POLITEKNIK NEGERI BALI

Journal of Engineering Design and Technology

logic

Vol. 21 No. 3 November 2021

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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PREFACE

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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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Vol.21 No.3 November 2021; p. 129 - 138

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

TESTING OF NUTMEG SHELL AS A NORMAL CONCRETE MATERIAL IN TERMS OF VOLUME WEIGHT AND COMPRESSIVE STRENGTH VALUE

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Abstract. Normal concrete uses fine aggregate and coarse aggregate with concrete density 2200 kg/m^3-2400 kg/m^3 with a compressive strength of about 15-40 MPa [1]. The purpose of this study is to determine characteristics of the concrete aggregate and the compressive strength of the concrete design based on the DOE (Department of Environment) method and the SNI Standard. In this research, the use of nugmet shell was varied as follows: 0%, 0,25%, 0,50%, 0,75% and 1% of the cement weight. The results showed that the use of nutmeg shells as a normal concrete affected the specific gravity and the value compressive strength of concrete. The higher the percentage of nutmeg shells, the lower the specific gravity and compressive strength of the concrete. The average value of density to nutmeg shell concrete (NSC) 2254.72 (kg/m^3) and normal concrete 2304.32 (kg/m^3). The compressive strength of normal concrete is 224.2 kg/cm^2 and the nutmeg shell concrete (NSC) the composition of 0.25% and 0.5% obtained by 129.6 kg/cm^2 and 140.0 kg/cm^2 increases the use of nutmeg shell 0.75% and 1% obtained value of 117.6 kg/cm^2 and 118.1 kg/cm^2 decreased at the age of 28 days. The compressive strength of normal concrete 22 MPa while the maximum nutmeg shell concrete (NSC) 14 MPa, so it does not meet the quality of normal concrete in general.

Keywords: aggregate characteristics, nutmeg shell, volume weight, characteristics compressive strength

1. INTRODUCTION

The use of concrete as a building material has been very popular in Indonesia because it can utilize local materials such as gravel, sand, cement and water which are easily obtained at relatively low prices [1]. Sometimes in certain areas it is very limited to get aggregate, especially gravel and river sand. Fakfak Regency is one of the regencies in West Papua Province with limited aggregate availability. Bomberay district with a distance of 200 km, one of the sub-districts that supplies the aggregate demand for construction in Fakfak [2], most of it must be imported from outside provinces such as Sulawesi. The limited natural resources in providing aggregates for the manufacture of concrete is a very important problem so that an alternative is needed to replace part or all of the aggregate. One example of efforts to overcome these limitations is the use of nutmeg shells for coarse aggregate material in the manufacture of concrete, both lightweight concrete and normal concrete.

The use of nutmeg shells as a concrete material has been previously tested as a lightweight concrete constituent. The results showed that the nutmeg shell reduced the weight of the concrete volume, the higher the percentage used in the concrete mixture, the lighter the weight of the concrete. The maximum compressive strength value is 32.68 kg/cm^2 (3.2 MPa) with 30% nutmeg shell percentage and 1792.4 kg/m^3 concrete weight obtained [3]. According to [4], lightweight concrete has a specific gravity of not more than 1900 kg/m^3 while according to [5] lightweight concrete has a density between 1000-2000 kg/m^3. According to [6], 1998 lightweight

concrete has a compressive strength value of 0.35-6.90 MPa, so that the nutmeg shell meets the specifications as a lightweight concrete constituent material. From these results the researchers developed further research by utilizing nutmeg shells as a partial substitute for coarse aggregate in normal concrete.

According to [1] normal concrete is concrete that uses sand aggregate as fine aggregate and gravel as coarse aggregate and has a concrete density between 2200 kg/m^3-2400 kg/m^3 with a compressive strength of about 15-40 MPa.

Research conducted [7] utilizes waste concrete as a partial replacement for coarse aggregate in normal concrete. The use of aggregate proportions of 25%, 50%, 75% and 100% of the total weight of natural aggregates. The results showed that the most optimum proportion was the aggregate proportion of 25% while [8] in his research the use of broken concrete as an alternative to partially substitute coarse aggregate as a concrete mixture of K-250 Kg/cm^2. The use of 100% waste concrete compared to the new aggregated concrete found that the average compressive strength at 28 was 257.12 Kg/cm^2 for normal concrete and 191.14 Kg/cm^2 for waste concrete.

Based on the explanation above, the author examines the development of nutmeg shells as a partial substitute for coarse aggregate in normal concrete mixtures. The research objective is to determine the specific gravity of concrete and the value of the compressive strength of concrete. The proportions of the mixture to be used are 0%, 0.25%, 0.5%, 0.75% and 1% of the cement weight with the stages of characteristic testing, making mix design specimens, each mix design being tested by slum test, making samples from cylindrical mold with a diameter of 15 cm and a height of 30 cm, concrete treatment at the age of 3, 7 and 28 days and a compression test with MTS STH Compression.

