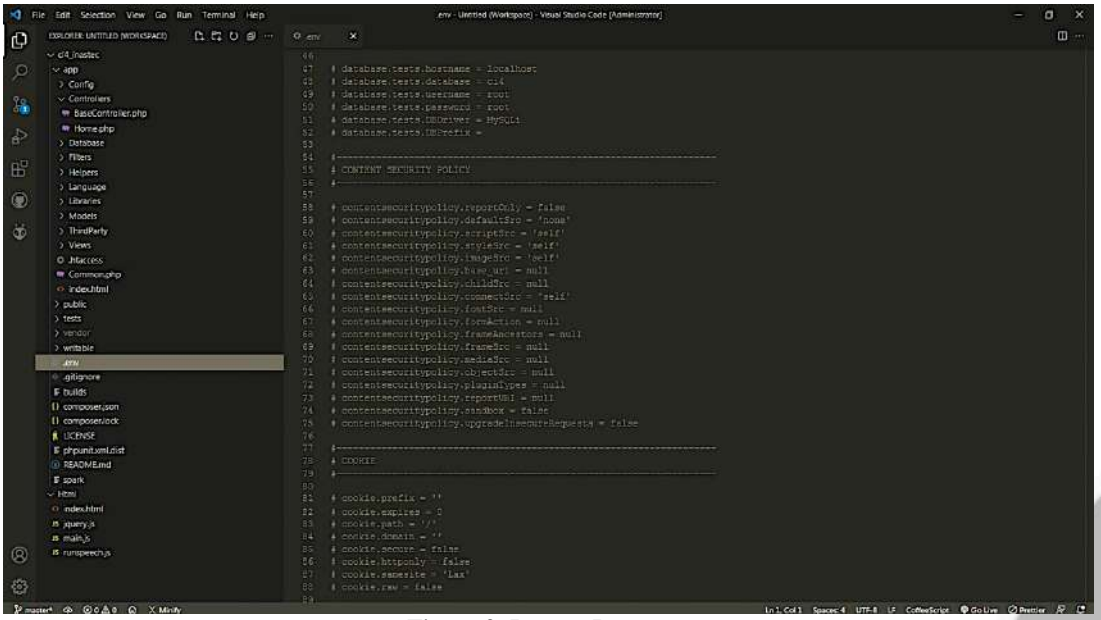

Figure 3. Inastec Program

The results of the application of the Inastec assistive technology model based on the internet of things are applied effectively as a learning medium for inclusive students. Inclusive students can understand the material presented by the lecturer easily, do assignments, and communicate efficiently. Figure 4 describes the effect of applying Inastec assistive technology on inclusive students with the following before and after conditions.

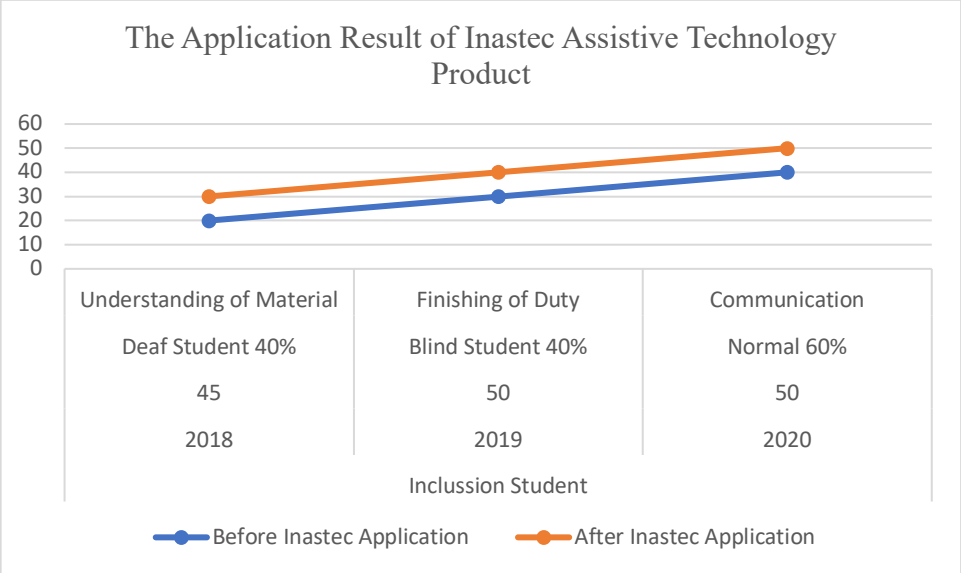


Figure 4. Application of Inastec Products to Inclusive Students

## 4. CONCLUSION

An inclusive student learning process can be achieved with adaptive technology. Technological innovation has an important role to solve problems and provide convenience for students with special needs. Teaching staff can adapt to technology-based learning media to provide equal quality education. So that inclusive students do not experience differences with other students. One of the applications of Inastec adaptive technology based on the internet of things has a significant impact such as understanding material, completing tasks, and communication in the learning process in the Extraordinary Education study program at PGRI Argopuro Jember University. In addition, the learning process can be monitored remotely by the lecturer.

## 5. ACKNOWLEDGEMENT

We express our deepest gratitude to the Directorate of Learning and Student Affairs, Directorate General of Higher Education, Ministry of Education, Culture, Research, and Technology in 2021 for providing Assistive Technology Funds for Learning in Higher Education. Rektor and Head of LPPM and the Extraordinary Education Study Program (PLB) Universitas PGRI Argopuro Jember.

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LOGIC
Journal of Engineering Design and Technology
Vol. 22 No.2 July 2022; p. 132 - 139

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# THE ANALYSIS OF THE USE OF INTERCOOLER ON A MULTI STAGE COLD STORAGE SIMULATOR TOWARD THE COMPRESSOR WORK

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***Abstract.*** Multistage type cold storage is a refrigeration machine required in an industry because it functions to store food products for a long time. Bali, as a world tourist destination, will rely heavily on this cooling system in preparing services for tourists, especially in the food and beverage sector. Multistage type cold storage is designed to reach the evaporator temperature below -30$^{o}$C thus the used compressor performance must be able to produce maximum refrigeration effect. Two compressors placed in succession or connected in series complete this cold storage system, which is expected to achieve higher operating pressures. The temperature occurring due to the pressure increase on the second compressor will be anticipated by installing an intercooler aiming at preventing excessive heat or over heat during the compression. The extent to which the important role of the intercooler as a stabilizer of operating temperature in this cooling cycle will be shown in its working cycle with a Mollier diagram (P-h diagram). The data obtained during the operation of the multistage type cold storage is then transferred to the P-h diagram of R134A to determine the cycle diagram and the enthalpy which then determines the amount of COP, the maximum temperature achieved by the system, and its energy requirements. The calculation results obtained using the intercooler COP is 1.83, and the maximum temperature achieved is 67$^{o}$C, and the energy consumption seen from the total entalphy difference due to compression work is 81 kJ/kg. Without using the intercooler, the system's COP is 1.72 and the maximum temperature achieved is 94.9$^{o}$C and 86 kJ/kg of energy consumption. The energy required for the operational becomes more eficient and the heat released to the environment is much less, therefore the multistage cold storage with intercooler can be categorized as an eco-friendly technology.

*Keywords : Compression work, Intercoole, and Performance .*

## 1. INTRODUCTION

A cold storage is often referred to as a cold room, which is one of the cooling machines or refrigerators that are widely required in the industrial sector. The ability to store products in sufficient quantities at a fairly low temperature for a long time makes it an alternative choice for the industrial sector in maintaining the freshness of its products. The stored products can vary from raw materials to processed products, when being produced in large quantities; it really depends on the cold storage. Bali as a world tourist destination will highly require the existence of cold storage. Every hotel that contributes the greatest support on tourism with a minimum level of three stars must have one or even more cold storages. In addition to hotels, businesses need the existence of cold storage as well for having essential role in tourism too.

Cold storage generally uses a vapor compression system, because it is more practical and simple in operation and maintenance [1][2]. The compressor is the main feature of the latest vapor compression system equipped with a condenser, an expansion device, and an evaporator. Several additional components will complete the system such as oil separator, liquid receiver, filter dryer, sigh glass, and accumulator. Compressors used in cold storage are mostly piston models because the cooling system is required to be able to achieve high working pressures, therefore a multi-stage compressor system is made, also known as multi-stage. Due to the high working pressure of the system, the operating temperature will also increase that it may cause overheating in cold storage. The inter cooler is finally used as an alternative to anticipate the process of the temperature

increase, especially in the second compressor. Thus, it is necessary to have an additional system in the form of a heat exchanger that will be placed at intermediate pressure. The inter cooler will function and be positioned on the suction line of the second compressor or the first compressor output. This second compressor is in charge of increasing the working pressure of the refrigerant which has also experienced compression in the first compressor so that with the presence of this inter cooler, it is expected that the working temperature of the cooling system will not continue to increase but can be stabilized [2][3]. An experimental study will be conducted to see the effect of the presence of inter cooler in multistage cold storage on the performance and the system performance during operation, as well as the energy concumption in relation with the eco-friendliness.

Refrigeration is a process to produce and keep something cold. This refrigerant has been widely used in all fields along with the rapid development of technology, including the refrigeration machines [4][5]. In general, the use of refrigeration machines is to preserve food because room temperature causes the food to rot or spoil faster due to quickly grown bacteria. The utilization of refrigeration machine is intended to freeze the food to certain temperature and humidity based on the requirements thus it is preserved. Whereas the utilization of food refrigeration machine or coolant engine is for rooms conditioning, beverage chilling, ice making and so on. As for the household purpose this machine is used to preserve vegetables, fruits, meat and so on. Preservation in large quantities can be found in meat cuts, shrimp storage, marine fish and so on. We can even find it on meat, vegetables, and fish transporting vehicles that carry their goods to distant places thus the food are still fresh until they reach their destination.

A cold storage is generally a specially designed room with certain temperature condition that will be used to store various kinds of products to maintain their freshness [6][7][8]. Cold storage is usually built based on the building area at the installation site. Cold storage machines are widely used by industrial parties to preserve the quality of food and beverages that are produced or will be produced. A multistage vapor compression refrigeration system (multistage) is an advanced vapor compression system that has two or more compressors as components that can pump and increase the pressure in series. This is done to obtain a low temperature that cannot be achieved with a typical vapor compression refrigeration system.

Figure 1. A Cold Storage

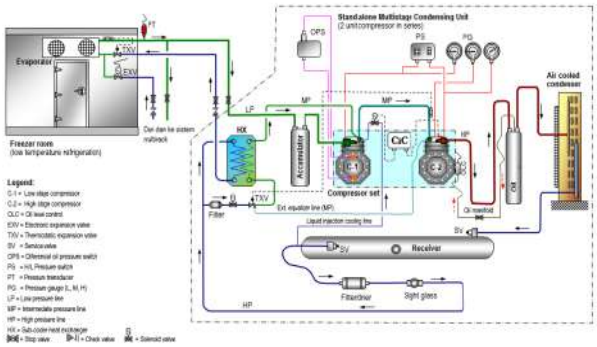


Figure 2. A Multi-stage Cold Storage Pipin

The intercooler is usually placed at an intermediate pressure or between high pressure and low pressure as well as between the two compression levels which will determine the compression work per kg of steam. For a system with compression levels or multistage, it will be able to save some work. Intercooling in a refrigeration system can be done a water cooled heat exchanger or by using a refrigerant [9][10][11]. A water-cooled intercooler may suffice for two-stage compressed air, but for refrigerant compression, the water is usually not cold enough. Another method is to use liquid refrigerant from the condenser to the intercooler. The gas released from the low-level compressor passes through the liquid in the intercooler. The refrigerant will leave the incooler in the form of saturated vapor. A 2-stage compressor with an intercooler is often an ideal way to service a single

low-temperature evaporator [12][13][14]. These systems require less power than a single compressor and these power savings will frequently affect the cost for extra equipment [15]. Moreover, this can be categorized as a more eco-friendly technology.

A P – h diagram is a diagram showing the characteristics of the refrigerant gas. The x-axis represents the enthalpy (h) and the y-axis shows the pressure (P) as shown by the following figure.

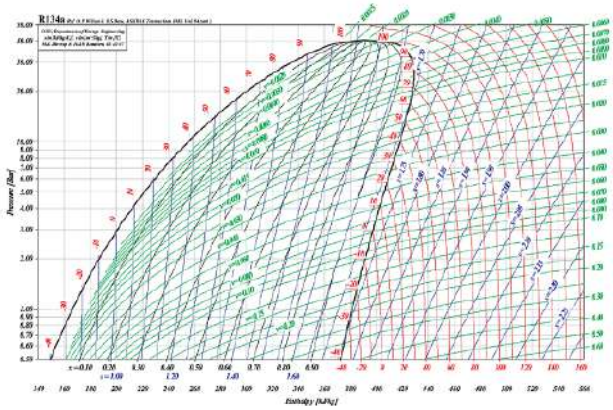

Figure 3. A P – h Diagram

Based on the description, it is deemed necessary to conduct research on the analysis of the use of intercooler on a multi stage cold storage simulator toward the compressor work.

## 2. METHODS

a. Research Design

The type of research carried out is the analysis of inter cooler on multi-stage type cold storage which includes numerical and experimental studies.

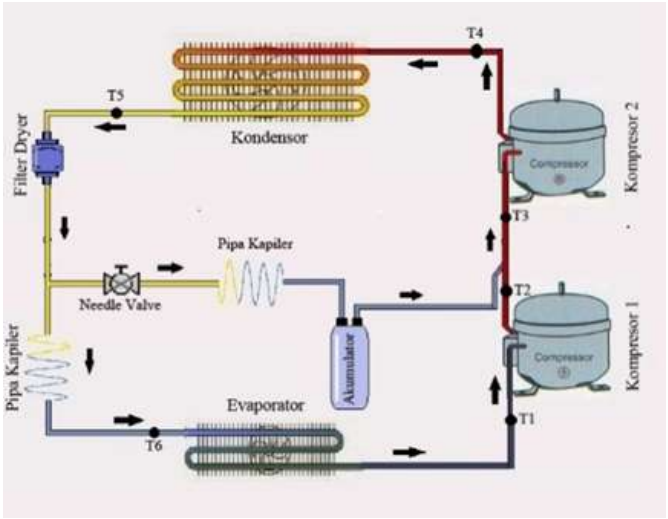


Figure 4. The design of multi-stage cold storage refrigeration simulation

b. Data Source

In this study, the data were obtained by conducting direct testing on cold storage simulations with a multistage system with and without an intercooler. The data can be retrieved after the system works normally. The data were immediately collected and carried out 10 times with a time difference of 5 minutes.

c. Research Resources

The testing equipment used in this study is a cold storage simulation with a multistage system designed at the Refrigeration Laboratory, Department of Mechanical Engineering, Politeknik Negeri Bali with the following specifications:

1) A Piston Compressor, 1/10 PK
2) A Condenser with fan cooling
3) An evaporator
4) A Capillary pipe
5) A Refrigerant R 134a

d. Research Instrument

To assist the research, it is essential to provide the supporting research instrument. The instruments are described as follows.

1) Clamp Meter, It is a measuring instrument used to measure electric current in a conductor cable energized by electric current using its two clamping jaws without having to have direct contact with the electrical terminals. In general, Clamp Meter has two functions: as an amperemeter and a multimeter. Thus in addition to having two clamping jaws, the Clamp Meter also has two probes that can be used to measure Resistance, AC Voltage, DC Voltage and there are even certain models that can measure Frequency, DC Electric Current, Capacitance and Temperature
2) Manifold Gauge, The manifold gauge has very large functions such as refrigerant filling, pressure monitoring, and repairing which involves the cooling medium, namely the refrigerant in the refrigeration system. The manifold is designed with a standard construction so that it is easy to understand. There are two gauges for checking the suction side and the discharge side. The low pressure gauge has a scale - 1 bar to 8.2 bar, meanwhile the high pressure gauge has a scale of 0 bar to 34 bar.
3) Thermocouple, a thermocouple is used to detect or calculate temperature through two different types of metal conductors which are joined at the ends to cause a thermo-electric effect.
4) Stop watch, a stop watch is used to set the duration when testing the system.

e. Research Procedure

The data collection process in a multistage cold storage simulation system is carried out by following the following test procedures

Preparation Steps

1) Preparing the measuring instruments that will be used to collect data and check high pressure components in the system.
2) Installing the thermocouple.
3) Installing the manifold gauge.
4) Ensuring that the measuring tools are properly installed.
5) Ensuring that all tools attached to the system function properly.

Data Collection Steps

The processes of cold storage simulation testing with a multistage system are carried out as follows.

1) Turn the multistage cold storage simulation engine on and make sure the system runs normally. Let it runs for ± 30 minutes.
2) After the system is running normally, record the results of data collection on the high pressure, medium pressure, and low pressure sides.
3) Perform data collection at the intervals of five minutes, and the recording is done for twelve times.
4) After completing data collection, turn off the system.
5) The test results are then recorded in a table.

## 3. RESULTS AND DISCUSSION

The data obtained from the multi stage type cold storage simulator covering the temperature, pressure, current, and voltage are presented in Table 1 and Table 2.

Table 1. Measurement Result Data on Multistage Cool Storage System with Intercooler

| Data | T1 (ºC) | T2 (ºC) | T3 (ºC) | T4 (ºC) | T5 (ºC) | T6 (ºC) | LP (Psi) | MP (Psi) | HP (Psi) | A1 (Amp) | A2 (Amp) | V (Volt) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -6 | 45 | 19 | 55 | 30 | -9 | 10 | 60 | 200 | 0,81 | 0,91 | 220 |
| 2 | -7 | 48 | 19 | 56 | 31 | -11 | 10 | 68 | 200 | 0,82 | 0,90 | 220 |
| 3 | -10 | 48 | 19 | 59 | 31 | -14 | 9 | 60 | 210 | 0,82 | 0,90 | 220 |
| 4 | -10 | 49 | 18 | 69 | 31 | -14 | 9 | 62 | 210 | 0,82 | 0,90 | 220 |
| 5 | -10 | 49 | 18 | 69 | 32 | -15 | 8 | 65 | 210 | 0,82 | 0,90 | 220 |
| 6 | -10 | 49 | 18 | 70 | 32 | -16 | 7 | 65 | 215 | 0,82 | 0,90 | 220 |
| 7 | -12 | 50 | 18 | 70 | 32 | -17 | 6 | 65 | 215 | 0,82 | 0,90 | 220 |
| 8 | -14 | 50 | 18 | 70 | 32 | -19 | 6 | 65 | 215 | 0,82 | 0,90 | 220 |
| 9 | -16 | 50 | 18 | 72 | 32 | -19 | 5 | 68 | 220 | 0,82 | 0,90 | 220 |
| 10 | -16 | 51 | 18 | 72 | 33 | -19 | 5 | 68 | 220 | 0,82 | 0,90 | 220 |
| 11 | -17 | 53 | 18 | 75 | 33 | -19 | 5 | 68 | 220 | 0,82 | 0,90 | 220 |
| 12 | -17 | 55 | 18 | 75 | 33 | -19 | 5 | 68 | 220 | 0,82 | 0,90 | 220 |
| R | -12 | 49,7 | 18,2 | 67 | 31,8 | -15,5 | 7,08 | 64,7 | 211 | 0,81 | 0,90 | 220 |
| | 1,56 (Bar) | | | | | | | | 5,46 (Bar) | 15,7 (Bar) | | |

Table 2. Measurement Result Data on Multistage Cool Storage System without Intercooler

| Data | T1 (ºC) | T2 (ºC) | T3 (ºC) | T4 (ºC) | LP (Psi) | MP (Psi) | HP (Psi) | A1 (Amp) | A2 (Amp) | V (Volt) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -6 | 87 | 37 | -11 | 10 | 60 | 200 | 0,81 | 0,91 | 220 |
| 2 | -7 | 89 | 38 | -14 | 10 | 68 | 200 | 0,82 | 0,90 | 220 |
| 3 | -9 | 90 | 38 | -14 | 9 | 60 | 210 | 0,82 | 0,90 | 220 |
| 4 | -10 | 92 | 38 | -15 | 9 | 62 | 210 | 0,82 | 0,90 | 220 |
| 5 | -11 | 96 | 39 | -16 | 8 | 65 | 210 | 0,82 | 0,90 | 220 |
| 6 | -12 | 97 | 39 | -17 | 7 | 65 | 215 | 0,82 | 0,90 | 220 |
| 7 | -14 | 98 | 39 | -19 | 6 | 65 | 215 | 0,82 | 0,90 | 220 |
| 8 | -14 | 98 | 39 | -19 | 6 | 65 | 215 | 0,82 | 0,90 | 220 |
| 9 | -16 | 99 | 39 | -19 | 5 | 68 | 220 | 0,82 | 0,90 | 220 |
| 10 | -18 | 99 | 40 | -20 | 5 | 68 | 220 | 0,82 | 0,90 | 220 |
| 11 | -18 | 99,5 | 40 | -20 | 5 | 68 | 220 | 0,82 | 0,90 | 220 |
| 12 | -18 | 99,5 | 40 | -20 | 5 | 68 | 220 | 0,82 | 0,90 | 220 |
| R | -12,7 | 94,9 | 39 | -17 | 7,08 | 64,7 | 211 | 0,81 | 0,90 | 220 |
| | | | | | 1,50 (Bar) | 5,46 (Bar) | 15,7 (Bar) | | | |

Based on table 1 and 2 a P-h diagram can be drawn as follow.

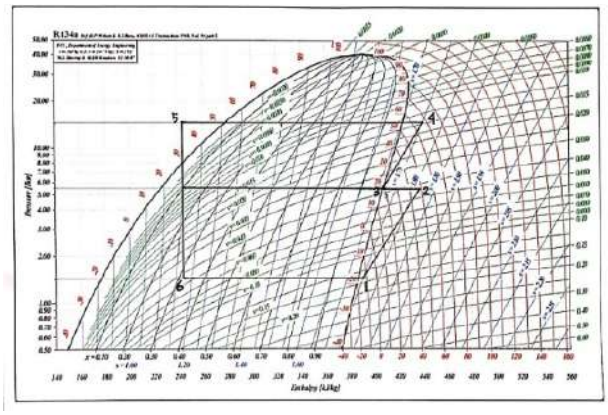

Figure 5. P-h Diagram system with intercooler

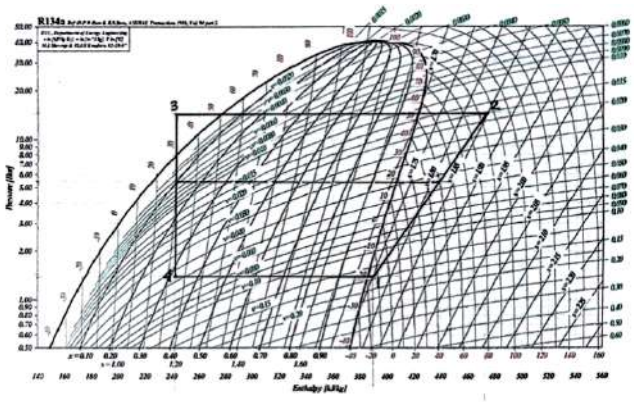

Figure 6. P-h Diagram system without intercooler

Based on the figure, the effect of refrigeration and compressor work from the system with an intercooler can be calculated as follows:

a. Refrigeratiom Effect (RE)
RE = h1 - h6 (kJ/kg)
= 390 – 242(kJ/kg)
= 148kJ/kg
Where:
RE = Refrigeration Effect
h1 = The enthalpy of refrigerant leaving the evaporator (kJ/kg)
h6 = The enthalpy of refrigerant entering the evaporator (kJ/kg)
Thus the refrigeration effect of a multistage cold storage system with an intercooler is 148 Kj/Kg.

b. Compression Work (Cw)
Cw = (h4 – h3) + (h2 – h1) (kJ/kg)
= (441 – 408) + (438 – 390) (kJ/kg)
= 33 + 48 (kJ/kg)
= 81kJ/kg
Where:
Cw = Compression work
h4 = enthalpy of refrigerant vapor leaving compressor 2 (kJ/kg)
h3 = enthalpy of refrigerant vapor entering compressor 2 (kJ/kg)
h2 = enthalpy of refrigerant vapor leaving compressor 1 (kJ/kg)

h1 = enthalpy of refrigerant vapor entering compressor 1 (kJ/kg)
Therefore the compression work of a multistage cold storage system with an intercooler is 81 Kj/Kg.

From the obtained results of the refrigeration effect and compression work, it can be applied into the following COP formula:

$$\text{COP} = \frac{RE}{Cw}$$
$$= \frac{148}{81}$$
$$= 1{,}83$$

Where:
COP = Coeffision of Performance
RE = Refrigeration Effect
Cw = Compression work

Therefore the theoretical COP obtained from a system with an intercooler is 1.83.
For a multistage cool-storage system without an intercooler, the following results are obtained.

a. Refrigeration Effect (RE)
RE = h1 – h4 (kJ/kg)
= 390 – 242(kJ/kg)
= 148kJ/kg
Where:
RE = Refrigeration Effect
h1 = The enthalpy of refrigerant leaving the evaporator (kJ/kg)
h2 = The enthalpy of refrigerant vapor leaving compressor 1 (kJ/kg)
So the refrigeration effect from cold storage without an intercooler is 135 Kj/Kg.

b. Compression work (Wc)
Wc = (h2 – h1) (kJ/kg)
= (476 – 390)(kJ/kg)
= 86 (kJ/kg)
Where:
W = Work compression
h4 = The enthalpy of refrigerant vapor leaving compressor 2 (kJ/kg)
h1 = The enthalpy of refrigerant vapor entering compressor 1 (kJ/kg)
So the compression work of a cold storage without an intercooler is 75 Kj/Kg.

From the obtained results of the refrigeration effect and compression work, it can be applied into the following COP formula:

$$\text{COP} = \frac{ER}{Wk}$$
$$= \frac{148}{86}$$
$$= 1{,}72$$

Where:
COP = Coeffision of Performance
RE = Refrigeration Effect
Cw = Compression work

Therefore the theoretical COP obtained from a system without an intercooler is 1.72. The maximum temperature of the system can also be directly seen on the pH diagram and the energy consumption will be obtained from the enthalpy difference in the system's compression work [16][17].