2. METHODS

2.1 Research Design

This experiment is a laboratory experiment which includes testing the characteristics of coarse aggregate and fine aggregate consisting of sieve analysis, silt content, moisture content, volume weight, fineness and coarseness modulus, organic content in sand. If the aggregate characteristics meet the standards, then proceed with the mix design, each mix design is carried out with a slum test, making samples from cylindrical molds with a diameter of 15 cm and a height of 30 cm, treatment of concrete at the age of 3, 7 and 28 days and a compression test with MTS STH Compression. The study sample design is presented as in Table 1.

Table 1. Sampel Reseacrh Design

No	Sample of concrete specimen	Percentage of LCP (%)	Testing (days)
1	9 Sample	0	3, 7, 28
2	9 Sample	0,25	3, 7, 28
3	9 Sample	0,50	3, 7, 28
4	9 Sample	0,75	3, 7, 28
5	9 Sample	1	3, 7, 28
∑	36 sample	-	-

2.2 Research Stages

The stages of research, prepare tools and materials. The material consists of sand, cement, water and nutmeg shells then by testing the characteristics of the aggregate. Several parameters that affect the fine aggregate (sand) and coarse aggregate in determining the quality of the concrete are sludge content, moisture content, volume weight, absorption, specific gravity, fineness modulus and organic content [9]

The level of sludge is the percentage of size that passes filter No.200 according to ASTM and British Standards or 80 DIN (Germany) or standard filter hole size = 0.075 mm. Laboratory testing is generally carried out by the washing method according to ASTM C-117 (2000 Sieve in Mineral Aggregate by Washing) Standard Test Method for Materials. Tolerance for testing the fine aggregate sludge content is 0.2% -6%.

The water content in the aggregate is greatly influenced by the amount of water contained in the aggregate. The bigger the difference between the original aggregate weight and the aggregate weight after oven drying, the more water is contained by the aggregate and vice versa. Tolerance of testing moisture content in fine aggregate is 3% -5%.

The volume weight is the ratio between the dry aggregate weight and its volume. The aim is to determine the weight of the fine aggregate. The test tolerance for fine aggregate is 1.4 kg / ltr-1.9 kg / ltr.

The absorption is the percentage by weight of water that can be absorbed by the material to the weight of dry aggregate. Tolerance of testing fine aggregate 0.2% -2% and coarse aggregate 0.2% -4%.

The specific gravity is the ratio between the weight of dry aggregate and the weight of distilled water

whose content is the same as the aggregate content in a saturated state at a certain temperature. The test tolerance for fine aggregate is 1.6% -3.3%.

The organic ingredients, are materials contained in aggregates that can cause damage to concrete. The organic substances contained in fine aggregates generally come from destroyed plants, especially in the form of humus and organic sludge. Harmful organic substances include sugar, oil and fat. Sugar can inhibit cement binding and the development of concrete strength, while oil and grease can reduce cement binding capacity. The test tolerance for fine aggregates is less than a value of 3.

If the test of the characteristics of the aggregate meets the criteria, it is continued with designing a concrete mix (mix design) with f'c 17,5 MPa. Making the composition of the concrete mixture with nutmeg shell variations of 0%, 0,25%, 0,50%, 0,75% and 1% of the weight cement. Concrete maintenance for 3,7 and 28 days. Testing the compressive strength of concrete with a target of f'c 17,5 Mpa, data analysis and conclusions.

2.3 Characteristic Testing

Aggregate characteristic testing uses study literatures as shown in Table 2.

Table 2: Aggregate testing method

Types of testing	Method
Filter Analysis	SNI 03-1968-1990
Specific Weight and Fine Aggregate Absorption	SNI 03-1970-1990
Specific Weight and Absorption of	SNI 03-1969-1990
Water Content	SNI 03-1971-1990
Volume Weight	SNI 03-4804-1998

Source: Attamimi [10].

2.4 Compressive Strength Testing

Concrete compressive strength test results using compression machine test were analyzed by using compressive strength equation [11]:

$$fc = \frac{P}{A} \quad (1)$$

In which:
fc = compressive strength (kg/cm2)
P = load (kg)
A= the weighted cross-sectional area (cm2)

3. RESULTS AND DISCUSSION

3.1 Testing of Aggregate Characteristic

The results of the characteristic test of coarse aggregate (gravel) are as in Table 3 whereas the results of fine aggregate testing (sand) as in Table 4.

Table 3. The Result of Coarse Aggregate Testing

Aggregate Characteristics	Interval	Testing result	Description
Mud levels	Max. 1%	0.270%	Qualified
Water content	0.5 - 2%	0.50%	Qualified
Volume weight	1.4 - 1.9 kg/litre	1.61	Qualified
Absorption	0.2 – 2%	2.04%	Qualified
Specific weight			
Dry-based S.W	1.6	2.450	Qualified
Dry-surfaced S.W.	1.6	2.579	Qualified
Roughness Modulus	5.5 – 8.5	8.390	Qualified

The results of the test in table 3, it is explained that the slurry content test on the coarse aggregate obtained a value of 0.27% meets the requirements and is feasible. According to [5] the coarse aggregate should not contain more than 1% silt. The coarse aggregate modulus in the zone is 4.75 - 40 mm. The graph of the results of the coarse aggregate gradation test is shown in Figure 1.