## 4. CONCLUSION

Based on the research results obtained a cool-storage system with intercooler has a COP of 1.83 and the maximum temperature of the system is 67oC and the use of compression energy is 81 kj/kg. Without an intercooler, its COP is 1.72 and the maximum temperature of the system is 94,9oC and the use of compression energy is 86 kJ/kg. Thus the system's performance by using an intercooler is better than without an intercooler. Furthermore, a more economical energy use on a cold storage with intercooler can be categorized as a more eco-friendly technology.

## 5. ACKNOWLEDGEMENT

Thank you to the Bali State Polytechnic for the financial assistance that has been given so that this research can be carried out.

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p.140 - 146

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# SIMULATION DESIGN OF AUTOMATIC SLIDING GATE CONTROL DEVICES

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***Abstract.*** The gate is a means of dividing the land between the house and the road. The gate also serves for security and comfort as a place to live. As a home security, the gate is made high and equipped with a safety lock. With a gate, you will feel comfortable because other people who come can't enter the house directly, and it's often difficult or overwhelmed when opening or closing the gate. In the case of a gate that has a large size and is also heavy, this will overwhelm us so that a lot of energy and time is needed. The automatic gate control device designed is an electric motor that makes it easier for people to open or close the gate by remote control while at home or at work. Based on the results of the design that has been made, the simulation of the automatic sliding gate control device is expected to solve the problems encountered in the field where the dimensions of the gate are 1500mm x 1000mm x 80mm with a weight of 27kg, the electric motor used is reversible AC which has a speed of 1300 RPM, a power of 60 watts and a 1: 60 gearbox which has become 1 part, the speed of the electric motor is transmitted by a gear with a diameter of 78mm, so that the average gate opening and closing speed is 12.52 and 13.21s with a difference of 0.69s, with the The controller used is the AK-T02 module and the AKJ027 remote can work up to a distance of 10 m. It is hoped that making this control device simulation can be a reference in making automatic gate control devices for homes and other gates.

*Keywords: gate, sliding gate, control device, automatic.*

## 1. INTRODUCTION

The gate is a means of dividing the land between the house and the road. The gate also functions for the safety and comfort of the residence, the house safety is made high and equipped with a safety lock. With the gate, you will feel comfortable because other people or guests who come do not directly enter the home page. In this regard, we tried to design a gate that is controlled automatically.

Design is a series of procedures for translating the results of the analysis of a system into a programming language to describe in detail how the system components are implemented [1][2][3]. Design or planning is an activity that can create a new system or replace or improve the existing system as a whole [4][5][6]. With the rapid development of technology today, we can see a lot of progress has been made. With so many technologies being made, there is also a lot of public interest in making technology that can make everyday life easier, one of which is at the gate. Usually we often have difficulty or are overwhelmed when opening or closing the gate as shown in Figure 2.1, in general in the field we often find cases of gates that have a large size and are also heavy, so this will make them overwhelmed when opening and closing the gate so that a lot of energy is lost. will be used. The automatic gate control device designed is an electric motor machine that makes it easier for us to open or close the gate by remote control while at home or outside the house when coming from work or when traveling. It is hoped that the simulation of this control device can be a reference in making automatic gate control devices for residential houses and other gates.

Based on the above understanding, we conclude that design is an activity or procedure to produce an analysis of a system or component so that it can create a new system or tool or improve an existing system or tool.

Making a tool requires a design or planning of components that will be used to meet the needs of the mechanism of the tool being made, and as for the considerations that must be made in a design of a tool, namely: easy and simple, economical, aesthetic and effective. [7][8][9].

Based on the scope of the problems in the simulation design of this automatic sliding gate control device, the problems can be formulated, namely: (a) How can the simulation design of the automatic sliding gate control device work optimally? Is the maximum load that can be driven by this designed control device?, (b) Is the automatic sliding gate control device able to work according to a predetermined time?.

In this design, the selection of materials and the manufacture of components must be in accordance with the results of the planning as well as the purchase of other components. We only discuss about the control devices that will be designed, namely: (a) design and build an automatic sliding gate control device, (b) calculating travel speed in the design of automatic sliding gates. Research purposes are design and build an automatic sliding gate control device with the ability to drive a sliding gate using an electric motor, and can test an automatic sliding gate control device with a predetermined load and time limit

## 2. METHODS

### a. Research procedure

In this simulation design of automatic sliding gate control device, we want to make a simulation design of automatic sliding gate control device with electric motor drive. Currently, there are still many who use manual methods or with human power, so the opening process will take a lot of time needed in the sense that it is too long and less efficient [10][11].

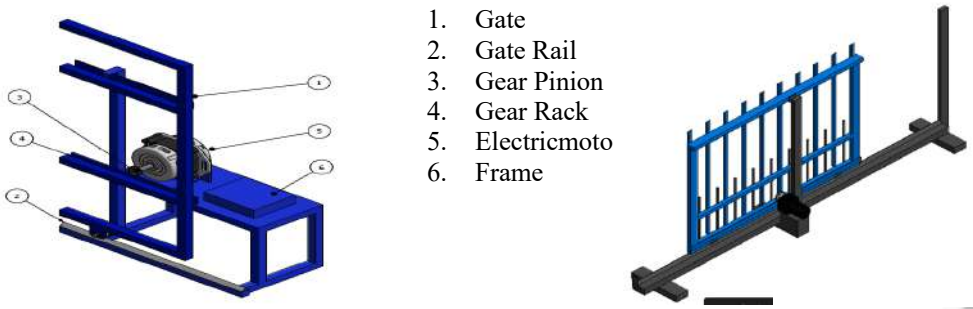
### b. Previousmodel

The previous model is a sliding gate that uses human power to open or close the door by pulling or pushing the gate on the East Ring of Bali Arum, Jimbaran, Badung which is one of the gates as a reference in this design, as shown in Figure 2.1. Older models provide less effectiveness and provide greater resistance [12][13][14].

**Figure 1.** Conventional sliding gate

### c. Design models created

The simulation design model for the automatic sliding gate control device is made as minimal as possible, both for this research or outside so that it can reduce space consumption but the power generated is as needed and of course still comfortable to look at [15][16][17]. The model of the design can be seen in the following Figure 2:



1. Gate
2. Gate Rail
3. Gear Pinion
4. Gear Rack
5. Electricmoto
6. Frame

**Figure 2.** Simulation design of automatic slidinggate control device

### d. Location and time

The simulation design for this automatic sliding gate was carried out at the East Bali Arum Circle, Jimbaran, Badung. We hope that this tool can simplify and streamline the time in opening and closing the gate. Making a simulation design for this automatic sliding gate control device at the Bali State Polytechnic Mechanical Engineering Work Shop, and the time it takes is approximately 3 months, starting from 1 December 2020 to 5 February 2021.

**e. Determination of data sources**

Determination of data sources is done through a literature review related to theories related to automatic sliding gates, rack pinion gears and carrying out a field survey. This design is expected to simplify the process of opening and closing sliding gates automatically.

**f. Instrument**

The research instrument is a tool needed to conduct testing on the design.

a. Stopwatch to measure gate travel time
b. Tachomete to measure the speed of the electric motor RPM
c. Scales are used to measure the mass of the scales
d. Gauges are used to measure the length and width of the frame and also the length of the gate rail line

## 3. RESULTS AND DISCUSSION

### 3.1 Design Result

Simulation design of automatic sliding gate control device is a remote control device that helps to open or close sliding gates both large and small with an electric motor as the driving device. This sliding gate is made of 60mmx30mmx1mm hollow steel with a length of 1.5m, a height of 1m and a width according to the hollow steel used. The weight obtained is 26.65 kg. if because of that to simplify the calculation, the weight is rounded to 27kg.

**a. Calculation of the force that occurs**

The friction that occurs is usually on the door wheel.

$$fs = \mu s.F \quad (1)$$

The value of μs for steel with steel is 0.74 can be seen in the table in the appendix. Then the calculation will be..

$F = m.g$, = 27kg. 9,81m/s$^2$, = 264.87N

With a value of F 264.87N, the value of the friction force that occurs on the gate wheels is

fs = 0,74 . 264,87N= 196,0036N

The value of the normal force on the gate is 264.87N and the frictional force that occurs at the gate is 196.0063N.

**b. Calculation of electric motor selection**

After getting the above calculations, the next step is to choose an electric motor that will be used to drive the sliding gate. Thus:

$$T = F_{total} \cdot r \quad (2)$$

Before calculating torque. Find the Total value first. The calculation as follows

$$Ftotal = F + fs$$

= 264,87N + 196,0036N= 460,87N

With a Ftotal value of 460.87N, to find the torque to move this sliding gate is

$T$ = 460,87N. 0.037m = 17.513 Nm

After getting the Torque value, it will then look for the required power value.

$$PD = \frac{2\pi\, n\, T}{60} \quad (3)$$

The value of n that we estimate is 20 RPM then the calculation is as follows

$PD = \frac{2\pi\ 20\ 17.513Nm}{60} = \frac{2199,623}{60}$ = 36,6watt

The design power obtained is multiplied again by the safety factor, then

$$P = PD \times fc \quad (4)$$

P = 36.6 x 1.5= 54.99watt

The fc value is the correction factor value for the transmitted power, a list of values can be seen in the appendix. The power required to drive the sliding gate is 54.99watts. Because the electric motor is 55.99 watts and 20 RPM and can do rounds back and forth (reversible), the motor used is 60 watts. After looking for an electric motor, it is obtained with the following specifications:

**Figure 3.** Electric motor

Specifications:

| | |
|---|---|
| Name of motor | : Oriental Motor |
| Type | : 6RK60GK-C2 |
| Revesible : yes | |
| RPM | : 1300 |
| Power | : 60watt |
| Volt | : 200v |
| Name of gearbox | : Oriental Motor Gear Head |
| Type | : 6GK60K |

Ratio : 1 : 60

**c. Calculation ofnuts and bolts selections**

$$d_i = \sqrt{\frac{4.F}{\pi.\sigma}} \quad (5)$$

Which:

$$\sigma = \frac{\sigma t}{v}, \qquad \sigma t = grade\ x\ 10N/mm^2 = 4\ x\ 6\ x\ 10N/mm^2 = 240\ N/mm^2$$

It was found that the tensile stress for bolts with grade 4.6 was 240N/mm2. Then for the allowable tensile stress is

$$\sigma = \frac{\sigma t}{v}, \sigma = \frac{240}{8}, \qquad \sigma = 30\text{MPa}$$

The value of v is the safety factor for the material, it can be seen in the appendix. With a allowable tensile stress of 30MPa, the diameter calculation to be used is

$$d_i = \sqrt{\frac{4.F}{\pi.\sigma}} = \sqrt{\frac{4\ x\ 264{,}87}{3.14\ x\ 30}} = \sqrt{\frac{1059{,}48}{94{,}2}} = \sqrt{11{,}24} = 3{,}35 \text{ x Sf} = 3{,}35 \text{ x } 2 = 6{,}7\text{mm} = \text{M7}$$

So, the bolts to be used are bolts that must exceed M7. Because the M7 bolt is too small for the gate wheel hole diameter, M12 bolts are used

**d. Rack pinion calculation**

$$\mathbf{Fn = Ftotal + m.a + F} \quad (6)$$

Fn = 460.87 + 27 .0.1 = 463,57N

$$\mathbf{Tn = \frac{(Fn.dp)}{2000}} \quad (7)$$

$$Tn = \frac{(463{,}57\ .\ 78)}{2000} = 17{,}61 \text{ Nm}$$

To move the rack pinion that supports the gate load, the torque needed is 17.61Nm

**e. Work process**

In the process of working on the Simulation Design of Automatic Sliding Gate Control Devices, first the components of the tools used to be made or purchased will be prepared. These components will be explained in Table 1 below:

Tabel 1 The Component ofToolsandMaterials

| No | Name | Spesifications | Total amount | Description |
|---|---|---|---|---|
| 1 | Hollow iron | 60mm x 30mm | 6 Meter | Bought |
| 2 | Hollow iron | 20mm x 20mm | 6 Meter | Bought |
| 3 | Hollow iron | 100mm x 50mm | 3 Meter | Bought |
| 4 | Elbowiron | 30mm x 30mm | 6 Meter | Bought |
| 5 | Metal | 10mm x 10mm | 6 Meter | Bought |
| 6 | Electric motor | 6RK60GK-C2 | 1 pc | Bought |
| 7 | Gearbox | 6GK60K | 1 pc | Bought |
| 8 | Wheelgate | $Ø70mm$ | 2 pcs | Bought |
| 9 | MCB | Brocco 4A | 1 pc | Bought |
| 10 | Module+Remote | AK-T02 + AKJ027 | 1 pc | Bought |
| 11 | Bolts | M12 | 2 pcs | Bought |
| 12 | Limit Switch | 260v 15A | 2 pcs | Bought |
| 13 | Rack Pinion | $Ø36\ T18$ | 1 pc | Bought |
| 14 | Cable | NYM 3 x 1.5 $mm^3$ | 3 Meter | Bought |
| 15 | Paint | Pioneer Ocean Blue | 1 liter | Bought |
| 16 | Welding electrode | RD400 $Ø2.0\ x\ 300mm$ | 1 box | Bought |
| 17 | Thinner A | - | 1 liter | Bought |
| 18 | Grinding | - | 1 pc | Borrowed |
| 19 | Grindingwheel | $Ø100\ x\ 1\ x\ 16mm$ | 1 box | Bought |
| 20 | Hand drill | - | 1 pc | Borrowed |
| 21 | Drill bit | $Ø10$ | 1 pc | Bought |
| 22 | Grinding sandpaper | $Ø100\ x\ 1\ x\ 16mm$ | 1 pc | Bought |
| 23 | Boxcontactor | 6uf 240v | 1 pc | Bought |

1) The following is the process of working on the Simulation Design for Automatic Gate Control Devices. Understanding the working drawings that have been made, preparing the tools and materials used, measuring and drawing according to the working drawings, then cutting, cutting 60mm x 30mm hollow iron, spot welding first on each side of the door followed by welding the whole, then do the drilling at the bottom to put the wheel on the gate, make cuts on the 20mm x 20mm hollow iron and 10mm x 10mm nako iron for weight-adding ornaments, do the welding according to the drawings and markings that have been given, then clean the whole weld.

**Figure 4.** Ironcutting

2) Manufacture of rail mounts. First, make cuts on 100mm x 50mm hollow iron, 60mm x 30mm hollow iron and 30mm x 30mm angle iron, determine the position of the rails, gate holders and boundaries according to working drawings, do spot welding first to ensure the position, after the frame is in accordance with position and shape according to the drawing then do the welding permanently, do the drilling on the gate holder pole for the electrical path and do the cleaning of the rest of the weld as a whole
3) The painting process is carried out after the assembly process. Then the tools that can be removed include electric motors, limit switches and others. Separate the gate and rails and then do some painting
4) The assembly process is carried out after the manufacturing process. Then the component assembly process is then carried out to form a series of gates according to the planned drawings to adjust all component positions.
5) Making electrical circuits, the electrical circuit is another important component to drive the gate later. Therefore, for the electrical circuit current is planned so that electricity does not occur damage or short circuit.

**Figure 5.** Electrical Installation Process

### 3.2 Discussions

**1. Design results**

After all the components have been assembled, the results of the assembly can be seen in the image below.

**Figure 6.** Design Results

After the assembly is complete, the next step is to test the simulation tool for the automatic sliding gate control device. The test of the simulation of the automatic sliding gate control device is the time taken when pressing the button on the remote until the gate reaches the fully open and close position or until the gate stops moving.

**2. Test result**

By testing the tool five times opening and closing the gate, the following data were obtained.

**Tabel 2** Data Pengujian

| No | Weight (kg) | Distance (cm) | Open (s) | Closed (s) |
|---|---|---|---|---|
| 1 | | | 13.2 | 13.42 |
| 2 | | | 12.45 | 12.78 |
| 3 | 27 | 130 | 12.39 | 13.13 |
| 4 | | | 12.37 | 13.34 |
| 5 | | | 12.17 | 13.38 |

With these data, we can find the average time taken, namely:

a. Average time to open the gate

$$\frac{13{,}2 + 12{,}45 + 12{,}39 + 12{,}39 + 12{,}17}{5} = 12{,}52\text{s}$$

b. Average time to close the gate

$$\frac{13{,}42 + 12{,}78 + 13{,}13 + 13{,}34 + 13{,}38}{5} = 13{,}21\text{s}$$

c. Average time diference

13,21 – 12,52 = 0,69s

From the data that has been obtained, the average time obtained with an electric motor of 20 RPM and a gear diameter of 78 mm can open the gate 12.52s and the average time to close the gate is 13.21s, so the difference obtained is 0 ,69s. The use of electric motors and remote controls will make work more effective [18][19].

**4. CONCLUSION**

Based on the design results that have been made, namely the simulation of the automatic sliding gate control device, it is expected to be able to answer the problem formulation so that it can be concluded that, the dimensions of the gate are 1500mm x 1000mm x 80mm with a weight obtained of 27kg, the electric motor used is reversible AC which has a speed of 1300 RPM, 60 watts of power and a 1:60 gearbox which has become 1 part, the speed of this electric motor is transmitted by a gear with a diameter of 78mm, resulting in an average gate opening and closing speed of 12.52 and 13.21s with a difference of 0.69s, with the control device used is the AK-T02 module and the AKJ027 remote can work up to a distance of 10m.

In the design of this tool still has many shortcomings. Therefore, it is hoped that this design can be developed for more perfect results. The speed of opening and closing the gate can be increased by changing the gears or accelerating the RPM of the motor. However, keep in mind the power and torque of the designed motor of this tool, and later it can be used for its actual form so that people can use it.

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p.147 - 153

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# DESIGN AND BUILD OF 1 (ONE) AXIS PLASMA CUTTING MECHANISM

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***Abstract.*** Plasma cutting is a cutting process that is widely used by the metal industry and individuals. Plasma cutting is widely used because it has many advantages, including: Cheap tools and widely sold in the market, low operating costs because they use electric power and compressed air from a compressor, unlike oxyacetylene cutting which requires oxygen, the available tools are more flexible and easy moved.

The use of plasma cutting is relatively easy, by setting the machine and then directing the plasma torch to the cutting plane as needed by maintaining a stable movement and height. However, when we are going to make repeated cuts, our concentration and physical power will automatically decrease, so we need a tool that can assist us in directing/regulating the plasma in which the tool functions as a plasma cutting mechanism.

Based on this background, the author made a 1 axis plasma cutting torch rail mechanism which is driven by an electric motor, this tool has a workspace/cutting length of 1300 mm, with tool sizes Length, width and height 1950 mm x 300mm x 100 mm. This mechanism/tool can be installed on torches of several brands of plasma cutting, with various bracket speeds that can be adjusted as needed depending on the thickness of the plate being cut, from cutting speeds of 300 mm/minute to 2,000 mm/minute, adjustable cutting height 0 mm up to 10 mm, with a cutting angle setting of 0o to 90o and this mechanism tool can also be used portable / can be moved according to the required work location. Plasma cutting mechanism can be used to make it easier to make straight/horizontal cuts.

*Keywords: design, plasma cutting, mechanism.*

## 1. INTRODUCTION

Plasma cutting is a metal cutting process that is widely used by the metal industry and individuals. Plasma cutting is widely used because it has many advantages, including: Cheap tools and widely sold in the market, low operating costs because they use electricity and compressed air from a compressor, unlike oxyacetylene cutting which requires oxygen, the available tools are more flexible and easy moved. Plasma gas is compressed air, nitrogen, oxygen or argon/hydrogen for cutting mild and high alloy steel, aluminum, copper and other metals and alloys [1]. The quality characteristics assessed include surface roughness, zone of heat influence and geometrical consistency of the cut. Using the experimental design and analysis of variance, it was found that the surface roughness and consistency are mainly affected by the cutting height, while the heat-affected zone is mainly affected by the cutting current [2]

The plasma process is suitable for electrically conducting materials with thicknesses from 1 to 600 mm. The plasma cutting process can be used to cut any conductive material, including carbon steel, stainless steel, aluminum, copper, brass, cast metals, and exotic alloys [3]. The quality characteristics assessed include surface roughness, zone of heat influence and geometrical consistency of the cut. Using the experimental design and analysis of variance, it was found that the surface roughness and consistency are mainly affected by the cutting height, while the heat-affected zone is mainly affected by the cutting current [4]. Plasma cutting, whether conventional or precision, is a fast and economical way to manufacture parts. Manufacturers must first understand the process, and then determine whether this process or another process produces parts more effectively [5].

The use of plasma cutting is relatively easy, namely by setting the machine and then directing the plasma torch to the cutting plane as needed by maintaining a stable movement and height. However, when we make repeated cuts, our concentration and physical strength will automatically decrease, so we need a tool that can help us direct/adjust the plasma torch, which is called a plasma cutting mechanism.

The lower the torch distance used, the smaller the value of the kerf width and surface roughness produced [6]. The results showed that the lower the rate of decline, the higher the hardness value and vice versa [7].

Based on this background and also looking at a simple plasma mechanism making motorized plasma cutting track [8], the previous author designed a 1-axis plasma cutting torch rail mechanism driven by a motor, where the rail movement speed and the height of the torch with cutting materials can be set to [9], the author has previously designed a 1 axis plasma cutting torch rail mechanism that is driven by an electric motor, where the speed of the rail movement and the height of the torch with the cutting material can be adjusted to [9], and now the author will realize the design by making a plasma cutting mechanism of 1 (one) Axis.

The objectives of the manufacture of mechanical tools are: 1. with the success of making this tool, it is hoped that it can make a useful contribution to the Workshop in increasing the effectiveness and time efficiency of metal cutting; 2. make it easier to make certain shapes and cut straight objects.

## 2. METHODS

Design is a process that consists of several stages, and these stages require a process that is not short. According to Booker, design is a process of simulating what we want to make before we make it, over and over again so that we can be satisfied with the final result [10]. In addition, the design aims to create better results (objects) than before. Design is a creative activity, involving a process to bring to something new and useful that was not previously there [11], and design is the main proposal that changes something that already exists into something better, through three processes: identifying problems, identify methods for problem solving, and implementation of problem solving. In other words, it is programming, drafting, and implementing plans [12]. Design is the making of a model of a tool (prototype) or a creation of something that has a physical reality. Making a tool requires planning the components that will be used to meet the needs of the mechanism of the tool being made. Strength is a consideration in building a tool, where strength depends on the selection, treatment and workmanship carried out on the material [13] which will be carried out is applied research, which is based on a problem.

Design is the making of a model of a tool (prototype) or a creation of something that has a physical reality. Making a tool requires planning the components that will be used to meet the needs of the mechanism of the tool being made. Strength is a consideration in building a tool, where strength depends on the selection, treatment and workmanship carried out on the material [14].

Activities planning or designing a construction must consider several criteria including the following:

- Easy and simple, easy to manufacture or common components on the market.
- Economical is an action/behavior where we can obtain inputs (goods or services) that have the best quality at the lowest possible price level.
- Aesthetics is a feeling that arises from how beautiful or charming an object is seen and the tool must be aesthetically pleasing in appearance and form.
- Appropriate, is a technology that is invented or invented or created with the aim of improving or making human work more smoothly. This can then increase the economic value as well, the technology is not only made but made precisely according to human needs

Machine elements are very often made of either metal or metal alloys such as steel, aluminum, cast iron, zinc, titanium or bronze. This section describes the important properties of materials that can affect the mechanical design [15].

Strength, elasticity and ductility properties for metals, plastics and other types of materials are usually determined from a tensile test in which a sample of the material, which is usually circular or flat rod, is clamped between clamps and pulled gently until it breaks. The magnitude of the force on the bar and the change in length (strain) are monitored and recorded continuously throughout the test. Since the stress in the rod is equal to the force acting on the rod divided by the area, the stress is proportional to the force acting on the rod.

The things that must be considered in the selection of materials for the design are as follows:

1. Hardness

   The resistance of a material to indentation by a penetrator is an indication of its hardness [15]. Several types of tools, procedures, and penetrators for measuring the hardness of the Brinell hardness tester and the Rockwell hardness tester are most commonly used for machine elements. For steel, the Brinell hardness tester uses a 10 mm diameter hardened steel ball as a penetrator with a load of 300 kg of force. The load causes permanent indentation in the test material, and the diameter of the indentation is associated with the Brinell hardness number, which is abbreviated as BHN or HB.

The actual quantity measured is the load divided by the area of the indentation box. For steels, HB values range from about 100 for annealed low carbon steels to more than 700 for as-quenched high-alloy steels. In the high range, above HB 500, penetrators are sometimes made of tungsten carbide instead of steel. For the softer metals, a load of 500 kg is used.

2. Strength

The ability of a material to withstand stress without breaking. Or the ability of a material to accept a load, the greater the load that can be received by the material, the object can be said to have high strength.

3. Brittleness

Refers to the nature of metal that is easy to crack or break when subjected to impact forces on it. An example of a brittle product is a machine frame made of gray cast iron. The brittleness property was tested using a charpy testing machine.

Steel Steel is a metal alloy between iron (Fe) and carbon (C), where iron is the basic element and carbon is the main alloying element. The carbon content in steel is less than 1.4% by weight according to its grade. In the steel-making process there will be other elements besides carbon that will be left in the steel such as manganese (Mn), silicon (Si), chromium (Cr), vanadium (V), and other elements. In terms of application, steel is often used as a raw material for tools, agricultural implements, automotive components, household needs. Steel can be classified based on chemical composition such as carbon content and alloy used [16].

The working principle of an electric motor is to convert electrical energy into mechanical energy. This change occurs by converting electric power into a magnet or called an electromagnet, then the result is a set of rotating fields around the stator. A conductor located in a moving magnetic field will have a current induced in it and a force will be exerted perpendicular to the conductor. This force acts around the rotor to create a torque which will rotate the rotor [16].

The shaft is a rotating part, which is attached to the force transfer elements, such as gears, and bearings. Shafts can accept tensile, flexural, compressive or torsional loads acting alone or in combination with one another. The word shaft includes several variations such as shaft or axle. Shaft is a shaft that rotates and receives torsional loads [17].

Another type of shaft is the transmission shaft type. This shaft will transmit power including clutch, gear, pulley, belt or chain sprocket and others. This type of shaft obtains pure torsional or torsional and bending loads. Large power may be required at start or a large load may continue to operate after starting. Thus, it is often necessary to correct the required average power using a planning correction factor of [18].

## 3. RESULTS AND DISCUSSION

Design and construction of plasma cutting mechanism 1 (one) Axis has a sliding type movement concept, which uses a sliding axle/groove consisting of 2 pieces and a sliding bearing connected to a plasma cutting torch bracket/holder as shown in Figure 1 [9].