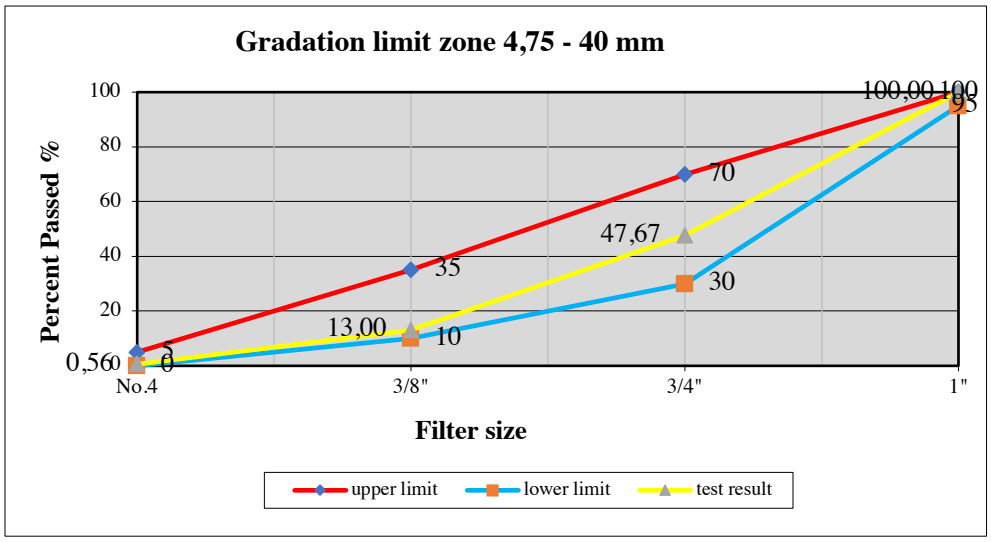

Figure 1. Graphic of coarse aggregate gradation (gravel)

Table 4. The Result of fine Aggregate Testing

Aggregate Characteristics	Interval	Testing result	Description
Mud levels	Max. 5%	3.60%	Qualified
Water content	0.5 - 5%	2.24%	Qualified
Volume weight	1.4 - 1.9 kg/litre	1.51	Qualified
Absorption	0.2 – 2%	1.08%	Qualified
Specific weight			
Real S.W.	1.6 - 3.3	2.330	Qualified
Dry-based S.W	1.6	2.280	Qualified
Dry-surfaced S.W.	1.6	2.300	Qualified
Roughness Modulus	1.50 – 3.80	3.660	Qualified

The result of table 4 the characteristics of the fine aggregate, the mud content value obtained is 3.6% which meets the requirements and is suitable for use in concrete mixtures. According to [1] fine aggregate must not contain more than 5% silt and must not contain organics that can damage the concrete. Its use is to fill the spaces between coarse aggregates and provide smoothness. The sand fineness modulus value of 3.66 meets the requirements of zone 1 by entering the coarse sand category. The graph of the results of the fine aggregate grain gradation test is shown in Figure 2.

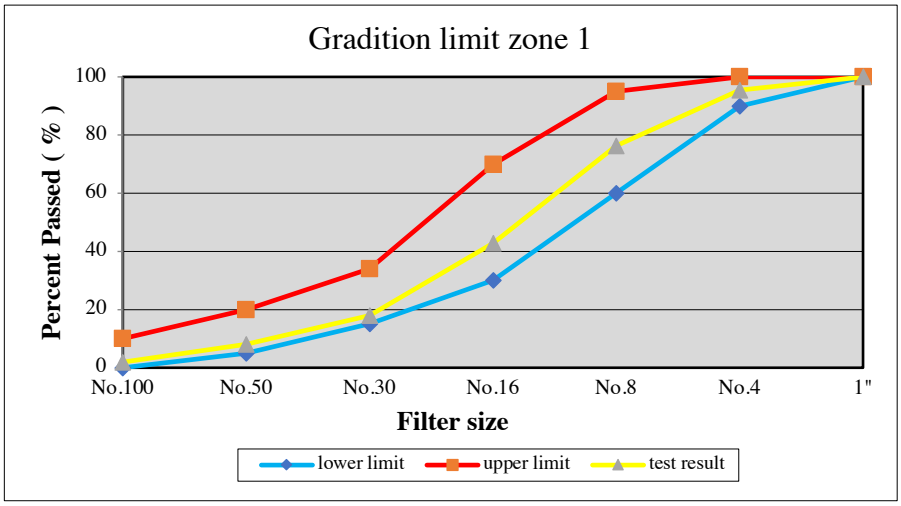

Figure 2. Graphic of fine aggregate gradation (sand)

Knowing the strength of the quality of concrete that will be produced using coarse aggregate (gravel) and fine aggregate (sand) used concrete quality f'c 175 MPa. Calculation of the combination of aggregates obtained 30% sand and 70% crushed stone in a concrete mixture (mix design) with a water-cement factor (W/C) = 0.75 as shown in Table 5 while for the use of nutmeg shell (CP) as a partial replacement material in coarse aggregate. using a composition of 0%, 0.25%, 0.50%, 0.75% and 1% by weight of cement as shown in Table 5, 6, 7, 8 and 9.