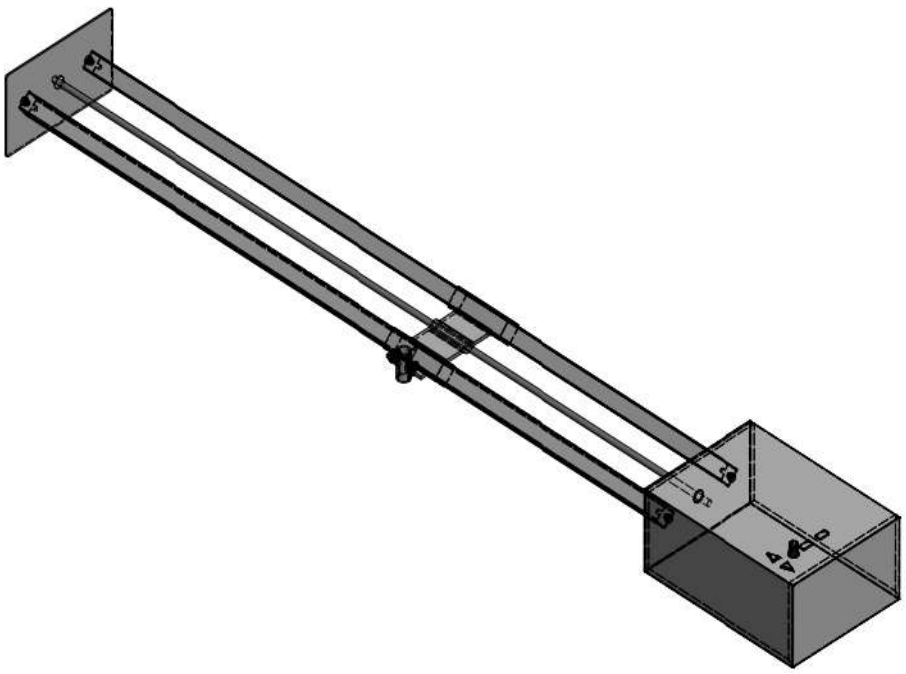

Figure 1. Design of 1 (one) axis plasma cutting torch rail mechanism [9]

This machine has several parts as shown in Figures 2 and 3;

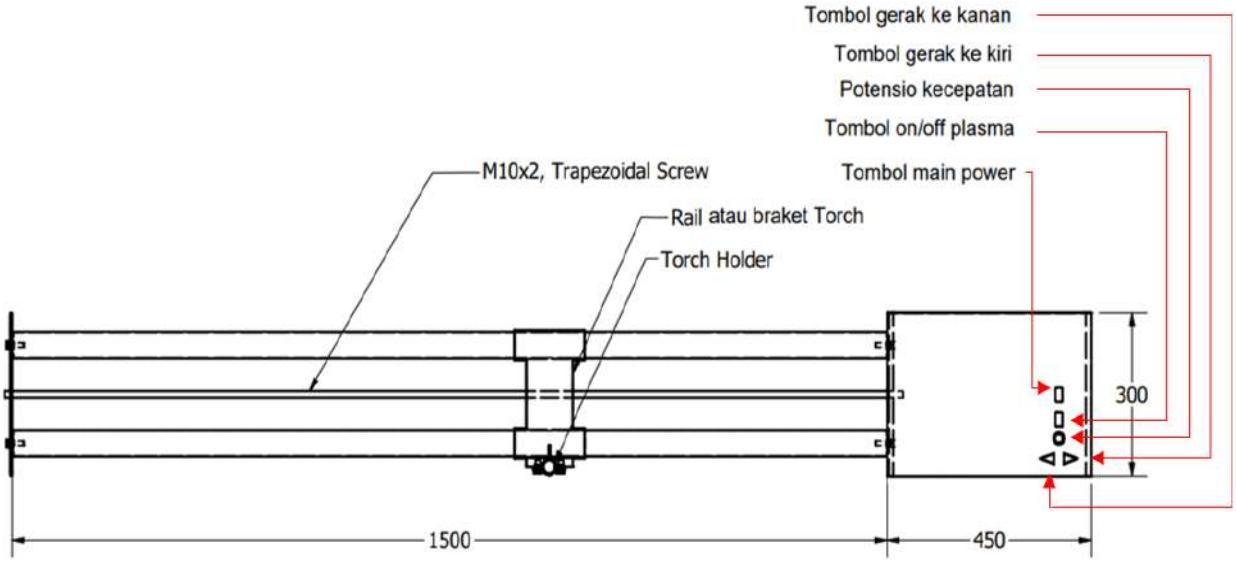


Figure 2. Description of the top view component [9]

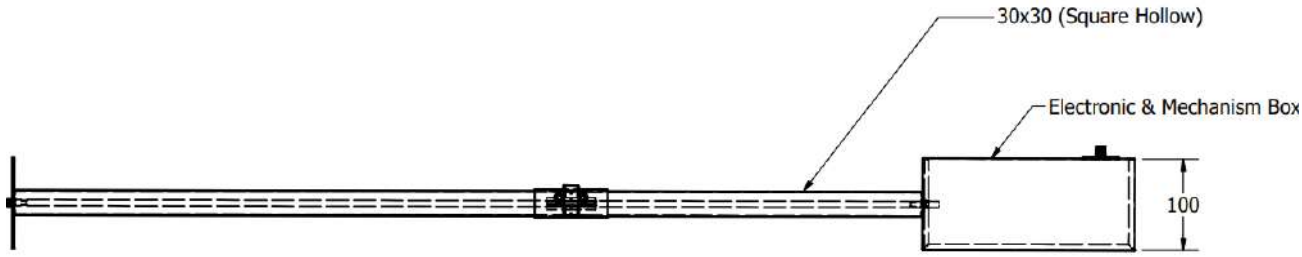


Figure 3. Description of front view components [9]

Tools and materials used in the manufacture of the main frame: electric welding machine, hand grinder, hammer, cleaning brush, elbow, ruler roll, steel ruler, scraper, pin, Rail consists of 2 pieces of hollow iron measuring 30 mm x 30 mm which arranged parallel and arranged on a body made of 10 mm thick iron plate, in the middle of the iron there is a threaded axle which is used as a medium for the successor/driver of the torch bracket which is powered by an electric motor as shown in Figures 2 and 3. The rail is only made of 1 (one) axis and bracket can move back and forth. Cut the parts according to the working drawings. After cutting, proceed with spot welding first for the manufacture of the left end frame and the middle and right end frames. After the frame is in accordance with the size that has been set, then do the welding of all parts permanently. For sharp welding parts, do grinding in addition to grinding safety, it also serves to increase the value of neatness on the tool. The holes in the frame are drilled with a hand drill according to the part to be installed on the frame.

The bracket is made of holo molded iron, plate and molded plate for plasma torch mount. The movement of the bracket is powered by a 12 volt DC motor, which is threaded to drive the bracket. The torch holder on the bracket on the bracket can be adjusted, the position of the plasma cutting torch can be adjusted in height and also the angle as needed so that apart from being able to be used for straight cuts, this mechanism can also be used to cut corners.

The threads are mounted on the frame with bearing bases and connected to the motor. Tools and materials used in the manufacture of electric motor mounts include: electric welding machines, elbows, hammers, cleaning brushes, hand grinders, hand drills, scrapers, pins, steel rulers, 1 mm thick iron plate. The process includes cutting using a hand grinder carefully in order to get maximum results and to maintain safety while working. Make holes for the placement of the electric motor and also make holes for the bolts. The source of motor power can be generated from PLN electrical energy which is converted to 12 volts by an inverter. The speed of the motor movement is regulated by a 12 volt potentio, so that the movement of the bracket can be adjusted as needed. Movement to the right/left of the motor is regulated by a 12 volt DC relay circuit and 2 (two) buttons.

1 (one) main switch is prepared as a main power regulator, 1 (one) switch is made as the on/off plasma cutting, which is connected to the plasma machine circuit and is arranged as the jack and receiver on the plasma

machine.

In this step, it is explained about the assembly of each component that has been made previously. Before carrying out the component assembly process, do the painting on the machine components you want to paint first. The assembly steps are:

a. Install the pillow block first on the frame according to the working drawings, then insert the bracket driver into the bearing, then tighten the screw holder for the threaded shaft on the bearing as shown in Figure 4.

Figure 4. Assembly of components, bracket rails, frame, drive screw shaft, bracket

b. Attach the rails to the frame as well as the threaded shaft, along with the torch bracket.
c. Mount the motor on the frame and connect the ends to the threaded shaft.
d. Install the switches on the cover, then attach the frame to the cover as shown in figure 5

Figure 5. Installation of the power switch and motor speed regulation

e. Check all components that have been installed and check the tightness of the bolts and nuts that are still not strong.
f. Check all electrical installations before turning it on as shown in Figure 6


Figure 6. Re-checking the electrical installation before trying it

After the tool components have been assembled, then the tool testing is carried out to determine the capabilities of the designed tool (see Figure 1). The test was carried out 5 times, by trying to use plasma cutting to cut a 10 mm plate with a ready-made mechanism as shown in Figure 7.


Figure 7. Testing of 1 axis plasma cutting mechanism

In this test, the minimum speed of the bracket movement is also tested, which is 300 mm/min and a maximum of 2,000 mm/min.

Every equipment requires maintenance to ensure the tool works according to standards and is ready for use. The maintenance carried out on the 1 (one) Axis plasma cutting mechanism is as follows:

a. Preventive Maintenance

Maintenance activities carried out to avoid equipment failure, such as:

1) Make sure the electric motor is in good condition and does not make noise.
2) The condition of the bracket rails is lubricated, so that the movement of the bracket can be carried out properly.
3) Clean the tool after use.
4) Always lubricate bearings for maximum life.

b. Corrective Maintenance (Corrective Maintenance)

Maintenance activities are carried out to restore the function of the tool in a condition that is suitable for reuse, such as:

1) Perform replacement if the electric motor is damaged.
2) Perform bearing replacements.
3) Unplanned maintenance

Are maintenance activities that must be carried out immediately after a malfunction or sudden damage occurs, such as:

1) Replacement on the electric motor.
2) Torch holder replacement
3) Replacement of short-circuited and burnt cables.

## 4. CONCLUSION

From the description, manufacture of tools and testing of 1 (one) axis plasma cutting mechanism, the following conclusions can be drawn:

a. The dimensions of the plasma cutting mechanism are 1 (one) axis, namely with a workspace/cutting length of 1300 mm, with tool sizes Length, width and height 1950 mm x 300mm x 100 mm
b. The 1 (one) axis plasma cutting torch rail mechanism can be installed on the torch of several brands of plasma cutting machines, with various bracket speeds that can be adjusted as needed depending on the thickness of the plate being cut, from cutting speeds of 300 mm/minute to 2,000 mm/ minutes, the cutting height can be adjusted from 0 mm to 10 mm, with the cutting angle setting 0o to 90o and this mechanism can also be used portable / can be moved according to the required work location.
c. Plasma cutting mechanism can be used to make it easier to make straight/horizontal cuts.

## 5. ACKNOWLEDGEMENT

Finally, I would like to thank everybody who was important to the successful realization of this paper. This paper is far from perfect, but it is expected that it will be useful not only for the researcher, but also for the readers. For this reason, constructive thoughtfull suggestion and critics are welcomed.

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No.2 July 2022; p.154 - 158

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# THE EFFECT OF PYROLYSIS TEMPERATURE ON THE HEAT VALUE OF PYRO-OIL USING PLASTIC WASTE

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***Abstract.*** *This work primarily investigated the pyrolysis of smalls scale fixed bed reactor using plastic wastes type LDPE during slow pyrolysis (non-isothermal) in a batch reactor to assess the effect of different temperatures on the product yield and heating value. The calorie bomb of Parr Instrument was performed to investigated heating value of pyro-oil product at different temperatures 250, 275, 300oC. The pyro-oil obtained at higher product yield of 300 °C while the increased temperature will affect to increase the product yield of pyro-oil. The highest heating value of pyro-oil produced at a reactor temperature of 300oC is 9,769.78 cal/gr. From the results of pyro-oil using plastic waste type LDPE, the characteristics of the heating value are equivalent to diesel fuel.*

*Keywords: fixed bed reactor, slow pyrolysis, plastic waste LDPE, heating value.*

## 1. INTRODUCTION

Pyrolysis is a process of decomposition of organic material with heat without containing oxygen. The products that can be produced can be in the form of gas (H2, CO, CO2, H2O, CH4), tar and charcoal. Charcoal formed during the pyrolysis process can be used as fuel or used as activated carbon. While the liquid oil produced from the pyrolysis process can be utilized as an addictive substance or used for fuel mixtures [1]. The advantages of pyrolysis as an alternative technology including having a high conversion ratio, its products have a high energy content, the resulting products can be increased into basic materials for other purposes as well as controlling an easier process when compared to the incineration process [2].

Plastic waste is a polymer compound with a very large molecular shape in which the main element is carbon. The term plastic, in a chemical sense, includes synthetic or semi-synthetic polymerization products. One type of plastic waste that is very easy to find is Low Density Polyethylene (LDPE). The derivative of this type of plastic is crackle plastic whose use is still very massive in the community so that its existence is quite abundant and is considered to have no economic value. Its main characteristics are that it is easy to process, easy to shape using heat, and is formed from petroleum-based materials.

A lot of works have been developed on pyrolysis in traditional reactors such as fluidized-bed [4],[5], fixed bed [6], [7], rotary kiln [8] reactors etc. Regarding product distribution at different operating conditions. Whilst recently the pyrolysis of terrestrial biomass has received a great deal of attention at various experimental conditions from rice husk and rice straw [9], palm [10], orange peel [11], and coconut leaf's [12]

Research on pyrolysis oil has begun to be developed, especially its characteristics. Pyrolysis gases from agricultural waste were investigated at different temperatures. The result of the rape straw residues pyrolysis conversion demonstrated that high temperatures determine an important increase of $H_2$ content in the gas phase, this strongly affecting the energy potential of the pyrolysis gas [13]. The physical properties of the liquid production from pyrolysis of waste plastic bag compared favorably with diesel oil, which shows that it can be used as diesel oil substitution [14]. The results and quality of the pyrolysis product using plastic waste are highly dependent on the parameter setting such as temperature, reactor type, residence time, pressure, different catalysts usage and type of fluidizing gas with its flow rate [15]. Furthermore, the TGA experiment showed when the heating rate increases, the decomposition temperature of the plastics samples also increases [16]. The aims of this paper

to study the effect of pyrolysis reactor temperature on the yield and heating value of pyro-oil obtained from LDPE type plastic waste which are immensely available in Indonesia.

## 2. METHODS

### *2.1 Experimental Method*

The reactor pyrolysis (diameter:260mm and high:250m) was made from stainless steel having the fuel feeder (header heigh:100mm, diameter:50mm) at top of reactor. A LDPE plastic waste was transfer into reactor by fuel feeder. Operating temperature at reactor was investigated at three different by 250 C, 275 C and 300 C. Non-circulating water condenser unit was setup with reactor and did not add of catalyst or extra chemical during process. Experiment was batch process fully closed system setup.

Temperature distribution of the reactor assessed by digital recording measurements on the reactor. Type K thermocouple installed on the reactor wall with 3 (three) measurement points to obtain the average temperature distribution that occurs. Temperature variations are carried out by controlling the valve on the heating furnace to achieve the required temperature setting.

Figure 1. Setup pyrolysis of LDPE plastic

The amount of LDPE plastic waste is put into the reactor is 0,7 kg. The batch type experiment was operating for up to 200 minutes until it reaches the set temperature. When the temperature inside the reactor reaches the pyrolytic temperature, the product gas is passed through the condenser where cooling water temperature is 30-35 ºC which causes the condensed gas to produce a pyro-oil. Then the liquid is collected from the reservoir and weighed. The product yield of condensate oil were determined by the following Eq. (1) respectively:

$$\text{Pyro} - \text{oil yield (wt\%)} = \frac{m.condensate}{m.feedstock} x\ 100\% \quad (1)$$

### *2.2 Heating Value Analysis*

The 1341 Calorimeter is an improved version of a plain, static jacket, oxygen bomb calorimeter that has been made by Parr for any solid or liquid material. The calorimeter requires no permanent connections. It can be set up and ready to operate in a few minutes and, when not in use, can be disassembled easily and stores on a s helf.

Figure 2. Standardization of bomb calori using benzoid acid.

The quantity of energy evolved by combustion of Parr Instrument Company benzoic acid, when burned under standard bomb conditions* is given below [17], where the mass is against brass weights in air ** **26454 J/g, 6318.4 IT cal/g**, **11373 Btu/lb.** This value is based on a comparison of the combustion energy with NIST Standard Reference Material (SRM) 39j benzoic acid under identical experimental conditions. The results of at least 20 paired tests using an equal number of interleaved Parr samples and 39j control samples demonstrate no significant difference (95% CF) between the two heat of combustion values.

*) Certificate of Analysis SRM 39j Benzoic Acid, National Institute of Standards and Technology.

**) The reduction of weight in air to weight in vacuum results in a heat of combustion value of 26434 J/g for benzoic acid. This value uses the following assumptions:

- The density of benzoic acid at 25C is 1.320 g/cc.
- The density of dry air (1 atm and 20 C) is 0.0012 g/cc.
- The density of brass is 8.4 g/cc.

The heating value for the combustion that occurs in the bomb can be written with the following equation [17]

$$Q = \frac{W.\Delta T}{m} \quad (2)$$

Where:

Q = Heating value of the sample (cal/gr)
W = Calorimeter Heat Coefficient (cal/$^o$C)
ΔT = Different Temperature ($^o$C)
m = Mass of sample (gr)

## 3. RESULTS AND DISCUSSION

### *3.1 Pyro-oil production yield*

The test is carried out for up to 200 minutes to ensure the pyrolysis process runs to completion. The resulting bio-oil product shows physical differences in the form of differences in color, level of turbidity and sedimentation. Figure 3 shows visual observations, namely differences in color, level of turbidity and the resulting precipitate. The higher the operating temperature, the cleaner and brighter bio-oil

Figure 3. Pyro-oil product with different pyrolysis temperature

The effect of reactor heating temperature on the pyrolysis process affects the amount of pyro-oil produced. Figure 4 shows the bio-oil yield increasing along with the increase temperature in the reactor. At a temperature of 250$^o$C, the yield was 22,4%wt, then increased to 35%wt at a temperature of 275$^o$C and the highest bio-oil yield 45,3%wt at a temperature of 300$^o$C.

Low heating rates (slow pyrolysis) such as 10 and 20 C/min was found to produce oil with low or no wax formation due to the high residence time of volatiles inside the heating zone for further cracking to produce low range hydrocarbons. At low temperature and heating rate, the dissociation mainly causes the formation of aliphatic olefins and paraffin [18]

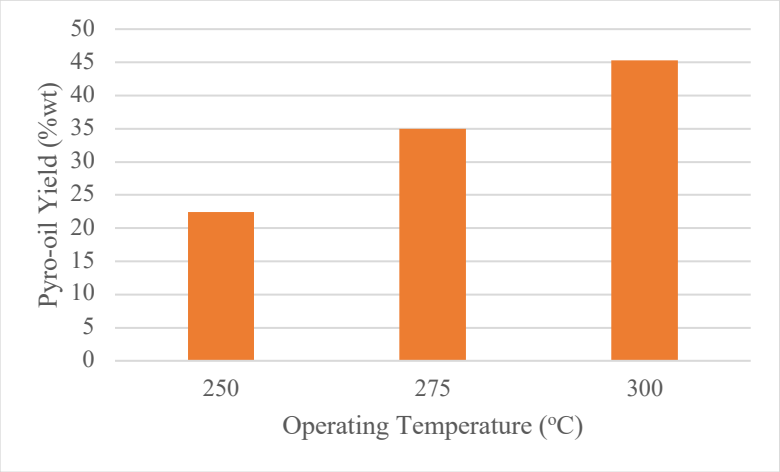


Figure 4. Average pyro-oil yield on pyrolysis of plastic LDPE

*3.2 Heating Value of Pyro-Oil*

The heating value was investigated repeated twice to provide a comparison of test results and reduce the risk of invalid data. Pyro-oil samples at a temperature of 250°C were tested twice and labeled A1, A2, 275°C with labels B1, B2, and 300°C with labels C1, C2. Bomb calorimeter test begins with standardizing procedure using a standard sample of benzoic acid. The weight of the samples tested in each is ± 1 gram. The temperature difference was measured in the water (water jacket) which was recorded in a stable condition, shortly before the bomb, and the highest temperature after doing the bomb. The comparison of the heating value presented in Table 1 where the resulting calorific value is an increase in line with the increase in the reactor temperature

| No | Calorimeter Heat Coefficient (cal/°C) | Sampel | Massa | ΔT (°C) | HHV (calgr) | Average |
|---|---|---|---|---|---|---|
| 1 | **1804,09** | A1 | 1,0147 | 5,41 | 9613,50 | **9612,85** |
| 2 | | A2 | 1,0154 | 5,41 | 9612,21 | |
| 3 | | B1 | 1,0219 | 5,54 | 9780,48 | **9674,80** |
| 4 | | B2 | 1,0341 | 5,49 | 9569,14 | |
| 5 | | C1 | 1,0162 | 5,45 | 9676,03 | **9769,78** |
| 6 | | C2 | 1,0142 | 5,55 | 9863,53 | |

Table 1. High Heating Value (HHV) of pyro-oil from different temperature of reactor

## 4. CONCLUSION

The results showed that pyrolysis product are highly dependent on parameter temperature setting. The highest temperature reactor at 300oC showed maximum pyro-oil yield of 45,3 %wt. Visual observation of the pyro-oil shows that there are differences in color degradation, where the higher of the reactor temperature, the brightness of the pyro-oil also increases. The highest calorific value of the bio-oil product is that which is produced from the highest operating temperature of 9.76.78 cal/g.

## 5. ACKNOWLEDGEMENT

The author would like to thank the board and reviewer of LOGIC Journal. Logic is a peer-reviewed research journal aiming at promoting and publishing original high quality research in all disciplines of engineering and applied technology. All research articles submitted to Logic should be original in nature, never previously published in any journal or presented in a conference or undergoing such process across the world. All the submissions will be peer-reviewed by the panel of experts associated with particular field. Submitted papers should meet the internationally accepted criteria and manuscripts should follow the style of the journal for the purpose of both reviewing and editing. And Acknowledgments also to colleagues for all the support and assistance provided in this study

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p. 159 - 165
p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# ANALYSIS OF SMK3 IMPLEMENTATION LEVEL AND ACCIDENT RISK IN THE ADMINISTRATION OFFICE BUILDING DEVELOPMENT PROJECT AT GUSTI NGURAH RAI AIRPORT BALI

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***Abstract.*** Every construction project, whether high-tech or simple, certainly has risks in its implementation process, therefore it is necessary to establish an Occupational Safety and Health Management System to minimize Occupational Safety and Health (K3) risks, but there are still many construction companies that are lacking in identifying K3 risks. and implementing an Occupational Health and Safety Management System (SMK3) in the process of implementing a construction project. The purpose of this study was to determine the level of OSH risk based on work items, as well as to measure the level of implementation of SMK3 in a construction project. In this research, the object of the case study is the construction project of the Administration Office Building at I Gusti Ngurah Rai Airport, Bali, during the lower structure work. After carrying out risk identification, 35 risk questions and 5 jobs are obtained, namely Borepile, Pilecap, Pendestal Column, Sloff, Roof Frame, then the results of the identification are processed and the risk level is obtained from the implementation of the Administration Office Building Construction Project at I Gusti Ngurah Rai Airport, Bali. Enter the Medium Category with a risk value of 8.69, while for the implementation of the Occupational Safety and Health Management System (SMK) the Administration Office Building Construction Project at I Gusti Ngurah Rai Airport, Bali is included in the good category with a total application value of 83%. Hopefully this research can become a reference in identifying K3 risks and a reference in implementing the Occupational Health and Safety Management System (SMK).

*Keywords: risk level, implementation of SMK3*

## 1. INTRODUCTION

Construction service activities are one of the most influential factors in economic development and growth throughout the world. The development of construction services in addition to providing benefits, also poses a considerable risk where in the construction industry work accidents are still very common. Work accidents that occur on a project will be one of the causes of delays and even cessation of work activities in the project. According to data from the International Labor Organization (ILO) in 2013, work accidents result in 1 worker in the world dying every 15 seconds and 160 workers experiencing work-related illness. Putra and Syahrial noted that there were 65,000 cases of work accidents that occurred in Indonesia in 2010 [1].

Work accidents often occur due to the lack of fulfillment of requirements in the implementation of K3. In this case, the government as a state administrator has an obligation to provide protection to workers. Project implementers often ignore the requirements and regulations in K3. This is because they are not aware of the magnitude of the risk that must be borne by the workforce and the company [2]. Therefore, implementing occupational safety and health (K3) management is very important because it aims to provide a good, comfortable

and safe environment and working conditions and can avoid accidents and occupational diseases. But all government efforts will not succeed without a response from companies and workers to address problems or violations of occupational safety and health (K3). Safety Planning is to analyze the risk of danger in the work which is the scope of the contract on the project in question, so that effective prevention and mitigation methods can be formulated. Meanwhile, from the website of the Employment Social Security Administering Agency (BPJS) it was noted that in July 2015 there were 50,089 accident cases where it was claimed to be down from the previous year [4]. However, data on the number of work accidents during 2015 amounted to 105,182 cases of which 2,375 cases of serious accidents were recorded [5]. Work accident data shows that the number of work accidents in Indonesia has reached 100,000 work accidents per year. The ILO estimates that around 2.3 million workers worldwide die from accidents and occupational illnesses in the construction sector each year, this corresponds to more than 6000 deaths every day. Data from the Central Bureau of Statistics (BPS) shows that the number of workers in construction has significantly increased, from 4,844,689 people in 2010 to almost double in 2015, as many as 8,208,086 people or about 7% of the 114 million workers [8]. Safety Planning is to analyze the risk of danger in the work which is the scope of the contract on the project in question, so that effective prevention and mitigation methods can be formulated[7]

From the statement above, it can be seen that work accidents in the construction world are still very common. Therefore, this researcher aims to measure the level of implementation of SMK3 and the level of accident risk in the Administration Office Building Project at I Gusti Ngurah Rai Airport.