Table 5. Mix Design of Normal Concrete

Concrete material	Weight (kg/m^3)	Ratio to the amount of the cement (kg)	Weight for one sample (kg)	Weight for 9 sample (kg)
Water	2.44.49	0.7859	1.555	13.998
Cement	311.11	1.000	1.979	17.812
Sand	487.43	1.5668	3.101	27.908
Gravel	1106.9	3.5581	7.042	63.379
Total	2,150.0		13,678	123.099

Table 6. Mix Design of Nutmeg Shell Concrete (NSC) 0,25%

Concrete material	Weight (kg/m^3)	Ratio to the amount of the cement (kg)	Weight for one sample (kg)	Weight for 9 sample (kg)
Water	2.44.49	0.7859	1.555	13.998
Cement	311.11	1.000	1.979	17.812
Sand	487.43	1.5668	3.101	27.908
Gravel	1101.5	3.540	7.007	63.070
NSC	5.392	0.017	0.034	0.3088
Total	2,150.0		13,678	123.099

Table 7. Mix Design of Nutmeg Shell Concrete (NSC) 0,50%

Concrete material	Weight (kg/m^3)	Ratio to the amount of the cement (kg)	Weight for one sample (kg)	Weight for 9 sample (kg)
Water	2.44.49	0.7859	1.555	13.998
Cement	311.11	1.000	1.979	17.812
Sand	487.43	1.5668	3.101	27.908
Gravel	1096.12	3.523	6.973	62.759
NSC	10.825	0.034	0.068	0.6198
Total	2,150.0		13,678	123.099

Table 8. Mix Design of Nutmeg Shell Concrete (NSC) 0,75%

Concrete material	Weight (kg/m^3)	Ratio to the amount of the cement (kg)	Weight for one sample (kg)	Weight for 9 sample (kg)
Water	2.44.49	0.7859	1.555	13.998
Cement	311.11	1.000	1.979	17.812
Sand	487.43	1.5668	3.101	27.908
Gravel	1090.82	3.506	6.939	62.456
NSC	16.125	0.051	0.102	0.923
Total	2,150.0		13,678	123.099

Table 9. Mix Design of Nutmeg Shell Concrete (NSC) 1%

Concrete material	Weight (kg/m^3)	Ratio to the amount of the cement (kg)	Weight for one sample (kg)	Weight for 9 sample (kg)
Water	2.44.49	0.7859	1.555	13.998
Cement	311.11	1.000	1.979	17.812
Sand	487.43	1.5668	3.101	27.908
Gravel	1085.45	3.489	20.716	62.148
NSC	21.500	0.069	0.410	1.231
Total	2,150.0		13,678	123.099

The calculation of the above design results obtained a difference in weight based on the percentage of the need for coarse aggregate and nutmeg shell material, namely the percentage of 0.25 nutmeg shell to the weight of cement requiring coarse aggregate 1101 (kg/m^3) and 5.39 (kg/m^3) nutmeg shell, a percentage of 0.5 requiring coarse aggregate 1096.1 (kg/m^3)and 10.82 (kg/m^3)of nutmeg shell, percentage 0.75 requires coarse aggregate 1090.8 (kg/m^3) and 16.12 (kg/m^3) and percentage 1 requires 1085.4 coarse aggregate and 21.5 (kg/m^3) nutmeg shell. This design value shows the higher the percentage of nutmeg shells used in the concrete mixture, the lower the demand for coarse aggregate.

According the calculation of the mix design of the concrete mixture with nutmeg shells, then an analysis of the weight value of the volume of fresh concrete is carried out by means of the average weight of fresh concrete divided by the volume of the cylindrical specimen as shown in Table 10.

Table 10. The weight of fresh concrete produced

No	Sample	Volume of Freshly Concrete (kg/m^3)
1	Normal Concrete	2304,32
2	Nutmeg Shell Concrete (NSC) 0,25%	2241,19
3	Nutmeg Shell Concrete (NSC) 0,50%	2245,81
4	Nutmeg Shell Concrete (NSC) 0,75%	2233,23
5	Nutmeg Shell Concrete (NSC) 1%	2298,66

The results of the calculation of the volume weight of fresh concrete in normal concrete obtained 2304.32 (kg/m^3), 0.25% nutmeg shell concrete 2241.19 (kg/m^3), 0.5% nutmeg shell concrete 2245.81(kg/m^3), 0.75% nutmeg shell concrete was 2233.23 (kg/m^3) and 1% nutmeg shell concrete by weight of cement was 2298.66 (kg/m^3).

The volume weight value of fresh concrete decreased after using a mixture of nutmeg shell material. According to [1] normal concrete is concrete that uses sand aggregate as fine aggregate and crushed stone as coarse aggregate so that it has a concrete density between 2200 kg/m^3 – 2400 kg/m^3. This shows that the use of nutmeg shell as a substitute material as a substitute for coarse aggregate is still adequate in terms of the specific gravity of the concrete.

The results of the characteristic compressive strength test of concrete (fc) using MTS at the age of 28 days obtained the maximum compressive strength value of each sample as shown in Figures 4,5,6,7 and 8.