## 2. METHODS

According to the problems and objectives of the existing research, this research belongs to the type of descriptive correlative research. Descriptive research is one type of research whose purpose is to present a complete picture of the social setting or is intended to explore and clarify a phenomenon or social reality, by describing a number of variables relating to the problem and the unit under study between the phenomena being tested. While correlative research is a study to determine the level of relationship between two or more variables without any effort to influence these variables so that there is no variable manipulation. This research was carried out directly by distributing questionnaires about the level of implementation of SMK3 and the risk of accidents in the construction project of the I Gusti Ngurah Rai Airport Administration Office Building, Bali.

For research on the level of implementation of SMK3 and the risk of accidents will be carried out on the Construction Project of the I Gusti Ngurah Rai Airport Administration Office Building in Bali. Can be seen in Figure 1 Research Locations.


Figure 1. Research Locations

Determination of data sources is raw data that needs to be processed so as to produce information or information, both qualitative and quantitative that show facts. The data obtained must be relevant, meaning data that has a direct relationship with the research. In addition, the data obtained is reliable data that is still hotly discussed and obtained from the first person (primary data). After the data is obtained, the data are grouped first before being used in the analysis process, namely as follows:

a. Primary data
Is data obtained from the first source. Primary data was obtained by conducting field studies. Field studies are conducted by surveying with related parties, so the approach to primary data is to conduct surveys or conduct questionnaires.

b. Secondary Data
Is data obtained from literature studies, such as books, papers, journals, previous research and can be in the form of data that can be processed and can also be data from the project. The data used by the author in this study are primary data (direct) and secondary data in the form of literature studies and project data.

A ccording to Sugiyono [10], population is a generalization area consisting of objects or subjects that have certain qualities and quantities and characteristics determined by researchers to be studied and then drawn conclusions. The population referred to in this research is the contractors and structural workers in the I Gusti Ngurah Rai airport administration office building project in Bali. The sample is a number of members of the population that represent the population as the object of research. Research that uses the entire population as the object of research is called a census or total sample. Research like this is done when the population is not too large. If the research is conducted on a large population such as this research population, it is necessary to do sampling. alidity test is a measure that shows the levels of validity or validity of an instrument [9]. An instrument is said to be valid if it is able to measure what is desired and can reveal data from the variables studied appropriately.

There are two ways to assess the validity of the questionnaire instrument, the first is whether or not an instrument is valid if the significance value (sig) is less than 0.05 then the data will be valid. While the second way is to compare the value of r-count with the value of r-table. If r-count is greater than r-table and positively correlated, then the item or question is valid. Or in other words, the question item is said to be valid if the question item score has a positive and significant correlation. In assessing the validity of each question item, it can be seen from the Corrected Item-Total Correlation value of each question item. A question is said to be valid if the value of r-count which is the value of Corrected Item-Total Correlation is greater than r-table.

## 3. RESULTS AND DISCUSSION

### Characteristics of Respondents

The respondents from the research on risk level analysis and the application of the Occupational Safety and Health System (SMK3) were taken from the project organization, the foreman and the chief handyman on the construction project of the Administration Office Building at I Gusti Ngurah Rai Airport, Bali.

Table 1. Characteristics of Respondents Based on Position

| | Characteristics | Classification | Number of Respondents (person) | Percentage of Respondents (%) |
|---|---|---|---|---|
| | Position | Site Enginer | 1 | 5 |
| | | Site Enginer MEP | 1 | 5 |
| | | Drafter | 1 | 5 |
| | | QC | 2 | 10 |
| | | QS | 1 | 5 |
| | | Technical staff | 3 | 15 |
| | | K3 Staff | 3 | 15 |
| | | MEP Staff | 2 | 10 |
| | | Executor | 3 | 15 |
| | | Foreman | 3 | 15 |
| | Total | | 20 | 100 |

From the Table 1 above shows that the positions of respondents who filled out the questionnaire consisted of Technical Staff, K3 Staff, Implementers, Foreman with a percentage of respondents that was 15% then followed by QC, MEP Staff with a percentage of respondents that was 10% then followed by Site Engineer, Site Engineer MEP, Drafter, QS percentage of respondents is 5%.

**Characteristics of Respondents Based on Education**

The results of the characteristic analysis based on the education of the respondents are presented in the following table 2 below.

Table 2. Characteristics of Respondents Based on Education

| No | Characteristics | Classification | Amount Respondent | Percentage Respondent (%) |
|---|---|---|---|---|
| 2 | Education | JUNIOR HIGH SCHOOL | 3 | 15 |
| | | SENIOR HIGH SCHOOL | 2 | 10 |
| | | 3-year diploma | 3 | 15 |
| | | 4-year diploma | 1 | 5 |
| | | Bachelor | 11 | 55 |
| | Total | | 20 | 100 |

From the table 2 above, it can be seen that respondents with undergraduate education have the most number, namely 11 people with a percentage of 55%. Respondents with junior high school education and diploma 3 have the least number of respondents, namely 3 people with a percentage of 15% each. Respondents with high school education have the same number of respondents, namely 2 people with a percentage of 10%. Respondents with diploma 4 education have the highest number of people with a percentage of 5%. So the most dominating education in this research is Bachelor.

## Risk Matrix

The definition of K3 is an activity that ensures the creation of safe working conditions, protected from physical and mental disorders through coaching and training, direction and control over the implementation of the duties of employees and providing assistance in accordance with applicable regulations, both from government agencies and the company where they work. [3]. Based on these data, a mapping of the existing risks based on the existing risk matrix is carried out in the Ungent, High, Medium, Low, None categories. Classified (risk level) can be seen in the following explanation:
URGENT (U): Filled with the letter U if the risk score is between 15-20
HIGH (H): Filled with the letter H if the risk score is between 10-<15
MEDIUM (M): Filled with the letter M if the risk score is between 5-<10
LOW (L): Filled with the letter L if the risk score is between 2-<5
NONE (N): Filled with the letter N if the risk score <2
To classify the level of risk, it is obtained by multiplying the average result of the frequency with the average result of the severity of each existing work risk, which can be seen in the Table 3 below.

Table 3. Risk Level Classification Results

| Risk Variable | frequency | severity | risk score | classified |
|---|---|---|---|---|
| Borepile Jobs | | | | |
| Struck by work tools/materials | 3 | 4 | 12 | H |
| Injured due to work tools | 3 | 3 | 9 | M |
| stabbed by a sharp object | 3 | 4 | 12 | H |
| Struck by iron material | 3 | 4 | 12 | H |
| Exposed to maneuvering heavy equipment | 2 | 4 | 8 | M |
| Exposed to Casting Tool | 2 | 3 | 6 | M |
| Get hit by readymix truck | 2 | 4 | 8 | M |
| Trapped by a tremi pipe | 2 | 3 | 6 | M |
| Pilecap Jobs | | | | |
| Struck by work tools/materials | 2 | 4 | 8 | M |
| stabbed by a sharp object | 3 | 4 | 12 | H |
| Injured due to work tools | 3 | 4 | 12 | H |
| Pierced by iron material | 3 | 4 | 12 | H |
| Struck by iron material | 3 | 4 | 12 | H |
| Exposed to maneuvering heavy equipment | 2 | 4 | 8 | M |
| Exposed to Casting Tool | 2 | 3 | 6 | M |
| Get hit by readymix truck | 2 | 4 | 8 | M |
| Pedestal Column Work | | | | |
| stabbed by a sharp object | 2 | 4 | 8 | M |
| Exposed to bar cutter and bar bending | 3 | 3 | 9 | M |
| Legs/hands hit by a saw | 2 | 2 | 4 | L |
| Exposed to Casting Tool | 2 | 3 | 6 | M |
| Get hit by readymix truck | 2 | 4 | 8 | M |
| Sloof Job | | | | |
| Hands/feet pinched by reinforcing iron | 2 | 4 | 8 | M |
| stabbed by a sharp object | 2 | 4 | 8 | M |
| Struck by material maneuver | 2 | 4 | 8 | M |
| Exposed to barcutter and barbending | 3 | 3 | 9 | M |

| Risk Variable | frequency | severity | risk score | classified |
|---|---|---|---|---|
| Legs/hands hit by a saw | 3 | 3 | 9 | M |
| Exposed to Casting Tool | 2 | 3 | 6 | M |
| Get hit by readymix truck | 2 | 4 | 8 | M |
| Steel Roof Frame Work | | | | |
| Falling from a height | 2 | 5 | 10 | H |
| stabbed by a sharp object | 2 | 5 | 10 | H |
| Hit by tower crane | 1 | 4 | 4 | L |
| The worker below is hit by the material | 2 | 4 | 8 | M |
| Workers below are exposed to welding sparks when welding steel frames | 2 | 3 | 6 | M |
| Being hit / hit by material when loading / unloading material | 3 | 4 | 12 | H |
| Material hit the building | 3 | 4 | 12 | H |
| Rata-Rata Risk Score | | | 8.69 | M |

From the table 3 above, the results of the classification of the risk level above when viewed as a whole against the 35 existing work risks, the work risk in the construction project of the Administration Office Building at I Gusti Ngurah Rai Airport, Bali is included in the Medium (M) category because it obtains average risk score of 8.69. The Occupational Health and Safety Management System is part of the overall management system which includes the organizational structure, planning, responsibilities, implementation, procedures, processes and resources needed for the development of implementation, achievement, review and maintenance of occupational safety and health policies in order to create a workplace safe, safe, efficient and productive work (Regulation of the Minister of Public Works, 2008) [6][11-15]. To Descriptive Table of SMK3 Implementation Level, which can be seen in the table 4 below.

Table 4. Descriptive Table of SMK3 Implementation Level

| Question | N | MEAN | TCR (%) | CATEGORY |
|---|---|---|---|---|
| Management Planning | 20 | 4.19 | 84 | Good |
| Implemetation | 20 | 4.19 | 83 | Good |
| Evaluation | 20 | 4.07 | 81 | Good |
| MEAN | | 4.14 | 83 | Good |

From the Table 4 above, based on the results of the descriptive analysis above, it shows that the level of application of the occupational safety and health system (SMK3) in the Administration Office Building Construction project at I Gusti Ngurah Rai Airport, Bali is in the "Good" category with the average TCR (Respondent's Level of Achievement) value of the 3 sub-variables of the implementation of SMK3 is 83 %. K3 will improve worker safety and increase work productivity [16][17].

## 4. CONCLUSION

The results of the analysis on Questionnaire 1, namely the risk variable based on the answers from 20 respondents, showed that the level of risk in the construction project of the Administrative Office Building at I Gusti Ngurah Rai Airport, Bali. included in the S (Medium) category by getting an average risk score of the Medium (M) category because it obtained an average risk score of 8.69. it can be concluded that the frequency of risk that has the highest value is Injury due to work tools on borepile, pilecap, sloof work, pendestal columns with a scale of 3 and on the roof truss the highest value is Affected / crushed by material when loading / unloading material with a scale of 3 while for the smallest value on borepile work, pilecap, sloff, pendestal column is exposed to retail tools with a scale of 2. for severity (severity) the risk in borepile work which has the highest value is being stabbed by sharp objects with a scale of 4, on pilecap work is being hit work tools/materials with a scale of 4, in the pendestal column work, it was hit by a readymix truck 4, in the sloff work it was hit by a material maneuver and on the roof truss work it was punctured by a sharp object with a scale of 5, while the smallest value in the borepile work was struck by a tremi pipe with a scale of 3, on pilecap work is exposed to casting tools with a scale of 3, on the pendestal column work, the feet/hands are exposed to a saw with a scale of 2, on the sloff work is exposed to barcutter and barbending with a scale of 3, on the roof truss work Workers below are exposed to welding sparks when welding a steel frame with a scale of 3.

The results of the analysis of the application of SMK3 show that the level of application of the occupational safety and health system (SMK3) in the Administration Office Building Construction project at I Gusti Ngurah Rai Airport, Bali is in the "Good" category with the average TCR value of the 3 sub-variables of the implementation of SMK3 is 83%.

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p. 166 - 170

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# EXPERIMENTAL STUDY OF THE EFFECT OF REACTOR TEMPERATURE RECONSTRUCTION ON FUEL CONSUMPTION AND DISTILLATE QUANTITY

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***Abstract.*** Temperature is a physical quantity as a measure the degree of hotness or coldness an object or system that is in thermal equilibrium. Heat flows naturally from high temperature objects to low temperature (reversible process). Heat is an energy that transferred between of two difference temperature. This heat transfer will occur and the process will be stops until thermal equilibrium occurs. The high temperature fluid in the distillation reactor will tend to be at the top, even though the heat treatment is carried out at the bottom side. The open model distillation reactor makes equilibrium to be reached in relatively long time. Time will affect to energy consumption. The pump aims to reconstruct of the temperature, so that can be reaches the thermal equilibrium more quickly. The process is carried out for 60 minutes using 25 liters of raw materials with the same quality and the temperature is set at $90^0$ C. The average temperature difference in the reactor is 86.11%, the decrease in fuel consumption is 30.3%, and the increase in distillation quantity between the reactor without a pump compared to with a pump is 16.67 %.

*Keywords : temperature, energy, reactor.*

## 1. INTRODUCTION

Distillation is a process to separating of two or more liquids based on their boiling points. Based on this theory, the process is most often carried out of heating. The result of the heat process will produce steam, the vapor is converted into a liquid phase again in the condenser. There are two main components in distillation apparatus, namely reactor and condenser. Steam is generated in the reactor components, so this device is closed to reduce steam leakage. The reactor is heated using a burner which is controlled by temperature sensor so that the heat can be adjusted as needed.

Temperature is a physical quantity as a measure the degree of hotness or coldness an object or system that in thermal equilibrium [1-3]. Heat is energy that is transferred between of two temperature difference in the system or its environment. The relationship between heat and temperature is not constant, the amount of temperature increase due of receiving a certain amount of heat will be influenced by the heat capacity of the object receiving [4-7]. Heat is known be able to move from a higher temperature to a lower temperature [8-10]. The statement expressed by R.J.E Clausius is the heat flows naturally from high temperature to low temperature objects (reversible process). The concept of second law thermodynamics will always occur and the process will stop until the concept of thermal equilibrium occurs. It can be concluded that an object or fluid will have heat and naturally heat can flow from a high temperature to a lower temperature until the concept of thermal equilibrium is formed.

Heat transfer is a science to studies the transfer of energy or heat that occurs due of two temperature differences between objects or materials. Heat transfer can take place in several ways, namely by convection, conduction and radiation [11-14]. The transfer of heat from a high concentration of adjacent substances to heat of a lower concentration as a result of interactions between particles is called conduction. Convection is a model

of heat transfer between adjacent surfaces of a gas or liquid and involves fluid motion. Radiation is the emission of energy from matter in the form of electromagnetic waves as a result of changes in the shape of molecules or atoms [15][16]. Heat transfer can occur through solid, liquid or gas because of the treatment.

Distillation reactor as one of the important tools in the separation [17-20]. Heat treatment through certain media can increase the temperature of the existing fluid. The second law of thermodynamics states that heat will tend move to a place of lower temperature until thermal equilibrium is reached. The high temperature fluid in distillation reactor will tend to be at top even though heat treatment is carried out at the bottom side. The open model distillation reactor makes equilibrium to be reached in a relatively long time. Time will affect energy consumption.

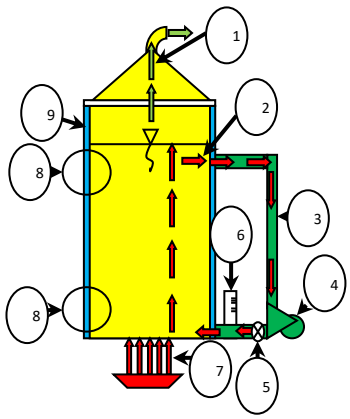
The treatment will be carried out on the reactor by adding a device whose purpose to achieve thermal equilibrium more quickly. It is hoped this equilibrium will affect energy consumption in production process. The fixed variables are temperature and fluid flow rate, while the independent variables are energy consumption and the amount of distillate.

The problem is how to design a distillation reactor with the addition of temperature reconstruction tool and whether temperature treatment can affect energy consumption and the quantity of distillate produced. Application of science to design appropriate technological tools that can speed up production time to reduce costs. The design of the distillation reactor uses 1.5 mm thick stainless steel plate with a base dimension is 40 cm and a height is 60 cm which is wrapped with a heat cover (glass wool and burlap sack). The heater uses an LPG stove with a control to regulate the temperature requirement of the reactor. Steam is conveyed using stainless steel pipes. Temperature data is recorded every 15 minutes. LPG weight is measured every 15 minutes to get the amount of energy use. The distillate quantity will be measured after the distillation process is stop.

## 2. METHODS

### 2.1. Research Design

Traditional distillers make alcoholic beverages with raw materials from coconut tree sap or palm sap. The raw materials required are at least 16 liters of palm sap, the time required to heat the raw materials into steam is about 3 to 4 hours, while the results obtained are about 1 liter of alcohol.




1 Steam flow
2 Hot fluid flow
3 Hot pipe
4 Pump
5 Ceck valve
6 Flow meter
7 Burner LPG
8 Temperature measurement point
9 Heat cover

Figure 1 Distillation reactor design with temperature reconstruction

The addition of a heat cover to prevent heat loss which causes relatively high energy requirements has been carried out in previous studies. The spread of heat in the reactor tube still adheres to the natural law where the highest heat will be on the surface of the fluid.

The fluid pump in this study was added to speed up the thermal equilibrium process so that the evaporation process would be faster. Understanding the pump in general is a tool used to move fluid from one place to another [21][22]. In principle, the pump converts the mechanical energy of the motor into fluid flow energy, the energy received by the fluid will be used to increase the pressure and overcome the losses that occur in the line. In this study, a centrifugal pump was used. This pump uses a rotating impeller to increase the fluid pressure. Centrifugal pumps are usually used to move fluids through piping systems. The fluid enters the pump impeller along or near the rotating axis and is accelerated by the impeller, flowing radial outward into the diffuser or volute (casing) chamber, from where it exits to the downstream piping system. Centrifugal pumps are used for large discharges through smaller heads. The working principle of the pump is driven by a motor. Power from the motor is supplied to the pump shaft to rotate the impeller mounted on the shaft. The fluid in the impeller will also rotate due to the thrust of the blades. Due to the presence of centrifugal force, the liquid flows from the center of the impeller out through the channels between the blades and leaves the impeller at high speed. The liquid that comes out of the impeller at high speed will then come out through a channel with a larger cross-section (volute/diffuse) resulting in a change from the velocity head to the pressure head. Suction occurs because after the liquid is thrown by the impeller, the space between the blades becomes lower in pressure so

that the liquid will be sucked in. The pump in the reactor is useful for flowing liquid from the surface to the bottom. The hot fluid at the surface is returned to the bottom of the reactor.

This type of pump is installed with a capacity of 10 liters per minute. The pump will be turned on during the process. The fluid in the tube is made to always circulate from the top side of the tube to the bottom side of the tube. The hot fluid on the top side will be forced to the bottom side of the tube to accelerate the equilibrium condition.

2.2. Research Instruments

The instruments used in this research are fuel consumption and distillate quantity. Retrieval data using a thermocouple to measure the temperature in distillation tube as shown in figure 2.

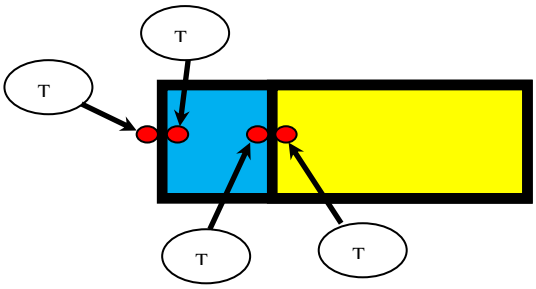


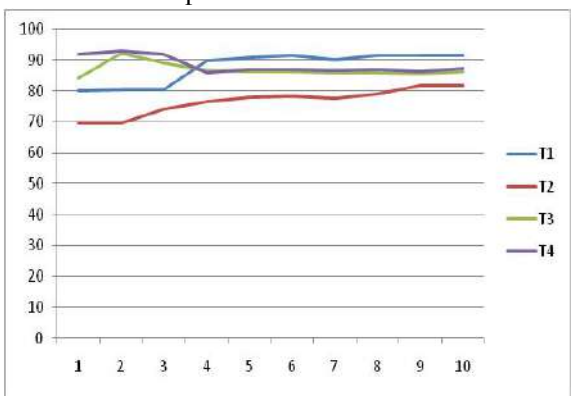

Figure 2 Location of data retrieval

Processing is done based on the data that has been taken and the variables that have been set. Fixed variables are heating temperature and fluid flow rate. The independent variables are fuel consumption and distillate quantity.

## 3. RESULTS AND DISCUSSION

The test was carried out for 5 times with the same quality raw materials for each treatment. The volume of raw materials is 25 liters. Preheating was done to reach a temperature to $90^0$ C. Data retrieval of temperature and weight of fuel when the reactor temperature has reached $90^0$ C and the circulation pump is turned on. Data were collected every 15 minutes for 60 minutes process. The quantity of distillate and final fuel weight were measured after 60 minutes of processing is done. The data is displayed according to graph 1.

Graph 1 Test result data




The difference is very significant between a reactor using a pump and without a pump as shown in graph 1. T1 and T2 are the temperature in the reactor without a pump. T3 and T4 are the temperatures in the reactor using a circulating pump.

The temperature of the reactor without a pump (T1 and T2) showed a very significant difference is $11.09^0$ C based on top side and bottom side of the reactor. This temperature difference affects the fuel consumption used. The initial fuel weight is on average 6.980 kg and after the process becomes an average of 6.585 kg, there is a decrease 0.395 kg of weight. That's an average of 5 times off/on burner with a very short time span from off burner to on burner to maintain a stable temperature. The quantity of distillation during the process obtained an average of 1,250 ml after one hour of processing.

The reactor temperature with the pump (T3 and T4) looks almost the same where there is only an average temperature difference of $1.54^0$ C based on top side and bottom side of the reactor. This almost small difference indicates that the temperature inside the reactor becomes more even with the addition of a pump for fluid circulation. This affects the fuel consumption used only 0.275 kg from an average initial weight of 6.950 kg to an average of 6.675 kg. That's an average of 2 burner off/on times with a long time span from off to on. The quantity of the distillate during the process obtained an average of 1,500 ml after one hour of processing.

There is a difference between a reactor without a pump and a reactor with a pump. The difference of temperature distribution between the top side and the bottom side in the tube is 86.11 %, that's indicates the heat balance can be achieved. This equilibrium condition affects the energy consumption. The decrease consumption of LPG is 30.38 % . The quantity of the distillation product also increases due the increasing heat balance in the reactor tube. The increase of distillate was 16.67 % from the reactor without a pump compared to the reactor with an added pump.

## 4. CONCLUSION

The conclusions of this study are:

1. The difference of temperature is 86.11% between the reactors without a pump compared to with a pump.
2. Decrease of fuel consumption is 30.3% between reactors without pumps compared with pumps.
3. Increase of distillate quantity is 16.67% between reactors without pumps compared with pumps.

## 5. ACKNOWLEDGEMENT

Thank you to The Bali State Polytechnic Research and Community Service Center, for providing full support to the implementation of this research.

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p.171 - 175

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# EXPERIMENTAL ANALYSIS OF THE EFFECT ADDITION HEAT COVER IN DISTILLATION REACTOR

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***Abstract.*** The process of separating two or more components in a liquid based on the boiling point of the substance is called distillation. Research on the distillation column or reactor has been carried out to improve the distillation system but is still discussing the reactions occur. Based on the second law of thermodynamics known as exergy analysis to obtain information about thermodynamic efficiency and locations of energy efficiency so that energy savings can be made. Distillation reactor as one of the main tools is very important points.
The addition of protective layer on the distillation reactor aims to reduce heat losses occur. Heat protection materials used in the form of jute and glass wool. The prototype of the distillation apparatus with this coating will be applied to the community as an appropriate technology. The combination of 3 cm jute on inside and then 3 cm glass wool gave the highest heat transfer value is 7864.21 watts.

*Keywords : jute, glass wool, distillation. reactor.*

## 1. INTRODUCTION

The process of separating two or more components of a substance based on their boiling points is called distillation. The reactor is the main component in the process of separating substances. The temperature is gradually increased to be able to evaporate the substance, the steam flows through the connecting pipe to the condenser. The phase change process from vapor to liquid occurs in the condenser.

Several studies discuss the reactions that occur in the reactor. The heat load Q as the x-axis and the carnot efficiency, 1 - T0/T as the y - axis are described using availability diagrams based on thermodynamic analysis [1-4]. The heat source path will always be higher than the heatsink path, the temperature at the heat source is always greater than the temperature at the heatsink, the distance between of two path is the energy lost [5-7]. Energy requirements and energy loss due to the distance are still an obstacle. Based on the exergy analysis, information about the efficiency of heat transfer and the location of heat loss can be obtained so that energy savings can be made [8-12]. This research has not provided a solution to overcome the problems that occur.

The distillation reactor is the main component in the separation step. Planning, manufacture and analysis of the reactor are the main concerns in every distillation process [13-16]. The energy used in the purification process has a greater percentage of the energy that can be obtained, which results in a purification efficiency of 11 % and technical efficiency of 20 % [17][18]. The energy needs of this research to produce distillates are still very large.

The temperature difference in the thermosyphon cover is affected by the heat - protective layer [19][20]. A decrease in temperature of $20^0$ C on indoor floor tiles as the effect of adding carpet [8]. The addition of a heat protective layer in the reactor is expected to have an effect of the thermodynamic process. The distillation reactor which is the most important part of the system, is a major concern in energy efficiency efforts. Heat protection material from glass wool and jute because they are easy to find and maintain. The distillation apparatus is designed to be prototyped and implemented for rural communities which is the application of appropriate technology.

## 2. METHODS

### 2.1. Design

The process of making alcoholic beverages with raw materials for coconut or palm tree sap in the community still uses a traditional tools. The raw materials needed are 16 liters of palm sap to get 1 liter of alcoholic beverage, the heating time of the raw materials is about 3 to 4 hours. The heat transfer that occurs and the heat loss in the reactor results in a long production time.

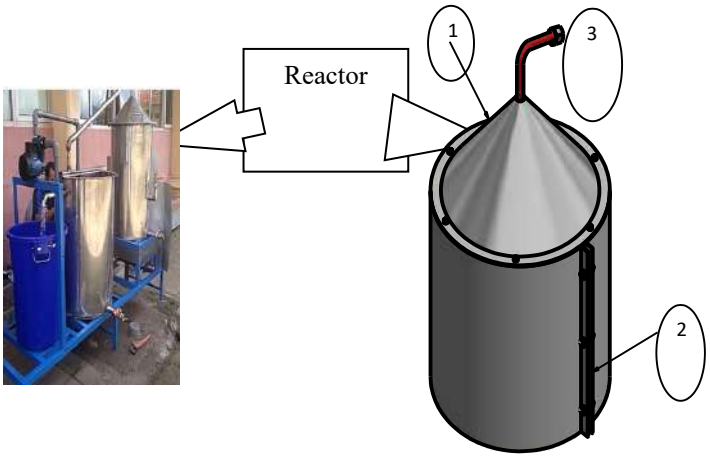


Figure 1. Distillation Tool

The addition of a protective layer on the distillation tube is made to retain heat. The addition of this layer is expected to increase the efficiency of production time. The heat protection layer reduces conduction and convection heat loss. The tube is closed to prevent any steam from escaping. The temperature is increased gradually by LPG burner to vaporize the substance. The steam flows through the connecting pipe and undergoes a phase change to liquid when it enters the spiral pipe in the condenser.

### 2.2. Research instrument

The fixed variables in the test are time and temperature used, while the independent variable is the heat transfer value. The test was carried out for 60 minutes for one process and data collection was carried out every 15 minutes. The test was carried out 5 times with the same reactor time and temperature in each process.

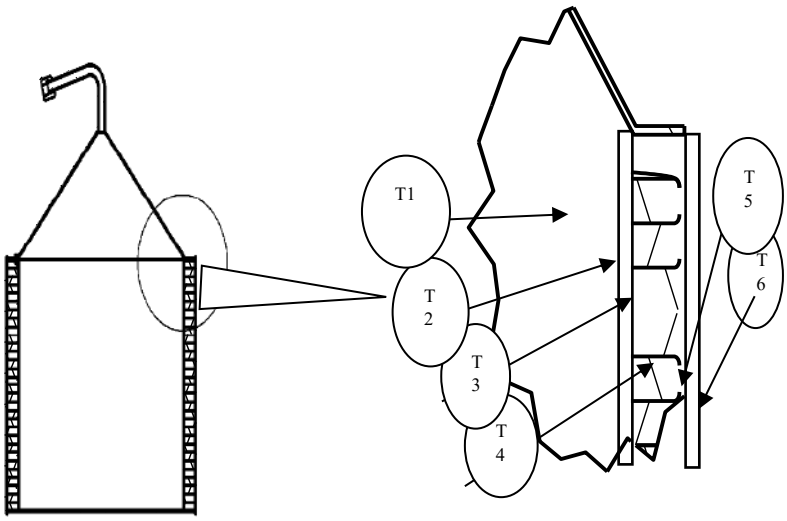


Figure 2. Location of data retrieval

## 3. RESULTS

### 3.1. *Result Of Data*

The materials used are glass wool and jute because they are easy to find and maintain. The heat protection layer is varied according to the research needs. The models is made like using only glass wool or jute and a combination of glass wool and jute. The thickness and variation of the heat protective layer material from 4 cm to 6 cm. The resulting data is as in Table 1.

Table 1 Result of experimental data

| Time (min) | Heat Transfer | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 4cm Glasswol | 4cm Jute | 2 cm Glas swoll 2 cm jute | 2 cm jute 2 cm Glas swoll | 6cm Glass woll | 6cm Jute | 3 cm Glass woll 3 cm jute | 3 cm jute 3 cm Glass woll |
| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 |
| 15 | 1130.54 | 1769.34 | 375431 | 3498.17 | 827.67 | 634.78 | 4231.19 | 4161.58 |
| 30 | 4327.30 | 3057.60 | 5129.38 | 4704.63 | 2136.92 | 877.36 | 5415.93 | 5337.00 |
| 45 | 8595.16 | 4433.69 | 6682.55 | 6498.53 | 6036.66 | 1628.66 | 7335.53 | 8189.64 |
| 60 | 7081.76 | 4532.79 | 9972.47 | 9149.16 | 8485.84 | 3303.01 | 10715.41 | 10916.46 |
| 75 | 6772.19 | 8657.05 | 9527.75 | 8854.45 | 7862.65 | 8546.09 | 10108.69 | 10238.27 |
| 90 | 5589.50 | 7850.73 | 9023.64 | 8808.16 | 6950.15 | 7147.84 | 9318.96 | 9410.06 |
| 105 | 4401.42 | 7167.30 | 8075.96 | 7832.10 | 5745.92 | 6488.28 | 8755.46 | 8921.82 |
| 120 | 3724.94 | 6633.02 | 7656.04 | 7343.44 | 4754.10 | 6166.77 | 7181.49 | 7947.37 |
| 135 | 3186.22 | 5683.89 | 6623.69 | 6366.34 | 3630.55 | 5339.09 | 6742.97 | 7224.95 |
| 150 | 2692.24 | 4941.31 | 5310.75 | 5389.66 | 2140.27 | 4835.31 | 5519.68 | 6295.00 |
| Rate | 4750.13 | 5472.67 | 71175.65 | 6844.46 | 4917.07 | 4496.72 | 7592.53 | 7864.21 |

The phenomenon of heat transfer that occurs is analyzed by graphical method. Descriptive method is used to describe the ability of the coating to withstand heat transfer. The phenomenon of heat transfer can be described as in Figure 3.

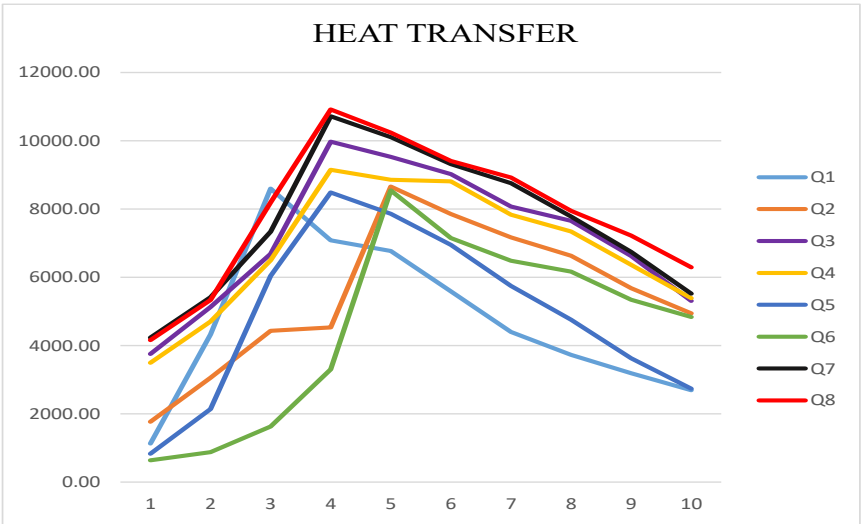


Figure 3 Heat transfer graph

The heat transfer that occurs due to the addition of a heat shield on the reactor can be seen in figure 3. Significant heat transfer occurs as a result of the addition a heat shield layer according by the variations made. Significant temperature differences as a result of layer variations affect to the heat transfer value. The smallest heat transfer value obtained from the heat protective layer only uses jute with a thickness of 6 cm is 4496.74 watts. Jute must have fibers that are not tight so that it affects to the heat transfer. The heat protection layer of glass wool with denser fibers is also not able to provide a good heat transfer value. The heat transfer value is 4917.07 watts with a layer thickness of 6 cm. The alloy of heat shielding material has a significant effect on its heat transfer value. The combination of 2 cm glass wool and 2 cm jute gives a value of 6844.46 watts where the inside uses jute and the outside uses glass wool. Alloys with the same thickness by swapping the inner side using

glass wool and the outer side using jute provide a heat transfer value of 7175.65 watts. From the graph, it can be seen that the mixture of jute on the inside with a thickness of 3 cm and glass wool on the outside with a thickness of 3 cm gives the highest heat transfer value, which is 7864.21 watts (Q8).

## 4. CONCLUSION

1. The type of heat protection material affects the value of heat transfer occurs.
2. The alloy of the heat shield type can provide the best heat transfer value, which is 7864.21 watts

## 5. ACKNOWLEDGEMENT

This research was fully funded by the Bali State Polytechnic Research and Community Service Center, thanks to the institution for the opportunity and award given.

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p. 176 - 180

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# REDESIGN OF HORIZONTAL COFFEE ROASTERS WITH TEMPERATURE, TIME AND ROTATION CONTROLS

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***Abstract.*** Coffee roasting is still using clay pans with the traditional method and heat is obtained from firewood fires. Only 20% of the national coffee bean production which reaches 600,000 tons per year is processed and marketed as secondary products. The physical mechanical properties of coffee at a faster decrease in water content, increase in brittleness and accelerated color change are affected by temperature and roasting time
The stirrer rotation speed control on the prototype horizontal roaster was added while still emphasizing the traditional method. The roaster is equipped with a temperature and time control to add product creations. The temperature of $120^0$ C has not shown the level of maturity where the weight has not been reduced properly and there is no aroma. A temperature of $180^0$ C for 15 minutes with a rotation of 100 RPM causes a significant weight loss of 60% and a strong coffee aroma has been smelled. The temperature was set to $220^0$ C despite varying times and rotations, resulting in a completely burnt and immature coffee exhibited by a weight loss of only 50%. The results showed that temperature, time and rotation greatly affect the quality of roasting results.

*Keywords: roaster, coffee, temperature, rotation.*

## 1. INTRODUCTION

Only 20% of the national coffee bean production of 600,000 tons per year can be processed and marketed in the form of secondary products, including roasted coffee, ground coffee, ready-to-eat coffee, and several other types of secondary coffee [1]. The role of the roasting process is very important in the final result of coffee (brewed coffee). The roasting process needs to be considered, including the roasting machine system, tube plate material, the stability of the ignition source, and the type of coffee raw material and its characteristics, other important aspects of roasting are temperature, time, skill, and roasting technique [2-5]. The coffee is roasted using a 25 cm and 16 cm diameter Teflon pan. The treatment studied was a temperature of around 180 to 250 C with a baking time of 12 minutes. The results showed that the roasting process using conduction heat with a closed roaster causes the heat to spread evenly so that the roasting process runs faster. Temperature treatment and roasting time have an effect on changes in the physical mechanical properties of coffee, namely a faster decrease in water content, an increase in brittleness and an acceleration of dark color change [6-8]. The study stated that the quality of roasting coffee beans is determined in terms of method, temperature and time, but the tools used still have large dimensions and are relatively expensive.

Automatic roasters and grinders are made with a microcontroller system [9-12]. A gas-fueled microcontroller roaster using a microcontroller as an electrical controller is made with only 3 settings for the coffee profile, namely light 12.8 minutes, medium 17 minutes and dark 25 minutes with a temperature setting of 245 degrees Celsius [13-15]. A microcontroller-based automatic system is implemented so that the desired profile quality can be determined.

Previous research has obtained a maximum roasting result of 30 minutes and an international standard coffee profile [16-18]. The weakness of the tool in the construction of the lid. The construction of the vertical

model has problems when opening or closing causing delays for pouring or picking up coffee beans. This construction has an impact on the preheating time lag so that it affects the shape of the pot that resembles a tube causing the coffee parts to not mix well. In this study, the lid will be redesigned and change the shape of the pot into a semicircle to reduce the time lag that occurs and the turbulence of stirring the coffee beans. The quality of the results is obtained by adding a stirrer rotation regulator

.

## 2. METHODS

### 2.1. Design

The lid and roasting pan were redesigned to optimize the roasting process. The effect of temperature, time and rotation on the roasting results is seen from the test results. Temperature, time and rotation are fixed variables, while the independent variable is coffee weight.

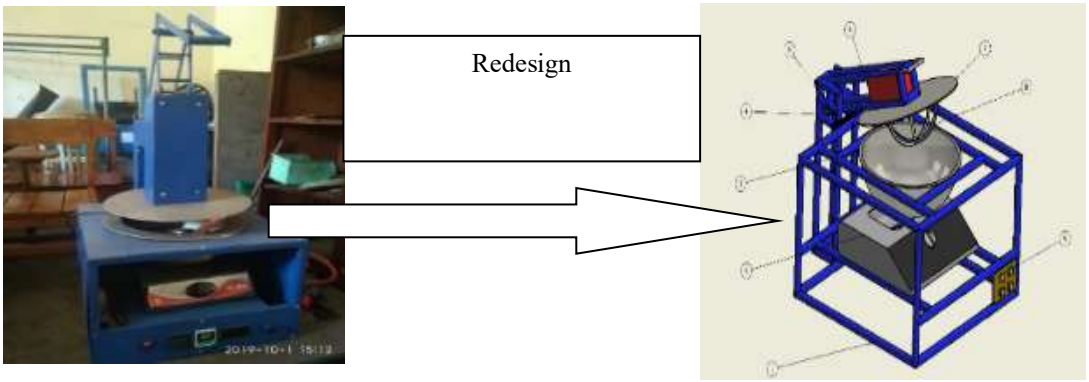


Figure 1. Redesign roaster tool

### 2.2. Research instrument

Coffee samples were taken from Pupuan because later the tool will be applied in the area. Pupuan sub-district is ranked first with production most robusta coffee for three consecutive years. According to data from the Bali Province Central Statistics Agency (2017), it shows that Pupuan District always ranks first for the highest Robusta coffee production in Tabanan Regency from 2014 to 2016. With a total of production in 2014 was 3,732.87 tons, in 2015 it reached 5,196.53 tons, and 5,170.99 tons in 2016. Judging from the large number of coffee plantations in Pupuan District, so that the community can take advantage of this potential by processing coffee beans into ground coffee (Dyah, 2019). Roasted profiles were recorded from weight and aroma based on temperature variables $120^0$ C – $220^0$ C, time 15 - 30 minutes and rotation 100 - 150 RPM.

## 3. RESULTS AND DISCUSSION

### 3.1. Result of Data

The Robusta coffee productivity in Pupuan District is evenly distributed in all villages in Pupuan District. Distribution of Robusta coffee productivity by area or region is found in each village [19]. Soil characteristics were: dark curved soil color, deep solum depth (>100 cm), high CEC, high base saturation, and good soil fertility. According to the Soil Taxonomy system, the soil family is Typic Hapludands, ash, isohyperthermic. Land suitability is quite suitable for coffee and salak [20][21]. The test was carried out with samples of Robusta coffee from Pupuan Tabanan. Testing by varying the temperature, time and stirrer rotation. Observations were made visually from color and aroma. The test results can be seen in Table 1.

Table 1. The test result

| Temp | RPM | Time (min) | Coffe (scent) | Visual | Water Content (%) | |
|---|---|---|---|---|---|---|
| | | | | | Before | After |
| 120 | 100 | 15 | Weak |  | 12.0 | 8.0 |
| | | 30 | Burnt |  | 5.0 | 3.0 |
| | 150 | 15 | Weak |  | 6.0 | 4.0 |
| | | 30 | Become strong |  | 4.0 | 4.0 |
| 160 | 100 | 15 | Become strong |  | 4.0 | 3.0 |
| | | 30 | Become strong |  | 4.0 | 2.0 |
| | 150 | 15 | Become strong |  | 7.0 | 5.0 |
| | | 30 | Become strong |  | 6.0 | 4.0 |
| 180 | 100 | 15 | Strong |  | 4.0 | 3.0 |
| | | 30 | Strong |  | 5.0 | 2.0 |
| | 150 | 15 | Strong |  | 5.0 | 3.0 |
| | | 30 | Strong |  | 4.0 | 3.0 |
| 220 | 100 | 15 | Become strong |  | 4.0 | 2.0 |
| | | 30 | Burnt |  | 4.0 | 2.0 |
| | 150 | 15 | Become strong |  | 4.0 | 2.0 |

3.2. Descriptive Analysis

The roasting process in the coffee processing process affects the characteristics of the coffee. Variations in temperature give the characteristics of the physical properties of the roast. The temperature of 120 C has not shown the level of maturity with the aroma yet to be smelled and the weight loss is not too good. A temperature of $180^0$ C for 15 minutes with a rotation of 100 RPM shows a good level of maturity where the coffee aroma is strong and there is a significant weight loss of 60%. The temperature was set to $220^0$ C despite varying the time and spin, resulting in a completely burnt and immature coffee, a weight loss of only 50%. Temperature, time and rotation greatly affect the quality of roasting results.

## 4. CONCLUSION

The redesign of the lid and pan as well as the addition of temperature, time and roasting rotation controls affect the characteristics of the roasted coffee.

## 5. ACKNOWLEDGEMENT

Thank you to The Bali State Polytechnic Research and Community Service Center, for providing full support to the implementation of this research.

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p. 181 - 190

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# DAMAGE ANALYSIS OF FRONT FINAL DRIVE PLANETARY GEAR BACKHOE LOADER CASE 580 SN

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***Abstract.*** Today's technology continues to develop and these developments are applied to the field of heavy equipment, therefore it is necessary to analyze one of the components of the Backhoe Loader Case 580SN heavy equipment unit, namely the Front Final Drive Planetary Gear. The Backhoe Loader is one of the heavy equipment units designed to be able to carry out one of the functions and activities of the construction process which is heavy when carried out by human labor, such as: transporting, lifting, loading, moving, digging, mixing, and so on in an easy, fast, efficient and safe way. This research method analyzes and directs spaciousness, this is because this company has a lot of heavy equipment, one of which is the Backhoe Loader which is the object of research. The results of field analysis Damage to the Front Final Drive Planetary Gear Backhoe Loader Case 580 SN is caused by a lack of Final Drive lubricant when the unit is running, this is because the O-Ring Final Drive is wearing out so that the lubricant seeps out.

*Keywords : Analysis, Front Final, Loader*

## 1. INTRODUCTION

From time to time today's technology continues to develop and these developments are applied to the field of heavy equipment, therefore it is necessary to analyze one of the components of the Backhoe Loader Case 580SN heavy equipment unit, namely the Front Final Drive Planetary Gear. Backhoe Loader is one of the units. heavy equipment designed to be able to carry out one of the functions and activities of the construction process which is heavy when carried out by human power, such as: transporting, lifting, loading, moving, digging, mixing, and so on in an easy, fast, efficient and safe way. With a variety of heavy work so that this unit requires more power than speed, this unit uses a final drive called Planetary Gear. Based on the problem of damage to the Planetary Gear Front Final Drive system, it is necessary to analyze "Front Final Drive Planetary Gear Backhoe Loader Case 580 SN Damage".

In Indonesia, the term treatment itself was modified by the Ministry of Technology (now the Ministry of Trade and Industry) in April 1970 to become Terotechnology. The word terotechnology is taken from the Greek word Terein which means to care for, maintain and protect. Therotechnology is a combination of management, finance, engineering and other activities applied to physical assets to achieve economic life cycle costs. It deals with specifications and designs for reliability and maintenance of plant, machinery, equipment, buildings and structures, and their installation, testing, maintenance, modification and replacement with feedback on design, performance and cost information [1].

Maintenance engineering comes from the word Maintenance Engineering. Maintenance can be interpreted as an activity to keep things in perfect condition. Engineering can be defined as the application of scientific principles to practice in the form of design, construction and operation of structures, equipment and systems. Thus maintenance techniques can be interpreted as the application of science that aims to maintain the condition of an equipment or machine in perfect condition. So maintenance is an activity that aims to maintain the condition of the machine so that it continues to work optimally and prevent damage as early as possible by checking equipment periodically using the senses or with sophisticated tools.

### 1.1 Maintenance Engineering Strategy

According to Corder, A. S; and Kusnul, Hadi [1] The maintenance engineering strategies that are currently generally applied include:

1. Breakdown Maintenance
2. Periodic maintenance (Scheduled Maintenance)
3. Predictive Maintenance

1. Breakdown Maintenance

Breakdown Maintenance can be interpreted as a maintenance strategy by means of which the machine is operated until it breaks and then it is repaired. This strategy is very imprecise, not good, can result in high maintenance costs, loss of production due to machine shutdowns, work safety is not guaranteed, machine conditions cannot be known, and time, effort and maintenance costs cannot be planned. This technique is also known as Failure Based Maintenance or maintenance based on damage. This maintenance strategy is not suitable for machines that have a high critical level and is only suitable for simple machines and tools.

2. Periodic Maintenance

Periodic maintenance is part of preventive maintenance, namely maintenance to prevent further damage. Periodic maintenance is a maintenance strategy with the aim of preventing further damage which is carried out periodically within a certain period of time. This maintenance strategy is also known as time-based maintenance.

3. Predictive Maintenance

Predictive maintenance is also part of Preventive maintenance. This predictive maintenance can be interpreted as maintenance where the maintenance is based on the condition of the machine itself. To determine the condition of the machine, inspection or monitoring is carried out. If there are signs of damage, immediate corrective action is taken to prevent further damage. If there are no signs of damage, monitoring will continue so that if symptoms occur, they can be identified as soon as possible. Predictive maintenance is also known as condition based maintenance, also known as engine condition monitoring

### 1.2 Definition of Power Train

Power Train is a group of components that work together to transfer power from a power source or the force is produced to the place used to do work[2]. This definition may be analogous to the process of transporting goods or "Freight Train". Freight Train is a series of components of a locomotive and a car that moves cargo from where it is produced to where it is needed. The term Power Train is actually not new, it has been used since ancient times to define a component that transmits Power from one place to another. One of the units that uses the Power Train System is as shown in Figure 1.


**Figure 1**. Backhoe Loader (General Machine) [3]

### 1.3 Power Train Function

Power Train on a machine is a system and a series of components that transmit power from the Engine, from the Torque Converter to the Final Drive, to the wheels or Tracks.

The Power Train functions are:

1. Connect and disconnect power from Engine
2. Change the moving speed and torque
3. Change the direction of motion of the Machine
4. Equalize the power distributed to the drive wheels

### 1.4 Main Components of Power Train

Basically, the main components in the Power Train series of a heavy equipment consist of:

1. Engine

Serves as a source of prime mover to be forwarded to other movers.

2. Coupling/Clutch

According to Siwonto [3] Coupling/Clutch serves to connect power from the engine to the transmission. This component can also cut off the flow of power from the Engine. This allows the engine to run while the engine is idle. There are two types of couplings found in heavy equipment, namely Flywheel Clutch and Torque Converter. Flywheel Clutch is a component that connects the Engine with Transmission mechanically, this connection can be connected or disconnected according to the needs of the operator. While the Torque Converter is a component that connects the Engine with the Transmission both mechanically and hydraulically. However, there is no direct mechanical relationship between the Engine and Transmission.

3.Transmission

Function to change the power or rotation so that you get back and forth motion and change the speed according to the desired gear. The Transmission functions as:

a. Motion direction changer (forward and backward)
b. Motion speed changer (fast and slow)
c. Torque converter (big and small)

4. Gear Transfer

Transfer Gear is used to transmit power to the Differential and also to lower the rotational axis from the Torque Converter to the Transmission. Some heavy equipment, such as the Backhoe Loader, have two Differentials, namely the front and rear Differentials. The use of Transfer Gear in this case to divide the power to the front and rear Differentials. Depending on the placement position, there are two types of Transfer Gear, namely:

a. Input Transfer Gear, located between Torque Converter and Transmission
b. Transfer Gear Output, located between Transmission and Differential

5. Differential

This component serves to transmit power from Transmission to Final Drive and allows the wheels to rotate at different speeds when turning. Differential is used on the Wheel Type Machine (Machine that uses wheels) while on the Track Type Machine (Machine that uses Track) Bevel Gear is used.

6. Final Drive

The components of the Power Train System as the final mover are towards the wheels or Track. Its function is to multiply Torque/Reduce the final rotation which aims to get more power. The sequence from Power Train to Final Drive is as shown in Figure 2.

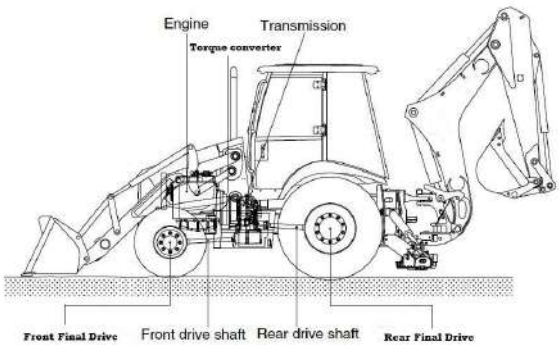


**Figure 2.** Power Train Backhoe Loader Components [4]

Backhoe Loader is a machine that uses a Drive Train Wheel Type Machine as shown above. Power Train components on this type of heavy equipment are:

a. Impeller Clutch Torque Converter
b. Gear Transfer Input
c. Transmission
d. Gear Transfer Output
e. Rear differential (not shown)
f. Rear Drive Shaft
g. Rear Final Drive
h. Front differential (not visible)
i. Front Drive Shaft
j. Front Final Drive

**1.5 Planetary Gear System Transmission**

The Planetary Gear system consists of three elements, namely: Sun Gear, Planet and Ring Gear. Sun Gear is located in the center of the Planetary Gear arrangement as a rotating shaft, then this Sun Gear is linked to the Planetary Gear, Planetary Gear can be three, four, and five pieces arranged on a frame called a Carrier. The Planet Gear rotates around the Sun Gear's central axis and is encircled by the Ring Gear. The Gear Ring acts like a fastener that holds the entire Gear Set in place. Most of the use of Planetary Gear is in the Transmission System which is used to change the direction of rotation so that it allows the unit to move forward or backward. There are two kinds of Planetary Gear, namely Planetary Single Pinion and Planetary Double Pinion.

1. Planetary Gear Single Pinion
   How it works when the Ring Gear is held down, the Planet Gear will rotate in the opposite direction to the Sun Gear and the Planet Gear will rotate around the Ring Gear. This is one of the applications on Planetary Gear Transmission to get a forward motion position by holding the Ring Gear, if as input the Sun Gear rotates to the right and as the output Planet Gear, the Planet Gear will rotate to the left around the Ring Gear. The Planetary Gear Single Pinion Type can be seen in Figure 3.