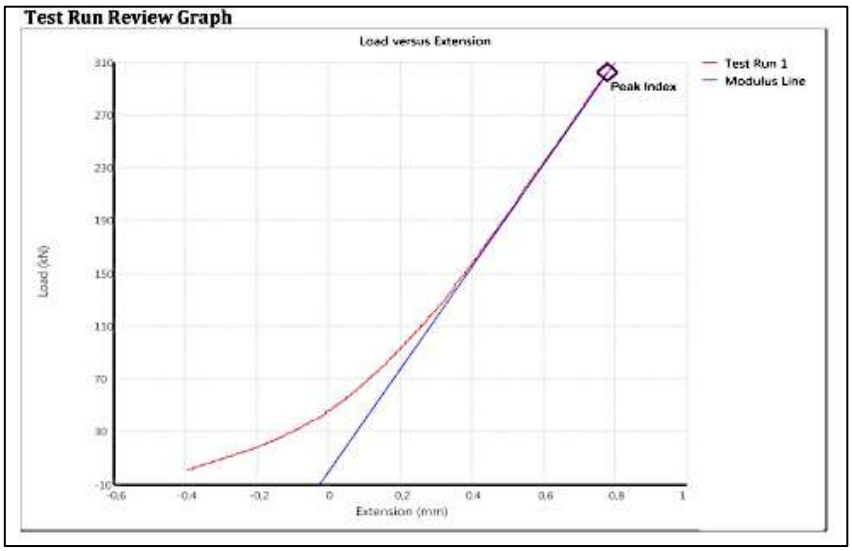

Figure 3. Test Results Normal Concrete with MTS Compression

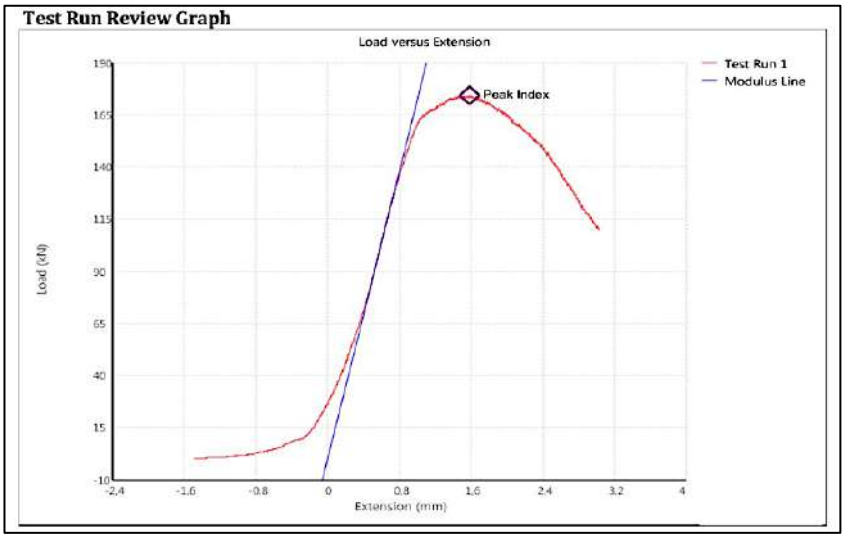

Figure 4. Test Results Nugmet Shell Concrete (NSC) 0,25% with MTS Compression

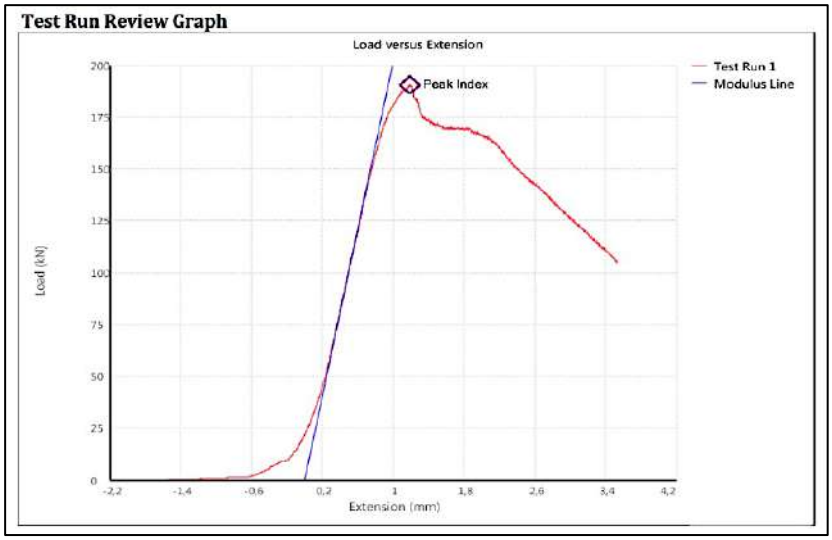

Figure 5. Test Results Nugmet Shell Concrete (NSC) 0,50% with MTS Compression

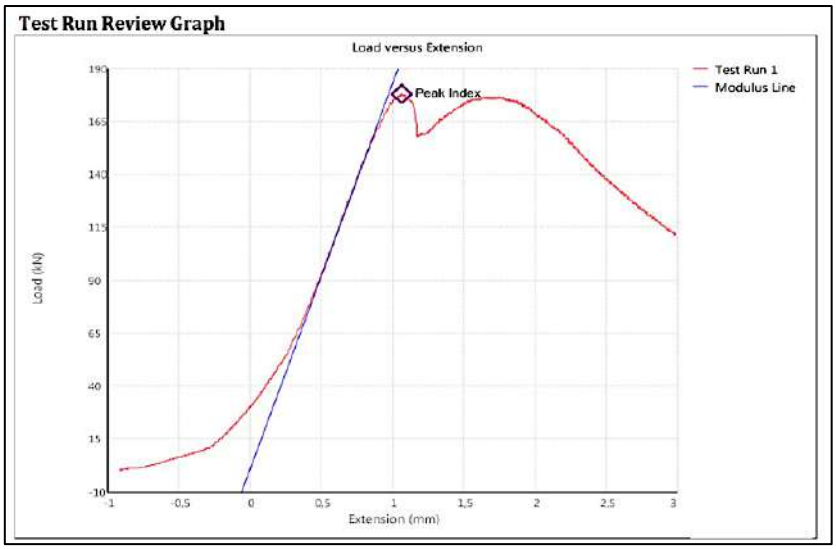

Figure 6. Test Results Nugmet Shell Concrete (NSC) 0,75% with MTS Compression

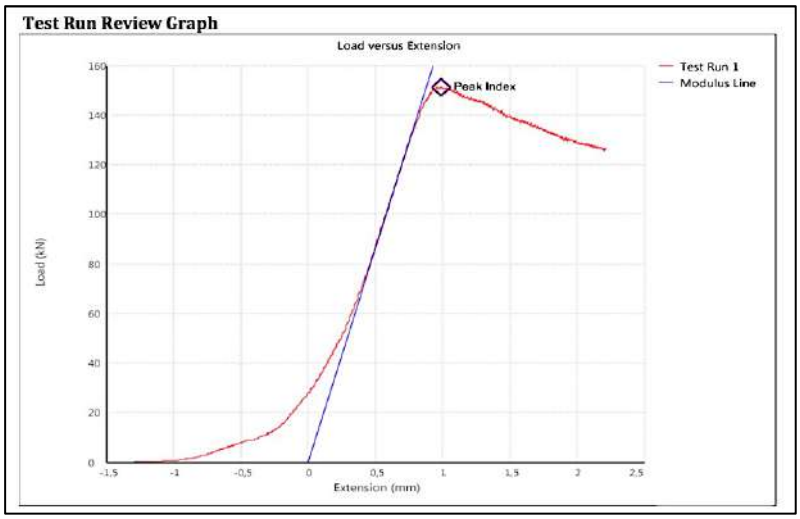

Figure 7. Test Results Nugmet Shell Concrete (NSC) 0,75% with MTS Compression

According to Figure 4,5,6,7 and 8 show the maximum compressive strength of normal concrete from 9 test samples of 302 KN while concrete using 0.25% **nutmeg** shell material as a partial replacement for maximum coarse aggregate obtained 174 KN The compressive strength value has decreased. For concrete using 0.50% nutmeg shell material, a maximum of 190 KN has increased compared to 0.25%. However, concrete using 0.75% and 1% nutmeg shell material, namely 177 KN and 151 KN, decreased. From this compressive strength value, it is concluded that the use of nutmeg shell material affects the quality of normal concrete, where the higher the percentage of the substitute material, the lower the compressive strength value.