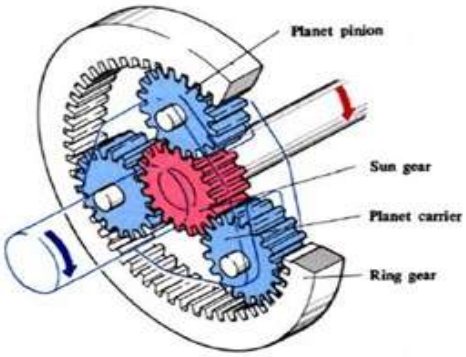


**Figure 3**. Planetary Gear Single Pinion Type [5]

2. Planetary Gear Dual Pinion Type
   In this system, if the Ring Gear is detained, the Carrier will fight with Sun Gea (Taufik, 2022). Applications of the Planetary Gear System as used for reverse motion (Reverse). That is Sun Gear as input rotation rotates to the right, Carrier as output will rotate to the left if the Ring Gear is held down. The Planetary Gear Dual Pinion Type can be seen in Figure 4.

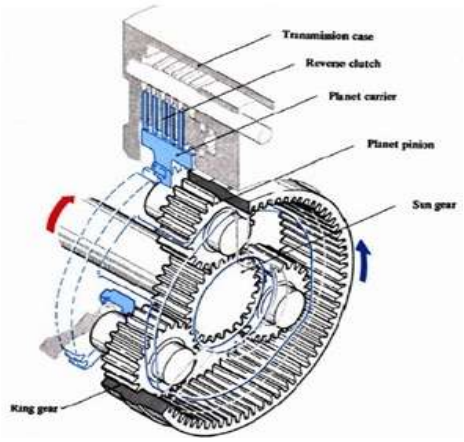


**Figure 4.** Planetary Gear Dual Pinion Type [5]

**1.6 Planetary Gear System Final Drive**

In the form of a set of straight gears and or a set of Planetary Gears as the final drive gear that serves to reduce rotation and increase torque on heavy equipment, such as Backhoe Loaders, Bulldozers, Dump Trucks, Wheel Loaders, and others. other. Final Drive has 2 parts, namely Front Final Drive and Rear Final Drive. The working

principle of Planetary Gear Final Drive is the same as the working principle of Planetary Gear on the transmission, where there is a reduction in rotational speed and an increase in torque by utilizing the difference in the number of teeth on the gear. The Planetary Gear Final Drive consists of three main components, namely Sun Gear, Planetary Gear and Ring Gear, of the three main components it is used to reduce rotation so that the final torque rotation becomes greater.

## 2. METHODS

This research method analyzes and directs spaciousness and interviews with mechanics, this is because this company has a lot of heavy equipment, one of which is the Backhoe Loader which is the object of research. The tools and materials used are as follows:

### 2.1 Tools

The tools used when conducting this research are as follows:

a. Shock Lock
b. Crocodile jack
c. Tire support
d. L key
e. Hammer
f. Snap pliers

### 2.2 Material

The materials used in this activity are as follows:

a. Planet Gear (3pcs)
b. Gasket Glue
c. O – Ring
d. SAE 140 (1 Liter) Oil
e. 1 unit Backhoe Loader

The materials used in the repair of the Planetary Gear Front Final Drive in this final project are as shown in Figure 5.

Planet Gear (3pcs)


Gasket Glue

O – Ring


Backhoe Loader

**Figure 5.** Materials used

### 2.3. Final Drive Planetary Gear Backhoe Loader Case 580 SN

The Backhoe Loader Case 580 SN unit uses Final Drive Planetary Gear both the front and rear wheels. Planetary Gear on the Backhoe Backhoe Loader Case 580 SN uses the Single Pinion type. The way it works is that the rotation that goes to the Final Drive is reduced (minimized) by the main Gear in it such as: Sun Gear, Planetary Gear, Ring Gear. So that the end result of the output rotation becomes smaller and the torque becomes

larger. On Final Drive 580 SN Sun Gear functions as input, then Planet Gear as an intermediary which is then forwarded to Ring Gear as output. The components of the Planetary Gear Single Pinion Final Drive consist of three main components as shown in Fig. 6 and Fig.7.


**Figure 6.** Sun Gear and Ring Gear

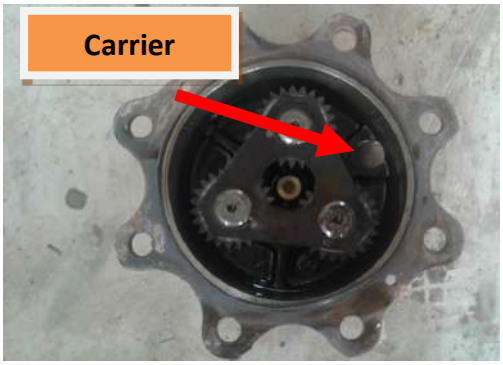


**Figure 7**. Planet Gear and Carrier

## 4. RESULTS AND DISCUSSION

### 4.1 How Front Final Drive Planetary Gears Work

In the Front Final Drive Planetary Gear Backhoe Loader Case 580 SN using the Single Pinion Planetary Gear type, the way it works is that the rotation that goes into the Final Drive is reduced (minimized) by the main gear inside, such as: Sun Gear, Planetary Gear, Ring Gear. So that the end result of the output rotation becomes smaller and the torque becomes larger. In Final Drive Backhoe Loader 580 SN Sun Gear functions as input, then Planet Gear as an intermediary which is then forwarded to Ring Gear as output. The components on the Planetary Gear Single Pinion Final Drive consist of three main components as shown in Figure 8.

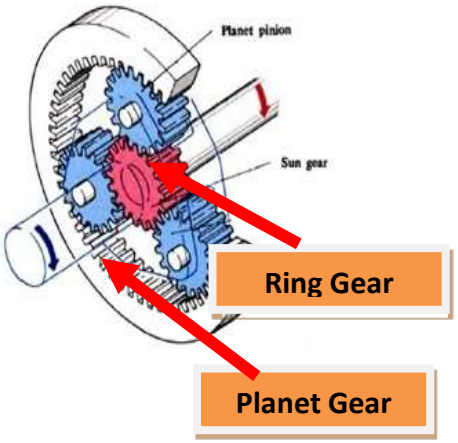


**Figure 8**. Planetary Gear Final Drive Components [5]

**4.2 Identification of Damage**

The damage that often occurs to the Planetary GearBackhoe Loader Case 580 SN component is that the teeth are damaged or fall out, this damage occurs due to a lack of maintenance carried out by the operator, namely not checking and maintaining the lubrication conditions in the Planetary Gear system such as checking for possible shortages in the amount of lubricant. [6][7]. Or the O-Ring on the Final Drive is damaged so that the lubricating oil becomes drastically reduced which results in the Planetary Gear components experiencing direct friction without getting lubrication. If not addressed immediately, this will cause more fatal damage, namely the teeth on the Front Final Drive Planetary Gear components will fall out and can even break so that it will greatly disturb the unit while operating, such as a loud noise when the unit is running or even the wheels on the damaged part. does not move at all if any of the Planetary Gear components are broken,[8] especially on Planetary Gear which often happens. To prevent damage to the Final Drive Planetary Gear, especially the Backhoe Loader Case 580 SN, the operator must carry out daily checks on the components of the unit being operated, one of which is the Final Drive Planetary Gear for possible damage to the O-Ring on the Final Drive which causes oil to seep out. so that the amount of oil in the Final Drive Planetary Gear is drastically reduced, in addition to doing regular maintenance by changing the Final Drive oil every 1000 working hours.[9].

**4.3 Damage Analysis**

After making repairs, the next step is to analyze the irregularities or damage that occurred in the Front Final Drive Planetary Gear Backhoe Loader 580 SN.

1. O-Ring Damaged

   Before making repairs, the first thing to do is to check for visual disturbances such as using sight or hearing. When the unit is running, there is a loud noise on the right front wheel which means there has been a disturbance in the Final Drive Planetary Gear, then an immediate inspection is carried out to see oil seeping out through the Final Drive Casing. after that, when the lubricant has been drained, the next step is to disassemble the Final Drive Planetary Gear components. At the time of disassembly it was seen that the O-Ring was damaged which resulted in Final Drive oil seeping out, the O-Ring damage was caused by dirt stuck to the Final Drive Casing while the unit was operating [10]. The damaged O-Ring can be seen in Figure 9. .

**Figure 9.** O-Ring Broken

2. Bram Mixed Lubricants

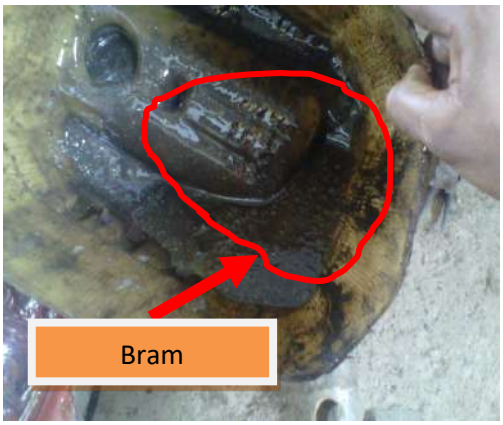


**Figure 10.** Oil already mixed with Brama

After draining the Planetary Gear Final Drive oil, there are a lot of brakes that have been mixed with oil, the brakes that have mixed with the Planetary Gear oil are due to direct friction on the Planetary Gear components when operating but experiencing a lack of lubricant caused by the O-Ring Final The drive is

damaged so the lubricant is seen seeping out during the previous inspection. The negligence of the operator who does not carry out routine daily checks on the operated unit, causes damage to the components of the Front Final Drive Planetary Gear which continue to operate when the unit is running [11][12][13]. The oil that has been mixed with bram can be seen in Figure 10.

3. The teeth on the planet gear are damaged

After disassembling the Planetary Gear and when doing an inspection, it turned out that the Planetary Gear was damaged where part of the teeth fell out. The damaged Planet Gear on the Backhoe Loader Case 580 SN causes a loud noise on the Front Final Drive when the unit is running, if in the long term no repairs are made it will cause the Planet Gear to break so the wheels cannot move when the unit is running [14]. This can also cause damage to other parts, especially the Sun Gear and Ring Gear which continue to experience friction with Planet Gear while operating. Damage that occurs to the Planetary Gear is caused by a lack of lubricant when the Planetary Gear components operate and excessive loads when the unit transports or pushes materials [15]. The Planet Gear that has experienced loss can be seen in Figure 4.7 below.

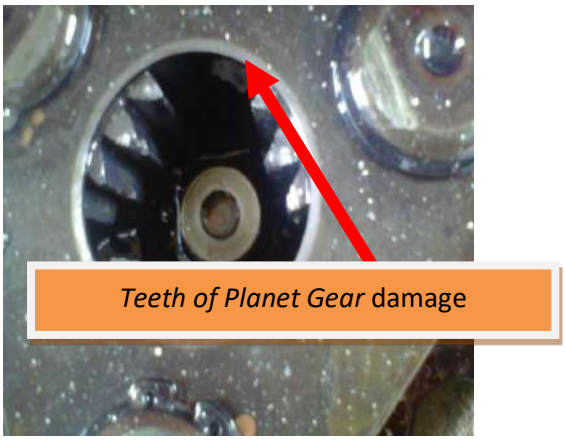


**Figure 11.** Planet Gear Broken

Based on the results of these inspections, where the Planetary Gear's teeth were damaged/lost severe enough so that the rotation of the Sun Gear could not be continued perfectly to move the Ring Gear which resulted in a noisy sound on the Planetary Gear's Front [15][16].Final Drive when the unit was running. Therefore, to overcome the damage that occurs, the Planetary Gear must be replaced with a new one when carrying out the process of reinstalling the Planetary Gear Front Final Drive components, unless the damage / loss that occurs is not too severe then if you just want to eliminate the noise on the Final Drive, simply replace the lubricant. use Grease / grease [17][18][19]. Replacement components are carried out so that the Planetary Gear can function optimally when continuing to rotate from the axle to drive the wheels, in addition to the damaged O-Ring Final Drive must also be replaced or given gasket glue to prevent similar damage where Planetary Gear lubricating oil seeps out of the Final. drives.[20].

## 5. CONCLUSION

From the research results obtained, for that there are several things that can be concluded, namely as follows:

1. To prevent premature damage, a daily inspection program (P2H) and periodic maintenance on the Front Final Drive Planetary Gear must be carried out, namely checking the condition of the Final Drive Planetary Gear components and changing the lubricating oil every 1000 working hours and carrying out daily inspections on the units operated in particular. on the Front Final Drive to prevent unforeseen damage.
2. If the Front Final Drive Planetary Gear component is damaged, it must be immediately replaced with a new one, if left unchecked this will cause noise and the wheels cannot move if any of the Planetary Gear components are broken so that it interferes with the operator while working.
3. Damage to the Front Final Drive Planetary Gear Backhoe Loader Case 580 SN is caused by a lack of Final Drive lubricant when the unit is running, this is because the O-Ring Final Drive is worn so that the lubricant seeps out. As a result, the Planetary Gear components experience high wear and friction so that the Planetary Gear is damaged/falls out which causes noise on the Front Final Drive when the unit is run.

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LOGIC
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p.190 - 200

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# FIELD EXPERIMENTATION ON WALL SURFACE TEMPERATURE WITH FABA BRICK IN HOT CONDITIONS

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***Abstract.*** The processing of coal waste into building materials from *fly ash bottom ash* has been stipulated in Regulation number 22 of 2021 as Non-Hazardous material, with a note that the management requirements must still meet the standards and technical requirements set out and listed in the environmental document approval. Previous studiesstated that one of the physical characteristics of the use of this waste (*fly ash bottom ash*) can be in improving the quality of construction materials and environmental quality. The research questions of this study are: Does the facing east orientation quantitatively receiving more heat of the morning sun than other orientations? Does FABA brick walls affect the indoor thermal performance? The wall surface temperature measurement is carried out by the field experimentation with extreme climatic conditions, both sunny and rainy weather in 2021. The results of this study found that the surface temperature profile of the brick wall oriented to the east in sunny rainy/cold weather is cooler 2 % compared to the temperature on the western side. The wall surface temperature profile in the morning is 25% warmer than the ambient air temperature in sunny weather and 9% cooler in rainy weather. wall material with FABA brick proves that the orientation, location and character of the microclimate are significant to the thermal value.

*Keywords : fly ash and bottom ash bricks, wall surface temperature, field research*

## 1. INTRODUCTION

Coal waste material composed of *Fly Ash Bottom Ash* (FABA) is classified as hazardous waste, but after special handling, the Government finally made Regulation Number 22 of 2021 (Organization of Environmental Protection and Management), that *fly ash bottom ash* is now included in Non-Hazardous Waste [1]. As a study of Ageng et al [2], informed that the use *fly ash bottom ash* in several other countries with very supportive regulations, finally obtained a condition of achievement of using fly ash bottom ash up to 97%. It is said that the use of *Fly Ash* has been successfully used in the construction industry since more than 50 years but so far its application is still limited due to the lack of understanding about the characteristics of *Fly Ash* itself and the properties of concrete containing *Fly Ash*.

In its development, the by-product of coal combustion or the amount of *fly ash bottom ash* (FABA) is quite large. According to Antoni [3], the quality of *fly ash* depends on the source of power generation. For new ash sources, it is better than old or accumulated ash sources. Rapid utilization of this waste can be said to have a smaller environmental impact in ecosystem..

Products from the combustion of every one tonne of coal carried out by steam-electric power station produce around 15% - 17% *fly ash bottom ash*, as stated by the Ministry of Environment and Forestry of the Republic of Indonesia (KLHK). The physical character of *Fly Ash* is a fine powder with pozzolanic properties. This property is in the form of a material that has a low Calcium Oxide content, so it does not have a binding ability [4]. *Fly ash bottom ash* from a steam-electric power station activity is categorized as non-hazardous waste, but the management requirements must still meet the standards and technical requirements set out and

listed in the environmental document approval. As for *Bottom Ash* , it has a larger size than *Fly Ash*, which makes it easier for *Bottom Ash* to fall to the bottom of the furnace. Bottom Ash is shaped like river sand but with a coarser texture. On the basis of these characteristics, it is the background to study the position of replacing clay by this material in the manufacture of bricks [5].

Nurul et al., [6] took a closer look at the effect of using building materials made with *fly ash bottom ash* on their environmental effects. The characteristics of the chemical elements in *fly ash bottom ash* which are strongly bonded to cement (made into a concrete mixture), it turns out that it is difficult to wash or leached, especially when this material is used for outer walls and is exposed to the sun's heat, it is confirmed that it does not cause problems to the environment.

And the progress of utilizing *fly ash bottom ash* in the world of building construction, by Maja et al [7], it is said that the use *fly ash bottom ash* is very safe for construction materials and adhesives in building materials. According to Tiwai [8], Fly Ash is also suitable for use as a raw material in various industries because it is a material rich in oxides. And it was emphasized again by Norhaliza [9] [10], that fly ash bottom ash can not only be used as a main ingredient or mixed material in building construction, but can also be used in brick making, ceramics, road construction, concrete production and construction. other activities. Several alternative types of *fly ash bottom ash* have been developed by the Paiton steam-electric power station.

Listening to the notes from Fauzi et al [11] that *Fly Ash* in the construction industry is not a new technology but is a developing technology in improving construction quality and environmental quality. The addition *Fly Ash* to concrete provides economic, ecological and technical benefits. Concrete that has been mixed *with Fly Ash* which was tested in extreme cold weather has elasticity or resistance of 78 – 91 out of a scale of 100, because it has a relatively low dynamic elasticity so that it has better durability [12]. Meanwhile, bricks with a mixture of *fly ash bottom ash* have better water absorption of 0.3 - 6.1% compared to bricks without a mixture of *fly ash bottom ash* and have fire resistance of up to 30% [13].

From the previous studies [2, 3, 10, 15] and results of our previous preliminary study [14] showed that building materials with *fly ash bottom ash* have so far been categorized as environmentally friendly materials. As stated in the background that the status of fly ash bottom ash in particular and as a building material has been confirmed by Government regulations. In the application of building design with an approach to the concept of Green or Environmentally Friendly Building, it is stated that one of the parameters is the aspect of recycling waste materials and the thermal/temperature effect of using the material in order to create a comfortable and safe interior environment/ambience [16,17,18]. Thus, many studies related to concrete using waste materials have been carried out [19,20]. In the world of architecture/building design, as stated by Prianto in 2007, that tropical buildings that accommodate local materials/local wisdom are a form of concern for the realm of engineering in the issue of global warming [21]. So the question in the research that we will examine is "How far is the thermal character of the wall material in the form of fly ash bottom ash in the extreme conditions of the microclimate in the field directly? and how far is the difference in the orientation of the placement of the wall material to its thermal value?". And in this study, we have obtained brick material made from this coal waste, which has so far been developed by the Paiton steam-electric power station.

## 2. METHODS

This section explain the object of research, what tools are used for research and also the stages of the process of measuring the object of research.

### 2.1 Research Object

First, brick wall *material fly ash bottom ash* that has been processed/printed with certain dimensions (40x20x10cm) at the Java-Bali Steam Power Plant (steam-electric power station) Paiton, Probolinggo, East Java (see figure 1).brick units *fly ash bottom ash* are arranged into a wall with a size of 1.00m x 1.00m x 0.1m. Due to the implementation of this further research being constrained by the progress and in the era of the COVID-19 pandemic, the implementation was carried out in the area closest to the researcher on St. Akper, Bangkinang City District, Kampar Regency, Riau City (0°17'11.3" North Latitude 101°01 '44.0" East Longitude). Third, the object that has been formed into a block of brick wall is placed in an area/field that is free from obstructions, with the intention that the object can be exposed to sunlight from morning to evening optimally. (see figure 2).

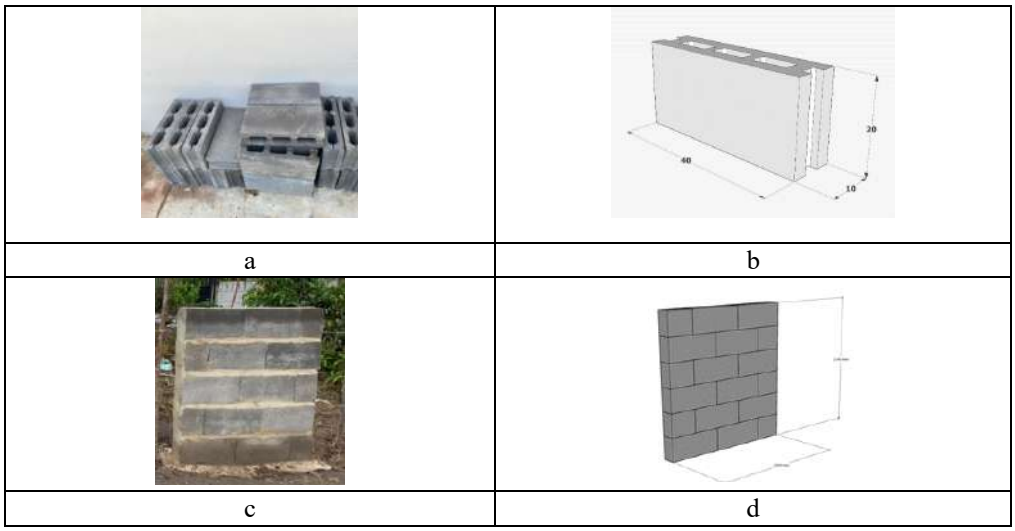



Figure 1. (a,b) Object and unit dimension sketches of *fly ash bottom ash* bricks and (c, d) Illustration of *fly ash bottom ash*

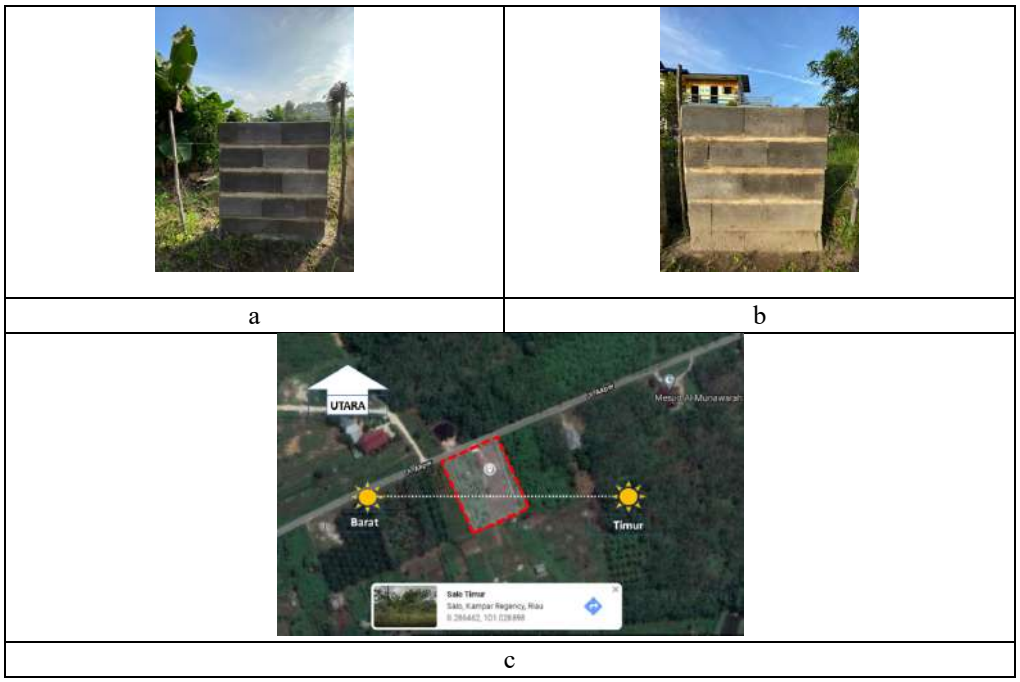
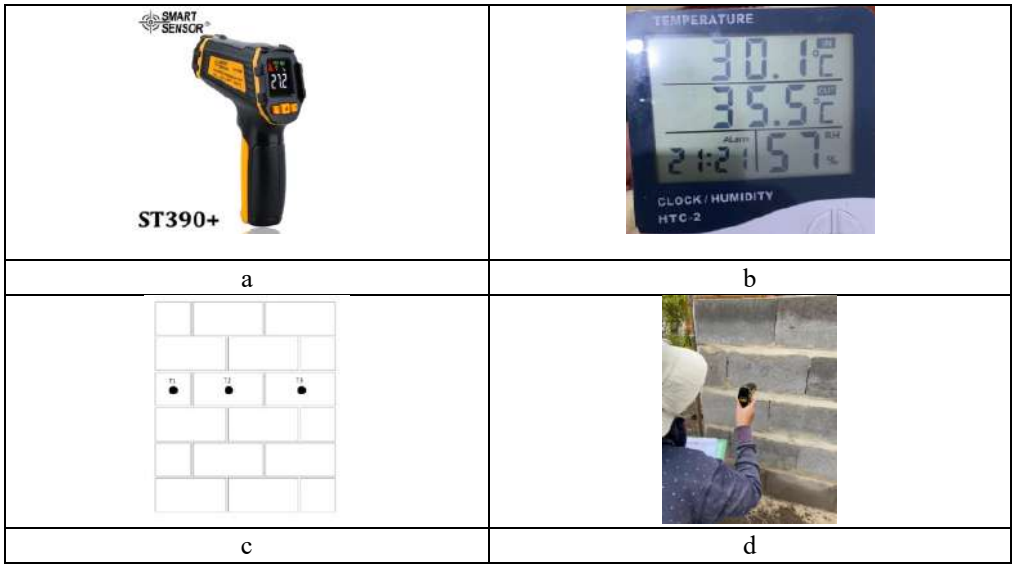



Figure 2. Visualization of objects facing east (b) Visualization of the object facing west (c) Situation of the research location in the city of Riau

**2.2 Measurement Tools**

There are two principal measuring instruments used in this observation, namely the Infrared Thermometer S7391 measuring instrument used to measure the wall surface temperature. And a digital thermometer is used to determine the air temperature and humidity of the environment around the test object.




a b

c d

Figure 3. (a, b) Measuring tools used and (c, d) Position of measuring points

**2.3 Stages of Measurement**

First, After the block units are arranged into a wall area measuring 1.00m x 1.00m, which is composed of 5 layers with 2.5 bricks for each layer, and their position is facing the exact East-West orientation (front side and back side of the wall), then a sample of 3 (three) measuring point positions is determined, both at the front of the wall and 3 measuring point positions at the back.

Second, at each measuring point, manual infrared shots were fired 3 times with a duration ranging from 10-15 seconds/shot and taken at 60 minute intervals from 06.00am to 18.00pm.