The results of the compressive test using MTS STH Compression continued with the calculation of the characteristic compressive strength analysis (fck') where the compressive strength value (fc') was shared with a correction factor as shown in Table 11.

Table 11. The value of Compressive Strength Characteristics of Concrete

Sample	Value read in the tool (KN)	Value analysis characteristic f'c (kg/cm^2)
Normal Concrete	302	224,2
Nutmeg Shell Concrete (NSC) 0,25%	174	129,6
Nutmeg Shell Concrete (NSC) 0,50%	190	140,0
Nutmeg Shell Concrete (NSC) 0,75%	177	118,1
Nutmeg Shell Concrete (NSC) 1%	151	117,6

According to table 11 the results of the analysis of the value of the compressive strength of concrete with the use of nutmeg shell as a substitute for coarse aggregate with a maximum test of 28 days showed that the use of nutmeg shell as a substitute for coarse aggregate in normal concrete mixtures affects the weight of concrete and the value of the compressive strength of concrete characteristics (fck').

The higher the percentage of the use of nutmeg shells, the weight of the concrete decreases compared to the weight of normal concrete without nutmeg shells. The value of the compressive strength of nutmeg shell concrete at a composition of 0.25% and 0.5% was obtained by 129.6 (kg/cm^2) and 140.0 (kg/cm^2) increased, while the use of nutmeg shell at a composition of 0.75% and 1% obtained a value of 117.6 (kg/cm^2) and 118.1 (kg/cm^2) decreased at the age of 28 days.