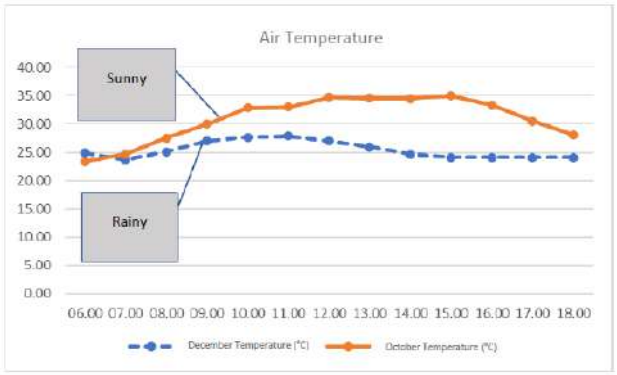
Third, three measurement data (wall surface temperature, ambient air temperature and humidity) were obtained in two extreme conditions (hot weather and rainy weather). Hot weather was presented on the measurement on October 13, 2021 and rainy weather was presented on December 13, 2021.

Fourth, after all the measurement results were tabulated, this data was then analyzed partially (each time period) and compared the two conditions so that it was obtained answer to this researcher's question.

## 3. RESULTS AND DISCUSSION

The scope of this research is limited to the microclimate of a location, because as we all know that this parameter has a very significant effect on the value of the results of field measurements (in-situ). Likewise with differences in location characters (object placement based on cardinal orientations) and the choice of measurement method that is carried out directly in the field, from various related studies so far it will be obtained the diversity and dynamics of the measurement results, so the choice of this method is very wide open for development. That's the method we chose to enrich our knowledge base in general and in particular related to material exploration from fly ash bottom ash in general or in particular to fly ash bottom ash bricks from the Paiton steam-electric power station production.

Hot weather conditions in the city of Riau in this case are represented by in-situ (field) measurements in October 2021, while cold/rainy weather conditions are represented by measurements in December 2021 this year. The pattern of this discussion is divided into two parts. The first part is related to the relationship between the microclimate profile of the city of Riau with the microclimate from around the location. And the second part is a specific discussion of the wall surface temperature profile of *fly ash bottom ash*.

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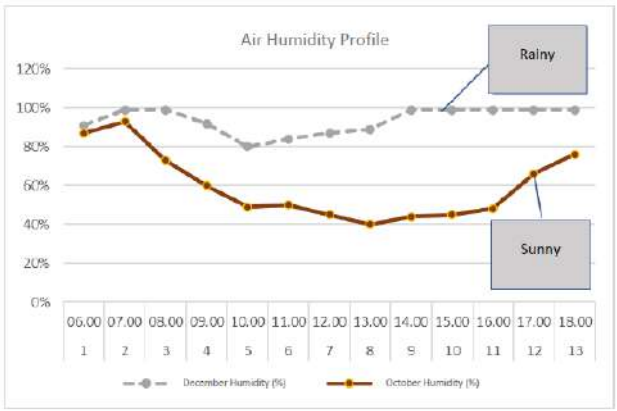



b

Figure 4. (a) Microclimate at the test site location in Riau city (b) Humidity profile

### 3.1 Measurements on sunny weather in October

1) Profile of air temperature and humidity in Riau city and microclimate of the measurement location.

The initial description related to the microclimate, we can convey first, that the difference in the average air temperature of Bangkinang District, Riau City according to Meteorological data (during October 2021, ranging from 23°C to 31°C [22], there are measurement data around the location there is no significant difference. The same thing happened to the profile of the data measuring the humidity of the air. The weather conditions in the measurements taken on October 13, we can assume the weather conditions are sunny or hot.

2) The wall surface temperature profile is between orientation to the east and West.

Based on the results of measurements of the surface temperature of the brick wall facing east, it has an average surface temperature of 40.2 °C, or a maximum temperature of around 47.6 °C which occurs at 10.00am and a minimum surface temperature of 20.2 °C. which happened at 06.00am. While the surface temperature profile of the brick wall facing west, has an average surface temperature of 37.6°C, or a maximum temperature condition of about 51.6°C which occurs at 15.00pm and a minimum surface temperature of 20.1°C which occurs at 06.00am (see figure 5). This graph also shows a condition of the average difference of the wall profiles in different directions, where there is a difference of 2.56°C or 2.8% cooler back wall/orientation to the west.

3) Wall surface temperature profile between morning session and afternoon session.

The graph in Figure 6 shows more detail regarding the temperature profile of the wall surface based on two different observation times, namely observations in the morning time range (06.00am-12.00pm) and afternoon time range (12.00pm-18.00pm). Where, both in the morning and during the day, the position of the wall surface temperature is above the average exterior air temperature / ambient air temperature.

a) Study of wall surface temperature in the morning against ambient air

The average temperature of the front wall surface in the morning has a difference of 25% (from 29.46°C to 39.49°C) hotter than the ambient air temperature . And the average back temperature is only 7% (from 29.46°C to 31.7°C). While the difference in temperature between the front and rear wall surfaces, has a difference of 25% hotter for the front.

b) Study of wall surface temperature during the day against ambient air temperature.

Meanwhile, during the day, the average front wall surface temperature has a difference of 20% (from 32.97°C to 41.43°C) hotter than the air temperature. environment. And the average temperature of the back reaches 26% (from 32.97°C to 44.33°C). While the difference in temperature between the surface of the wall, has a difference of 7% hotter for the back.

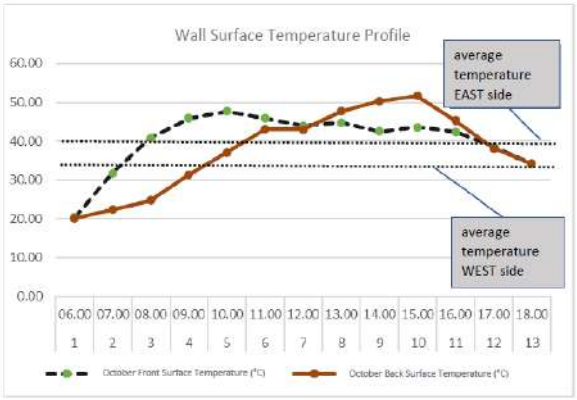
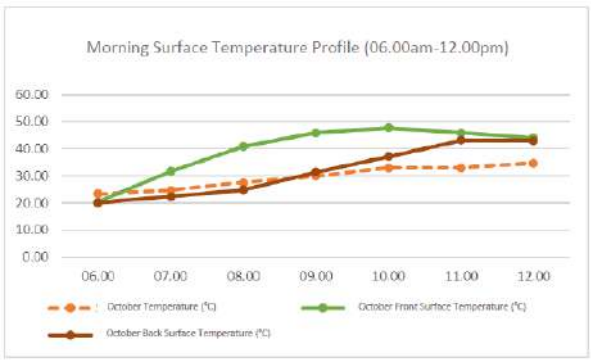



Figure 5. Surface temperature profile of *fly ash bottom ash* in a sunny atmosphere (October 2021)

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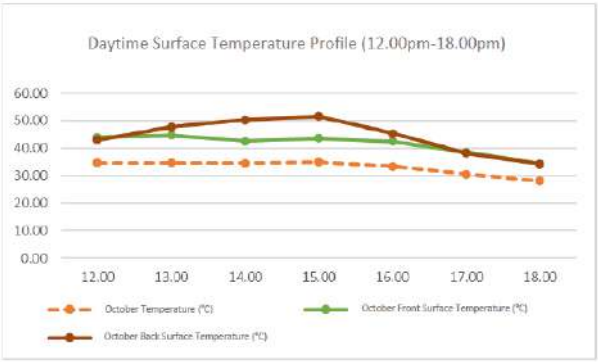


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Figure 6. Surface temperature profile of fly ash bottom ash in sunny conditions (a) measurements in the morning (06.00am-12.00pm), (b) measurements during the day (12.00pm-18.00pm)

### 3.2 Measurements on rainy weather in December

1) Profiles of air temperature and humidity in the city of Riau and the microclimate of the measurement location.

From the Meteorological data on the weatherspark page, it was noted that in December, the air temperature ranged from 23°C to 30°C which was not much different from the data in December [21].

2) Wall surface temperature profile between orientation to East and West.

Brick wall fly ash bottom ash in rainy/wet conditions, the results of measuring the surface temperature of the bricks facing east/forward were still measured, where the average surface temperature was 23.7°C, and conditions the maximum temperature reached 27.7°C which occurred at 10.00am, and the minimum average surface temperature of 20.1°C which occurred at 06.00am. While the surface temperature profile of the brick wall facing west, has an average surface temperature of 24.2°C, or a maximum temperature condition of about 28.7 °C which occurs at 10.00am and a minimum surface temperature of 20.7 °C which occurs at 06.00am (see figure 7). This graph also shows the condition of the average difference of the wall profiles in different directions, where there is a difference of 0.49°C or 2% colder the wall on the front/east direction. This is inversely proportional to the same conditions in the October measurement.

3) Wall surface temperature profile between morning session and afternoon session.

The graph in Figure 08 shows the wall surface temperature profile based on two different observation times, namely observations in the morning time range (06.00am-12.00pm) and afternoon time range (12.00pm-18.00pm) as was done in the data study in October. However, the graph also shows the opposite condition compared to the general conditions in the measurements in October, that both in the morning and afternoon conditions, the position of the wall surface temperature is below the average exterior air temperature / ambient air temperature.

a) Study of wall surface temperature in the morning against ambient air

The average front/eastern wall surface temperature is 9% different (from 26.19°C to 23.93°C) cooler than the ambient air temperature. And the average temperature of the back is only 6% (from 26.19 °C to 24.73 °C). While the difference in temperature between the surface of the wall between the front and back, has a difference of 3% hotter for the front.

b) Study of wall surface temperature during the day against ambient air

Meanwhile, the average front wall surface temperature has a difference of 5% (from 24.87°C to 23.72°C) which is cooler than the ambient air temperature. And the average temperature of the back is only 4% (from 24.87°C to 23.98°C). Meanwhile, the difference in temperature between the front and rear wall surfaces, has a difference of 1% hotter for the back.

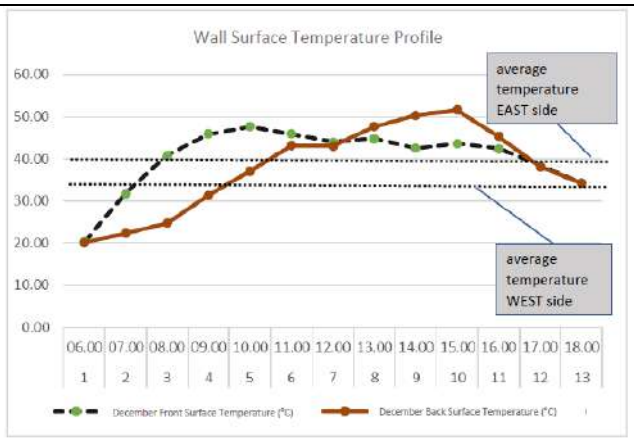
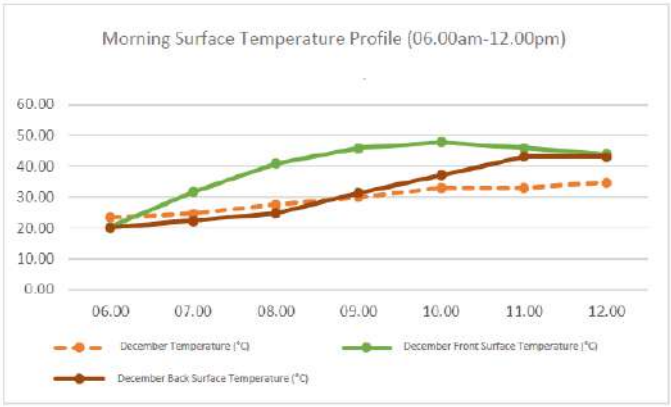



Figure 7. Surface temperature profile of *fly ash bottom ash* in rainy conditions (December 2021)

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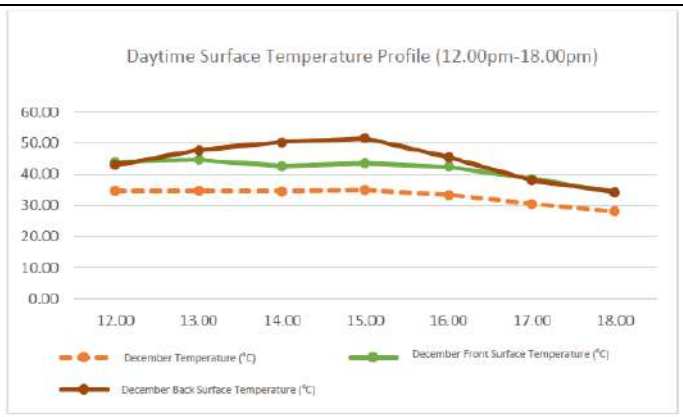


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Figure 8. Surface temperature profile of *fly ash bottom ash* in rainy conditions (a) measurement in the morning (06.00am-12.00pm), (b) measurements during the day (12.00pm-18.00pm)

### 3.3 Characteristics of Comparison of Profiles of Average Surface Temperature of ash bottom ash between Two Different Weathers.

In this section, we will compare the two surface temperature profiles of *fly ash bottom ash* between observations of hot/sunny conditions and cold/rainy conditions. We can see this in Figure 9 below.

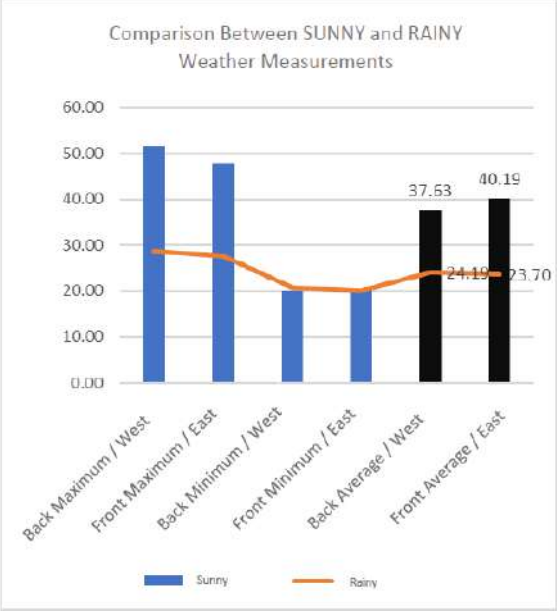


Figure 9. Comparison of measurements between sunny and rainy conditions

First, the maximum temperature comparison profile of the *fly ash bottom ash* brick wall on the Back / West in sunny atmosphere is much higher / hot than in rainy atmosphere, which has a difference of 79.5% hotter. Second, the comparison profile for the front wall, although it only has a difference of 72.1%. But the minimum temperature comparison profile of this brick wall on the Back / West and front / East in the SUNNY atmosphere is slightly lower than in the RAINY atmosphere, that is. It has a difference of 3.3% and 1%. And Third, Comparison of average surface temperatures, the graph shows that the value of the surface temperature of the wall in SUNNY weather has a higher position / heat than rainy weather by 55.6% for the West and 69.6% for the East.

Diagramanicly the value of the amount of surface temperature of the brick wall *fly ash bottom ash* in two different weather conditions can be seen in the following table. Where in his understanding that the positive value (+) in table 01 reads a condition of the situation becomes colder and vice versa for the value (-).

Table 1. Nilai Presentase Perbedaan Selisih dari Kondisi Pengukuran Pada Cuaca Cerah ke Cuaca Hujan

| | Temperature (°C) | Humidity (%) | Front Facade Temperature(°C) | Back Facade Temperature(°C) |
|---|---|---|---|---|
| Maximum Difference | 20.3% | -6.5% | 41.9% | 44.3% |
| Minimun Difference | -1.3% | -100.0% | 1.0% | -3.4% |
| Average Difference | 17.9% | -56.7% | 41.0% | 35,7% |

## 4. CONCLUSION

### 4.1 Conclusion

Based on the results of research and data analysis that has been implemented, it can be concluded some points as follows:

**A) Some notes from measurements in sunny air (lots of sunlight)**

The average surface temperature profile of east-oriented walls is 2.8% warmer than west-oriented walls. The average surface temperature profile in the morning session for the front/east is 25% warmer than the ambient air temperature. And for the wall on the back is only 7%. While the difference between the surface temperature of the front and rear walls is a difference of 25% hotter for the front. The average surface temperature profile during the daytime session for the front/east is 20% hotter than the ambient air temperature. And for the wall on the back it reaches 26%. While the difference between the surface temperature of the front and rear walls is 7% hotter for the back.

**B) The following is a note from measurements on rainy air (lots of rainfall)**

The average profile of the surface temperature of the east-oriented walls is 2% cooler than the west-oriented walls. The average surface temperature profile in the morning session for the front/east is 9% cooler than the ambient air temperature. And for the wall on the back is only 6%. While the difference between the surface temperature of the front and rear walls is a difference of 3% hotter for the front. The average surface temperature profile during the daytime session for the front/east is 5% cooler than the ambient air temperature. And for the wall on the back reaches 4%. While the difference between the surface temperature of the front and rear walls is 1% hotter for the back.

The characteristics of the wall surface temperature comparison between measurements in sunny conditions have a higher/hot position than measurements in rainy weather, namely there is a difference of 55.6% for the West and 69.6% for the East. From the study above, in response to the results of Nurul's study [3], that the character of this fly ash bottom ash will reduce its environmental impact when it is optimally positioned in the sun, and from our measurement results, where the object is measured at different weather conditions ( rainy days and hot days) and different orientations (orientation to the east and west), finally we can recommend that the use of dominating fly ash bottom ash (eg for the main faade of buildings) should be positioned towards the EAST for a hot area location (eg. for buildings in coastal cities). And vice versa, positioned towards the WEST for cold areas (eg buildings in mountainous areas).

### 4.2 Suggestion

Based on the conclusion,the suggestion or recommendation from this research is as follows:

1. First, a direct measurement result in the field so that it can represent the humid tropics, with the case in Riau City, it should be equipped with a measurement time that represents summer conditions (range from June to August, generally has an average air temperature range between 24°C to 34°C) and rainy season conditions (range from December to February, generally have an average air temperature range between 23°C). C to 31°C).
2. Second, optimization of the value of measuring the surface temperature of the fly ash bottom ash brick wall, and also measured on the diversity of wall orientation according to the direction of the wind. When in this case, it is carried out on the orianation facing East and West, with the result that the hottest value is obtained in the orientation to the East, both in the hot musin (October measurement) and the rainy season (December measurement), what about the direction of orientation of other buildings? For this reason, one of the research object facilities in the form of a model house developed in the Technic Faculty Building Technology laboratory of Diponegoro University, the building is placed on a rotary rail.
3. Third, for the closer benefit of the needs of the broad community reel (not just academic study / theoretical development), then it would be nice for the measurement results to be compared also with the position of the object covered by the roof, even if possible an object with a scale of 1: 1.

## 5. ACKNOWLEDGEMENT

Researchers would like to thank the parties from steam-electric power station Paiton, Probolinggo, East Java who have allowed and provided samples of fly ash bottom ash to be used as objects in this study.

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LOGIC
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p. 201 - 207

p-ISSN : 1412-114X
e-ISSN : 2580-5649
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# THE IMPLEMENTATION OF 5S WORK CULTURE (*SEIRI, SEITON, SEISO, SEIKETSU* AND *SHITSUKE*) AT KHANSA OTO CARE

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***Abstract.*** Khansa Oto Care is a service provider to pamper vehicles with its services, namely car wash, nitrogen filling, oil and air filter change service, and accessories sale to make vehicles interiors comfortable. The work environment has not implemented the 5S system such as unused items are present in the work environment (*Seiri*), items have no storing place (*Seiton*), there is a lot of oil and plastic waste (*Seiso*), lack of caring for work equipment (*Seiketsu*), and the lack of the workers discipline in implementing the work culture (*Shitsuke*). The purposes of this research were to implement the 5S Work Culture and to find out its effect on the workers activities after the implementation. The approach taken was by observation, distributing questionnaires using the Likert scale method, interviews, and documentation of the 5S implementation. Based on the implementation of the 5S Work Culture, it provided comfort and flexibility for the workers in carrying out their work (*Seiri*), it eased the workers to find the work items (*Seiton*), it provided comfort for the workers in doing their work (*Seiso*), it made the work equipment always in an optimal condition and reduced the risk of machine damage, thus, it could minimize the equipment damage cost (*Seiketsu*), and as an implementation form of commitment of the owner and the work (*Shitsuke*). Based on the program score, the score before the 5S implementation was 34.3% which was in the category of bad. After the implementation, it showed the score of 92.5% which was in the category of very good. It means that all of the workers recognized that the 5S Work Culture had a good impact on the work environment.

*Keywords :* work culture, 5S, likert scale

## 1. INTRODUCTION

Technological development gives birth to the change of motorized vehicles from time to time, the examples are cars and motorcycles. Cars and motorcycles are vehicles that are commonly used as a means of daily transportation by individuals and companies. Every day, other than as a means of personal transportation, motorized vehicles are also used for public transportation. The growth of motorized vehicles is increasing rapidly and continuously each year [1]. Each vehicle has different specifications, in terms of engines, features, security systems, and others.

The thing that needs to be considered on a motorized vehicle is to maintain it periodically with various degrees of difficulty. A short-term or routine maintenance can be done alone such as cleaning or washing, controlling brakes, checking fuel adequacy, lights and others. In addition to the routine maintenance, it is necessary to change the oil and air filter regularly, wash the parts that are difficult to clean by our self and check the air pressure. Extra care is needed when the vehicle owner starts to feel uncomfortable with the condition of his/her vehicle. It can be done by visiting the vehicle salon services. Cars need to be maintained and serviced regularly and periodically so that they will always be in a top condition and ready to be used by the owners at any time [2]. In addition to having the advantages of making a dull vehicle shiny, it can also make the vehicle interior clean in detail and smells good so it will be very comfortable when it is being used.

Khansa Oto Care is a service provider to pamper vehicles with its services, namely car wash, nitrogen filling, oil and air filter change service, and also accessories sale to make vehicle interiors comfortable. To ensure

this, Khansa Oto Care applies a clean culture, equipment has its own place, the floor is clean from oil spill, and the workers are committed to maintain it which are in accordance with the 5S goals (*Seiri, Seito, Seiso, Seiketsu,*and *Sheitsuke*) to maintain safety, comfort, cleanliness and a conducive environment [3]. The business which is carried out by Khansa Oto Care is a service business that requires fast time and satisfactory results to win the hearts of customers through quality service.

The problems faced by Khansa Oto Care are related to services that are not optimal to consumers due to the physical condition of the work station environment that is less organized and dirty. This condition is shown at the vehicle washing work station which is not tidy. The unused items remain in the work environment such as sacks filled with dirt and sand from vehicles and plastic waste. To facilitate subsequent use, the workspace and all equipment are kept in a clean and tidy condition [4]. A simple problem also occurs in the vehicle drying work station. Items such as plywoods, small ladders, paint buckets, tables, and other small items are still placed on the storage. The used-soap buckets are not stored in the used-items storage.

The unused items are placed in the improper place such as rags (*Kanebo*), footwear stickers, jack, ring locks and wrenches are not stored properly. Oil spill that has not been cleaned makes the floor slippery, there are used-oil bottles that are not stored in order. These conditions make the workers feel uncomfortable in carrying out their activities. Khansa Oto Care needs to apply the *Seiso* principle, which will give a comfortable effect for its workers [5]. The conditions above can hamper the service process because a lot of time is wasted due to a lot of movement [6]. In addition, the lack of habits and discipline of the workers in caring for the work environment is due to the absent of the three principles of 5S cultures.

Based on the ten observations on the workers activities from taking the hose until turning on the tap, it took 9.51 seconds with a distance of 1.5 meters. The time to turn off the switch and the tap, and to store the hose, it took an average of 9.97 seconds. The worker required 4.41 seconds to take the sponge, in which, the distance between the sponge container and the car was 1 meter. Meanwhile, it took an average of 4.7 seconds to store the sponge in the sponge container. The worker required 4.19 seconds to take the dry cloth (*Kanebo*), in which, the distance between the dry cloth container and the vehicle was 2 meters. Meanwhile, to store the dry cloth, it took an average of 4.67 seconds. The average time for the worker to take the polish bucket was 5.48 seconds, in which, the distance between the polish bucket and the vehicle was 2.5 meters.

A lot of time was wasted because of the repetitive activities of picking up back and forth and the distance was a bit far. Goods or tools to be easily found quickly, proper storage is needed [7], this will make it easier to get them and work efficiency will increase [8]. The Loss of working time can be minimized by applying the 5S management properly and minimizing unnecessary movements [3].

Items or tools to be easily found quickly, need to be stored properly

## 2. METHODS

This research was conducted at Khansa Oto Care which is a service provider for car washing, nitrogen gas filling, oil and air filter changing, and also accessories sales for vehicle interiors. The research used the 5S method (*Seiri, Seiton, Seiso, Seiketsu,* and *Shitsuke*). The respondents were 12 workers of Khansa Oto Care. The research used an experimental design with the same subject (treatment by subject design). The treatment was carried out in two ways, namely: (i) car service workers in the initial condition, and (ii) car service workers with the work facilities after the implementation of the 5S method. To measure the success of this study, a questionnaire was given to 12 workers before and after the implementation of 5S with the same questions. Success is seen from the score of the 5S program (%), if after the implementation of 5S the score is greater than before the implementation of 5S then it is said to be good.

## 3. RESULTS AND DISCUSSION

### 3.1. Program Score Before and After the 5S Work Culture Application

The questionnaire assessment of 12 respondents was divided into five categories, in which, each category had two kinds of statements and each statement had a Likert scale score from 1 to 5. Score 1 = very bad with the percentage score of 0% -20%, score 2 = bad with the percentage score of 21%-40%, score 3 = average with the percentage score of 41%-60%, score 4 = good with the percentage score of 61%-80% and score 5 = very good with the percentage score of 81%-100%.

The formula for 5S program (%) is as follows. [9]

$$\frac{\text{Total assessment score}}{\text{Maximum total score}} \text{ X } 100\ \%$$

Information :

Total assessment score = score x total questionnaire score of the respondent

Maximum total score = Total correspondents x Likert scale score x total questions

The program score before the implementation of 5S work culture at Khansa Oto Care is served on Table 1 below.

Table 1 Program Score Before the Implementation of 5S Work Culture

| Score | Likert Scale | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Questionnaire total score | 54 | 92 | 90 | 0 | 0 |
| Assessment total score | | | 260 | | |
| Maximum total score = 600 | | | | | |
| Program score 5(%) = (206/600) * 100 = 34.3% | | | | | |

The calculation result showed the score of 34.3% which is in the percentage of 21% - 40%. It means that the work environment before the implementation of 5S was bad.

Before the implementation of 5S at Khansa Oto Care, all of the workers were given a briefing related to the importance of 5S work culture in a work environment. Some information related to Compactness (*seiri*), Neatness (*seito*), Cleanliness (*seiso*), Maintenance (*seiketsu*) and Diligence (*shitsuke*) which was applied at Khansa Oto Care is shown on Table 2. below.

Table 2 The Implementation of 5S Work Culture at Khansa Oto Care

| Category | Information |
|---|---|
| Compactness (*Seiri)* | 1. The implementation of tidiness (*Seiri*) which the researchers conducted was by elimination procedure, such as:<br>a. Proposing a disposal, sacks filled with sand were taken by the seller of sand/soil backfill once a week so that there was no accumulation of the used sacks.<br>b. Moving various items which were not included in the work items to other places.<br>2. Making storage rack for work items in the oil change work station. |
| Neatness (*Seiton)* | 1. Making a label/tool mark for storage place |
| Cleanliness *(Seiso)* | 1. Making rack for storing large size items.<br>2. Proposing a picket agenda for morning and evening. |
| Maintenance (*Seiketsu)* | 1. Proposing a reward system for the workers<br>2. Briefing on 5S |
| Diligence (*Shitsuke)* | 1. Making 5S work culture posters. |

The program score after the implementation of 5S work culture can be seen on Table 3 below.

Table 3 Program Score After the Implementation of 5S Work Culture

| Score | Skala Likert | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Questionnaire total score | 0 | 0 | 0 | 180 | 375 |
| Assessment total score | | | 260 | | |
| Maximum total score = 555 | | | | | |
| Program score 5(%) = (555/600) * 100 = 92.5% | | | | | |

The calculation result showed the score of 92.5% which is in the percentage score of 81% - 100%. It means that the condition of the work environment after the implementation of 5S was very good.

### 3.2 Result of the Implementation of 5S Work Culture at Khansa Oto Care

3.2.1 The Application of Compactness (*Seiri*)

The application of Compactness (*Seiri*) was carried out by sorting out the important and unimportant items, items that were not important at the work station needed to be disposed. By eliminating the unnecessary

items, the work place become clean [10]. The results of the implementation of Compactness (*Seiri*) provided comfort and flexibility for workers in carrying out their work. The results can be seen on Figure 3.1. An effective Compactness activity will create a feeling of a more spacious space because there are only the necessary items remain, so that workers feel comfortable and more flexible in carrying out their work [11].

Figure 1. Before the Implementation (Left) After the Implementation (Right) in the Washing Work Station

3.2.2 The Implementation of Neatness (*Seiton*)
Determining the neat layout so that the items that will be used will be easily found.

Figure 2a Before the Implementation (Left) After the Implementation (Right) in the Drying Work Place

Figure 2b. Before the Implementation (Left) After the Implementation (Right) in the Oil Change Work Station

Figure 2c. before the Implication (Left) After the Implication (Right) in the Storage Rack

The implication of Neatness (*Seiton*) was carried out by making a place for each items and labeling each place to make it easier for the workers to find the items. Other than making it easier for the workers to find the items, it also saved time, so the workers could do other jobs. In addition, it made it easier for items to be used and returned to their original place because the items were neatly and systematically arranged [10, 12, 13]. The results of the implementation of Neatness for each place are shown on Figures 3.2a, 3.2b, and 3.2c. The Neatness Principle prioritizes functional management and elimination of the search process [14].

3.2.3 The Implementation of Cleanliness *(Seiso*)

Figure 3. Before the Implementation (Left) After the Implementation (Right) in the Oil Change and Dry Stations

The application of Cleanliness (*Seiso*) was carried out by making a picket schedule for the workers to clean the entire work area at the beginning and at the end of the work time so that the work environment was in a clean condition and could provide comfort for the workers in doing their jobs. Although it was difficult to make the workers to comply with the schedule due to the real condition, it needed to be done. One of the functions of the 5S evaluation system is to assess the workers discipline and consistency [15]. The results of the implication of Cleanliness can be seen on Figure 3.3. The purpose of the *seiso* design is to create a clean work environment because the cleanliness of the work environment can also indirectly affect the performance of every worker who works in the work environment [16]. A clean environment can create a pleasant work environment and ultimately can provide an optimal result. A quality work environment condition can be based on a clean and tidy work environment which is expected to lead to a high work performance [17]. An optimal performance can be achieved on a clean environment condition through workers discipline and consistency.

3.2.4 The Implementation of Maintenance (*Seiketsu*)

Figure 4. Before the Implementation (Left) After the Implementation (Right)

The implementation of Maintenance (*Seiketsu*) was done by making a routine checklist schedule for routine maintenance of the work equipment weekly or monthly as needed. The checklist was made so that it could be easily seen (visible) by the workers, so that work equipment would always be in a good condition when it was going to be used. Then, making it as a habit for the workers to see the checklist and carry out the activity on a scheduled basis. A good equipment condition is expected to provide an optimal result, reduce the risk of machine damage, and minimize the cost of equipment damage. The implementation of Maintenance causes efficiency in the use of equipment and materials thus, it can minimize expenses and increase profits [18].

3.2.5 The Implementation of Diligence (*Shitsuke*)

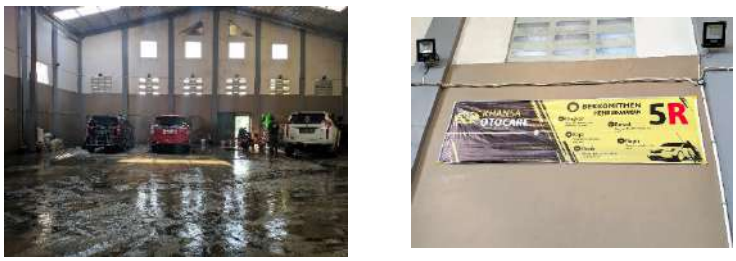


Figure 5 Before the Implementation (Left) After the Implementation (Right) of the Poster Installment

The implementation of Diligence (*Shitsuke*) was carried out by installing 5S Work Culture posters in several places which could be seen easily as a form of Khansa Oto Care's commitment in implementing the 5S Work Culture. In addition to familiarization of the 5S culture at Khansa Oto Care, it also created a more optimal work environment [6]. To familiarize the workers to commit a diligence culture, it was necessary to remind them using posters which were installed on strategic locations, as shown on Figure 3.5. The discipline to make the 5S

become a habit consisted of working according to the rules, agreements, and a strong commitment to implement this methodology [19].

The implementation of the 5S work culture is very good to be conducted in various companies, offices, warehouses, workshops and car services. The physical changes in the work environment at Khansa Oto Care after the implementation of the 5S work culture became visible. One of the biggest obstacles was how to make the 5S practice becomes a habit in the lives of the workers [20]. Even though there are many obstacles, Khansa Oto Care still applies it in the process of serving its consumers.

This research has a direct impact on workers, namely making them comfortable and free to do work, easy to find workpieces, making machines and equipment in prime condition and increasing commitment to the work done. The impact for the service owner of Khansa Oto Care is that it minimizes the level of risk of machine damage and can eliminate the cost of dredging machines or tools, a clean environment makes employee performance increase and makes customers feel satisfied. Overall the implementation of 5S can shorten service time, increase production, and the level of discipline of employees and organizations [21]

## 5. CONCLUSION

After the implementation of 5S Work Culture at Khansa Oto Care, the total score increased into 92.5% which means that the assessment result on the environment condition was very good. This kind of environment condition has made the workers acknowledge the importance of 5S Work Culture implementation, thus, it is expected that all of the workers will become more discipline in caring and maintaining the work environment. Seeing that the work environment is getting better after implementing 5S for 30 days, Khansa Oto Care services need to continue this program and provide rewards for employees who have achievements in working and running 5S program.

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**LOGIC**
Journal of Engineering Design and Technology
Vol. 22 No. 2 July 2022; p. 208 - 213

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

# LOW DENSITY AND VISCOSITY OF USED LUBRICANT OIL CONVERSION OVER $ALPO_4$ CATALYST TOWARDS FUEL OIL

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***Abstract.*** The conversion of used lubricating oil towards fuel oil by catalytic conversion is a suitable way to recycle waste oil. Catalyst has a key role in used lubricating oil conversion. Therefore this research was to study the catalytic cracking of used lubricating oil, and thus its properties as an alternative for fuel oil over aluminum fosfate. The experiments were carried out in a batch microreactor at a temperature of 350-400 ºC, atmospheric initial air pressure, 5% w/w catalyst concentration, and reaction time of 5 min over aluminum fosfate catalyst. Aluminum fosfate catalyst produced low-density liquid product, and low viscosity of used lubricant oil conversion at any temperature of 350 – 400 ºC, compared with those over alumina. Moreover, product converted at 400 ºC is easy to flare. The credible reason for the low density and viscosity of $AlPO_4$ can be proposed by three potentials: this catalyst is an acid type, the acid type is Bronsted and Lewis and this catalyst has a resistance toward contaminant.

*Keywords : aluminum fosfate, catalyst, fuel oil, nickel, used lubricant oil, low density, low viscosity.*

## 1. INTRODUCTION

The demand for fuel oil is increasing as the need for transportation and electricity increases. One of the alternative resources is used lubricating oil. Essentially, it is a hydrocarbon consisting of 20 to 50 carbon atoms and categorized as petroleum-, and vegetable oil-based lubricating oil. This resource is generated, after use, in a large and increasing volume, as the usage of machines increases. However, this resource has some properties such as low API gravity, high viscosity, and low flammability. This is well known that the longer the hydrocarbon chains of oil, the viscosity is higher; and vice versa, as the hydrocarbon chain is shorter, the viscosity is lower. To meet fuel oil criteria, it needs viscosity reduction and applicable flammability. To achieve that, it might be upgraded through catalytic pyrolysis, thermal cracking, or catalytic cracking.[1] One of the most important processes in converting low-value hydrocarbons with higher viscous ones into various high-value marketable products with lower viscous ones is catalytic cracking. [2] This process involves pressure, temperature, time, and catalyst. The presence of catalysts accelerates the cracking reactions of long carbon chains under mild conditions processing among others temperature and pressure. Mostly, the range temperature is 390 – 470 ºC, 0 – 6% w/w catalyst, initial hydrogen pressure 0 – 200 psi, reaction time 5 – 90 minutes [3], [4].

Many researchers reported catalysts for catalytic cracking of used lubricating oil. The catalysts included or exclude active metals. Some catalysts are based on zeolite, silica-alumina, gamma-alumina, and sulfated zirconia. Makvisai et al published $Fe/Al_2O_3$ catalyst for catalytic cracking of used lubricating oil. The product of this catalyst was composed of gas, liquid, and solid. They also reported that the oil and solid product of catalytic cracking is lower than a thermal cracking process of used lubricating oil, and gasses products were higher on catalytic cracking, compared with those on thermal cracking [4]. Gamma alumina is often used because it has an economical price, a stable structure, and a controllable pore size. This alumina is relatively stable at high temperatures and has a high specific area (160-300 $m^2/g$). Sulfated zirconia, an acidic material, was reported as a reactive cracking catalyst for long-chain hydrocarbons under mild conditions.[5], [6] It was converted from used

lubricating oil into naphtha, kerosene, and light gas oil [3]. Prasad et al. showed HZSM-5, a family of zeolite with a specific ratio of $SiO_2$ and $Al_2O_3$ and 5 nm pore in diameter, present to be most efficient in the oil cracking processes of aromatic hydrocarbons of canola oil towards organic fuel oil [7]

It is well known that aluminum phosphate ($AlPO_4$) is an inorganic material that is included in the metal phosphate category and has stability at high temperatures. This material is categorized as an acidic material, by fosfate structure. Aluminum fosfate has been used widely for many reactions, for instance, transesterification of soybean oil [8], dehydrogenation of cyclohexane [9], selective hydrogenolysis of glycerol to 1,3-propanediol in the vapor phase [10], alcohol conversion, and cumene cracking/dehydrogenation[11]. Thermodynamically, aluminum phosphate remains stable until it melts at a temperature of 2000 ºC [12]. The stability of aluminum phosphate depends on the phase present, for example, berlinite is stable up to 700 ºC), tridymite is stable up to 1050 ºC and the highest is cristobalite [13]. This material also has good resistance to thermal shock, oxidation, and thermal insulation. Aluminum fosfate properties have been studied well. Based on the acid type, aluminum phosphate has Lewis and Bronsted acid, in contrast to alumina which has only Lewis acid sites [14].
Here, aluminum fosfate was applied to the catalytic cracking of used lubricating oil towards fuel oil, and the effects of temperature were investigated under initial atmospheric air pressure.

## 2. METHODS

Aluminum phosphate ($AlPO_4$) was prepared from a commercial hydrated aluminum sulfate (Indonesia Acid Industry), ammonia solution (Merck, 25% in wt.), phosphoric acid (food grade), and distilled water. All materials were used as received without further purification. A dropwise ammonia solution was added to aluminum sulfate and phosphoric acid solution until the pH of the supernatant reached 5. The resulting white gel was aged for 1 hour, then washed several times with distilled water, and dried in air at 110 °C. The solid product was calcined in air at 900 °C for 3 hours. Gamma-alumina (g-$Al_2O_3$) was prepared by precipitation of aluminum sulfate solution. Ammonia solution was added dropwise until the pH of the supernatant reached 9. Then the supernatant was aged for 1 hour, washed, and dried at 110 °C. The solid obtained was calcined at 600 °C for 6 hours.
The catalytic activity test was carried out in a stainless-steel batch reactor. A total of 5% by weight of cylindrical catalyst (5 mm in diameter, and 3 mm in thickness) was placed in a stainless-steel basket and immersed in the used lubricating oil of the motorcycle with stirring. The initial pressure in the reactor is atmospheric air pressure, and the reaction time is 10 minutes.

Furthermore, the density, viscosity, and flammability tests of the product were carried out. The density test was measured by a pycnometer, the viscosity test was performed by a viscometer Ostwald, and the flammability test was performed by a fire near the liquid product.

## 3. RESULTS AND DISCUSSION

### 3.1 Effect Temperature on Density

Figure 1 shows the density of the product under a catalytic cracking process of used lubricating oil over catalysts as a function of temperature. The product was a liquid. The densities of product over $AlPO_4$ catalyst tend to decrease as temperature increases. Similar results were shown as a product over $Al_2O_3$. For all of the temperatures, only at maximum temperature (400 ºC) is the product density of both catalysts comparable. It shows a tendency as the reaction temperature increases, the density decreases. It is well known as temperature increases the cracking of carbon chain takes place rapidly. So that a shorter carbon chain is produced. The carbon chain contributed to its density by its low weight under the same volume. The shorter carbon chains, the smaller their density. Conversely, the longer the carbon chain, the higher its density.

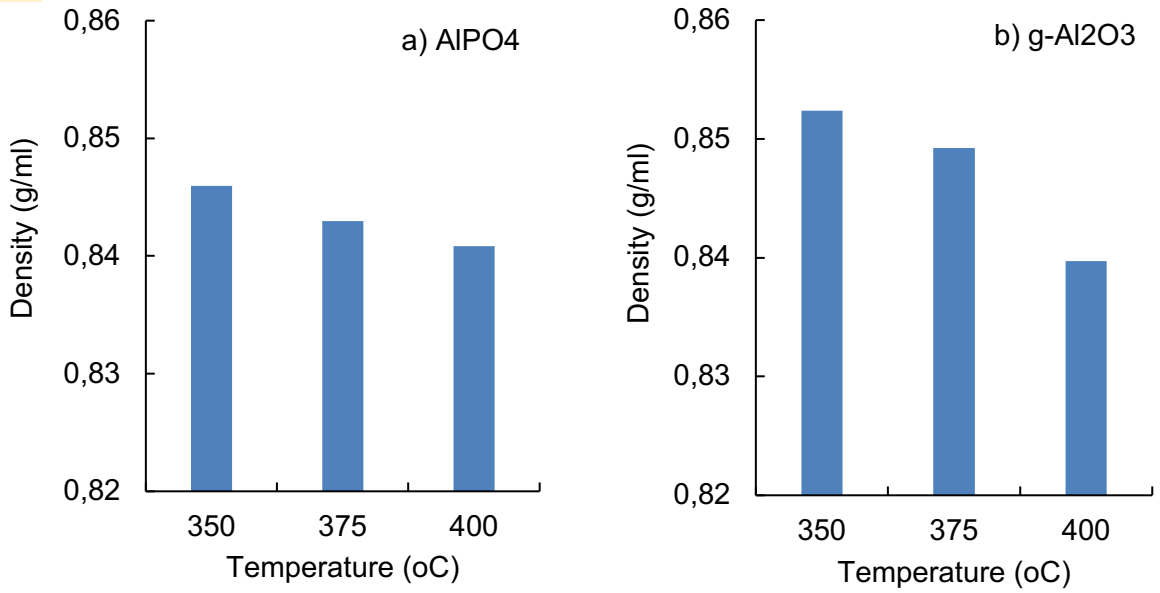


Figure 1. The density of product under catalytic cracking process a) $AlPO_4$, b) g-$Al_2O_3$. The initial air pressure was atmospheric, and the reaction time was 10 minutes under vigorous stirring.

Comparing the density of products over $AlPO_4$ and g-$Al_2O_3$, they show that the liquid density of those produced by $AlPO_4$ is lower than those over g-$Al_2O_3$. For instance, at a temperature of 350 ºC, the density of those over $AlPO_4$ is around 0.8460 gram/ml, compared with those over g-$Al_2O_3$ i.e. 0.8520 gram/ml. It can be understood that the cracking of the carbon chain over $AlPO_4$ takes place intensively and the product is a shorter carbon chain compared with those over g-$Al_2O_3$.

**3.2 Effect Temperature on Viscosity**

Figure 2 shows the dynamic viscosity of the liquid product under the catalytic cracking process of RBD used lubricating oil over catalysts as a function of temperature. The dynamic viscosity of the product over the $AlPO_4$ catalyst tends to decrease as temperature increases. Similar results were shown by a product over g-$Al_2O_3$. At all temperatures, only at maximum temperature (400 ºC) the product dynamic viscosity of both catalysts is comparable. It shows a tendency as the reaction temperature increases, the dynamic viscosity decreases. For a given sample, $\mu_{din}$ is dynamic viscosity (mPa. s), $\rho$ is density ($kg/cm^3$), and t is flowing time (s), the dynamic viscosity was correlated by a formula:

$$\mu_{din} sample = \frac{\rho_{sample} \times t_{sample}}{\rho_{water} \, x \, t_{water}} \, x \, \mu_{din} water$$

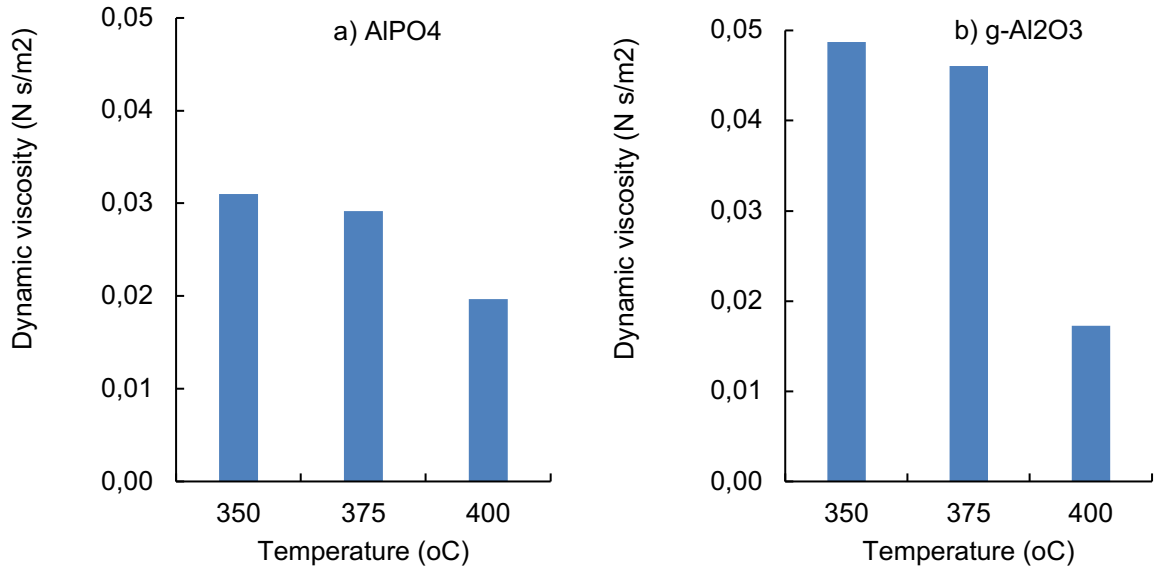


Figure 2. The viscosity of product under catalytic cracking process a) $AlPO_4$, b) g-$Al_2O_3$. The initial air pressure was atmospheric, and the reaction time was 10 minutes under vigorous stirring.

Based on the correlation, the dynamic viscosity is affected by the density and flowing time of samples, as the properties of water are constant. As density and/or flow time decrease, the dynamic viscosity decrease. Vice-versa, as density and/or flow time increase, the dynamic viscosity increase. It is well known that low-density liquid is commonly easy to flow so that the time flow is in low number.

Comparing the dynamic viscosity of the product over $AlPO_4$ and g-$Al_2O_3$, they show that the dynamic viscosity of liquid produced by $AlPO_4$ is lower than those of g-$Al_2O_3$. For instance, at temperature 350 $^oC$, the density of those over $AlPO_4$ is around 0.0310 N s/$m^2$, compared with those over g-$Al_2O_3$ i.e. 0.0487 N s/$m^2$. It can be understood that the cracking of the carbon chain over $AlPO_4$ takes place intensively and the product is a shorter carbon chain compared with those over g-$Al_2O_3$.

**3.3 Effect Temperature on Flammability**

Table 1 shows the flammability test of the product. For both $AlPO_4$ and g-$Al_2O_3$ catalysts only at a temperature of 400 $^oC$ the products are easily burned/ignite. This showed that the conversion of used lubricating oil into fuel occurs at 400 $^oC$ under initial atmospheric air pressure.

Table 1. Flammability test of a product under catalytic cracking process. The initial air pressure was atmospheric, 5%w/w catalyst, and the reaction time was 10 minutes under vigorous stirring.

| Catalyst | Temperature $^oC$) | Flammability test |
|---|---|---|
| $AlPO_4$ | 350 | Not easy to burn/ignite |
| $AlPO_4$ | 375 | Not easy to burn/ignite |
| $AlPO_4$ | 400 | Easily burn/ignite |
| g-$Al_2O_3$ | 350 | Not easy to burn/ignite |
| g-$Al_2O_3$ | 375 | Not easy to burn/ignite |
| g-$Al_2O_3$ | 400 | Easily burn/ignite |

**3.4 Possible reason**

The present study demonstrates that $AlPO_4$ catalyst exhibits a lower density and viscosity liquid product. These phenomena can be associated with the following two features of metal fosfate. First, the catalytic performance might be affected by its acidity. It is well known that aluminum fosfate is an acidic material by its fosfate structure while g-$Al_2O_3$ tends to be basic material by its oxide. To estimate the acid strength, one of the methods is electronegativity. Electronegativity is a chemical property relating to the ability of an atom (or more precisely a functional group) to attract electrons (or electron density) towards itself in a covalent bond. A small number of

electronegativity means the material is a base, and a high number of electronegativity means the material is acidic. Based on Sanderson electronegativity, for a compound $X_xY_yZ_z$, the mean electronegativity (S) is the geometric mean of the electronegativities of each of the constituent atoms ($S_X$, $S_Y$, and $S_Z$) given by the equation:

$$S = \left[S_X^x \,.\, S_Y^y \,.\, S_Z^z\right]^{1/(x+y+z)}$$

Table 2. The geometric mean of the electronegativities is based on the Sanderson correlation.

| Compound | The geometric mean of the electronegativities |
|---|---|
| $AlPO_4$ | 2.81 |
| g-$Al_2O_3$ | 2.54 |

The obtained parameter has been successfully correlated with physicochemical properties such as the $NO_x$ conversion efficiency, [15] the acidity of $ZrO_2$, and acidity of metal phosphates. The geometric mean of the electronegativities was shown in Table 2. Clearly, Table 2 shows that the geometric means of the electronegativities on $AlPO_4$ is higher than that on g-$Al_2O_3$. That means $AlPO_4$ has higher acidity than g-$Al_2O_3$. Second, this can be related to the acid-base properties of materials. Aluminum fosfate contains Lewis and Bronsted acid types, in contrast to g-$Al_2O_3$ which has Lewis acid type only. Moreover, $AlPO_4$ was dominated by acid type, rather than base type; in contrast to g-$Al_2O_3$ which was dominated by base type rather than acid type.[14]
Third, note that the used lubricating oil contains contaminants. The contaminants reported include metal, water content, phosphorus, and sulfur.[16], [17] These contaminants affected the catalytic activities. For instance, the presence of phosphorus and sulfur was reported to decrease catalytic activities. [14] Aluminum fosfate was reported to have a resiliency toward phosphorus and sulfur poisoning, in contrast to g-$Al_2O_3$.

## 4. CONCLUSION

The conversion of used lubricating oil over $AlPO_4$ and g-$Al_2O_3$ was successfully achieved. Liquid density product over $AlPO_4$ catalysts shows a low number compared with those over g-$Al_2O_3$. In all of the temperatures, only at maximum temperature (400 ºC) the product density of both catalysts is comparable. Aluminum fosfate resulted in a lower dynamic viscosity than g-$Al_2O_3$ at all temperatures, except at maximum temperature (400 ºC). At 400 ºC, the dynamic viscosity of both catalysts is equivalent. The flammability test shows only at 400 ºC the liquid product is easily burned. The possible reason for the low density and viscosity of $AlPO_4$ can be suggested by three possibilities: this catalyst is an acid type, acid the type is Bronsted and Lewis, and this catalyst has a resilience toward contaminant.

## 5. ACKNOWLEDGEMENT

The author would like to thank UPT P2M Politeknik Negeri Malang DIPA No. SP DIPA SP DIPA-023.18.2.677606/2020 for financial support.

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