The strength value has decreased when compared to normal concrete, which is 224.2 (kg/cm^2) (22 Mpa). The decrease in compressive strength is influenced by the high percentage of the use of nutmeg shells into the concrete mix so that the aggregate grains are not wrapped in mortar and reduce the volume of concrete that should be filled with cement paste. The same thing was expressed by [12], that for good concrete, each aggregate grain is completely covered with mortar. Likewise, the space between the aggregates must be filled with mortar. So the quality of the paste or mortar determines the quality of the concrete.

According to [1] normal concrete is concrete that has a compressive strength value of around 15-40 Mpa. Based on the range of compressive strength values, it shows that the results of normal concrete research without nutmeg shells are in the category of 22 MPa while concrete using nutmeg shells at the age of 28 days is a maximum of 14 MPa so it is concluded that the use of nutmeg shells as coarse aggregate material in normal concrete reduces the strength value press. The use of nutmeg shells as a concrete building material is recommended for the lightweight concrete category and can be implemented directly in the manufacture of lightweight concrete blocks.

Research on nutmeg shell as a substitute for coarse aggregate for normal concrete has an effect on the compressive strength of concrete characteristics, where the higher the percentage of substitute material used, the lower the compressive strength value. According to [7] concluded that the higher the percentage of use of substitute or substitute materials for coarse aggregate, the lower the compressive strength value, the same thing was conveyed by [8] by utilizing broken concrete as an alternative to partial replacement of coarse aggregate, [13] utilizing recycled aggregate, [14] utilizes rice husk ash and waste concrete mix, in contrast to the expression [15] which uses nickel slag as a substitute for coarse aggregate, where the higher the percentage of substitute aggregate, the higher the compressive strength of concrete will be. The relationship of this research with previous research can both contribute as a substitute for coarse aggregate in normal concrete.

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:

1. The use of nutmeg shells as a partial replacement of coarse aggregate in the concrete mixture affects the specific gravity and the value of the compressive strength of the concrete characteristics. The higher the percentage of nutmeg shell, the density and compressive strength of the concrete decreased. The average value of the specific gravity of concrete from nutmeg shell was 2254.72 (kg/m^3) while normal concrete was 2304.32 (kg/m^3).
2. The compressive strength value of normal concrete is 224.2 (kg/cm^2) while the concrete from nutmeg shell at the composition of 0.25% and 0.5% is obtained by 129.6 (kg/cm^2) and 140.0 (kg/cm^2) increases while the use of nutmeg shell at the composition of 0.75% and 1% obtained values of 117.6 (kg/cm^2) and 118.1 (kg/cm^2) decreased at the age of 28 days. The compressive strength of normal concrete is 22 MPa while the maximum nutmeg shell concrete is 14 MPa.

4.2 Suggestion

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

1. The results of this study affect the specific gravity for each percentage, so it is necessary to conduct further research by examining the relationship between specific gravity and other parameters, namely the value of the modulus.
2. It is recommended to use nutmeg shell as an aggregate material for lightweight concrete, in addition to saving costs, it can also reduce waste that has an impact on the environment.

5. ACKNOWLEDGEMENT

Gratitude is given to the Research and Development Agency, Deputy for Strengthening Research and Development with research funds and the Department of Civil Engineering for permission to use laboratory facilities.

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LOGIC
Journal of Engineering Design and Technology
Vol. 21 No. 3 November 2021; p. 139 - 148

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

DESIGN AND CONSTRUCTION OF CROP SUITABILITY PREDICTION SYSTEM USING FUZZY LOGIC CLASSIFIER METHOD

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Abstract. The potential of land in Indonesia which is quite large and has not been used optimally is one of the problems. this study focused on developing fuzzy logic models to predict plants that are suitable for planting on agricultural land to enable the land use more optimal. In conducting this study, there were two stages of implementation, namely hardware design, and software design which included system workflow design using the Fuzzy Logic Classifier method where three input variables were used, namely soil pH, soil temperature, and humidity. The findings of this study are in the form of predictions consisting of eight outputs, namely Unfavorable Land, Spinach, Cayenne Pepper, Beans, Long Beans, Cucumber, Eggplant, and Tomatoo. The prediction results generated were directly displayed on the LCD of the instrument that has been designed.

Keywords : fuzzy logic, agriculture land, prediction

1. INTRODUCTION

Agriculture has an important role in human life because it functions as a provider of food, feed for livestock, and bioenergy. Indonesia has considerable land potential and has not been used optimally. Most of the land is suboptimal, such as dry land, tidal swamps, and lowland swamps with low productivity due to various constraints, such as water shortage and/or excess, high soil acidity and salinity, as well as toxicity and nutrient deficiency [1]. Basically, farmers need prior expert knowledge to make decisions during land preparation, sowing, fertilizer management, irrigation management, integrated pest control, storage, etc. for higher crop production [2]. Land preparation is one of the most important factors that need to be done in starting a cultivation business. Good land preparation has a big effect on plant productivity. Many studies have shown that land preparation before cultivating can increase crop yields by up to 30% [3]. Therefore, optimal land use can be done, one of which is knowing information related to the land which is needed to increase agricultural productivity. Therefore, in order to minimize the possibility of crop failure, the community needs information about the condition of the land in order to estimate the plants that are suitable for planting. Information about the land might be analyzed based on data taken directly in the field using three measurement parameters, namely soil pH, temperature and soil moisture.

The nutrients contained in the soil directly affect the growth and development of plants in addition to the ability of plants to absorb nutrients from the soil. The ability of plants to carry out the process of absorbing nutrients is also influenced by the main factor, namely the level of acidity or soil pH. By knowing the pH level in the soil, farmers can determine what crops are suitable for planting or cultivating because each plant has different needs for different pH levels [4]. In addition, soil temperature and humidity are also elements that affect plant growth [5]. Soil temperature affects water absorption [6], the lower the temperature, the less water is absorbed by the roots, therefore a sudden drop in soil temperature can cause plants to wither. While soil moisture will determine the availability of water in the soil for plant growth, the factors that determine soil moisture are rainfall, soil type, and the rate of evapotranspiration [7]. Therefore, by using these three measurement parameters, it is hoped that it can help provide information to the public about predictions of plants that are suitable for planting.

A previous study [8] conducted in 2020 was a study that used the fuzzy classifier as a model to determine the sustainability of aquatic animals and plants by assessing the quality of pond water. The output of this study resulted in fairly good classification performance. In addition, another study [9] combined seasonal index forecasting algorithms and Fuzzy-MCDM development in a model to determine plants that are suitable for planting in Salatiga areas. Meanwhile, this study was using the Fuzzy Logic method in a model in the form of an instrument design to predict plants that are suitable to be planted on land to optimize agricultural land.

At this time fuzzy logic has been widely used in various studies. Fuzzy logic was used in rainfall modeling for South Western Nigeria [10]. A fuzzy expert system was developed to recognize changes in temperature, humidity and lighting within a plant area and determine the level of light intensity [11]. Fuzzy logic based structure for plant disease forecasting system, it has been shown that the proposed method can be implemented with minimum weather data such as temperature and humidity [12]. Using a weather model based on fuzzy logic, the proposed system is a hybrid system that is used to solve one problem, namely to produce the best irrigation advice for farmers [13]. Fuzzy logic is used to deal with imprecision, ambiguity and insufficient knowledge. Fuzzy logic allows expert systems to work optimally with uncertain or ambiguous data and knowledge [2].

2. METHODS

In this study, two stages of implementation were conducted, namely the hardware design stage and software design in the form of predictive system modeling using the fuzzy logic method. In addition, it will also explain how to use the tool.

2.1 Hardware Design

In designing the hardware, components to be used were selected and tool designs and circuit schematics were used. The components used were the soil pH sensor, YL-69 Humidity sensor, and DS18B20 Temperature sensor which later entered the Atmega 328 Microcontroller (Arduino Uno) input for processing. Then, to seen the output, the output will be displayed directly on the LCD. In this tool the power source used is a 2000 mAH Lipo Battery which will be connected to the UBEC 5A. Figure 2 below visualizes the design of the tool and the schematic of the circuit used.

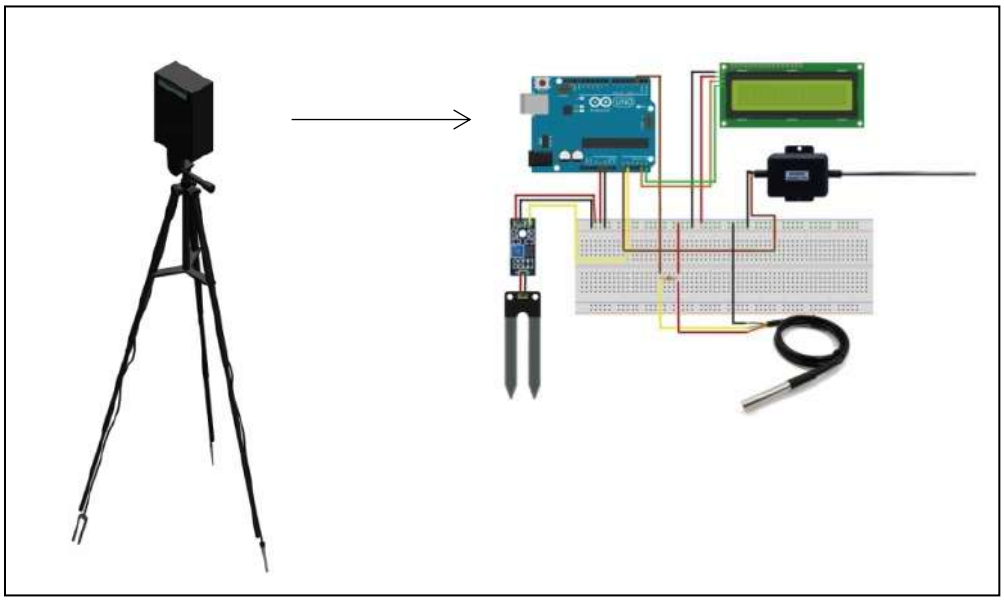

Figure 1. Tool Design and Hardware Circuit Schematic

2.2 Software Design

The design of the software that was made is very important in terms of the mathematical processing of the entire program. The core of this software design is the system workflow design using the Fuzzy Logic method.

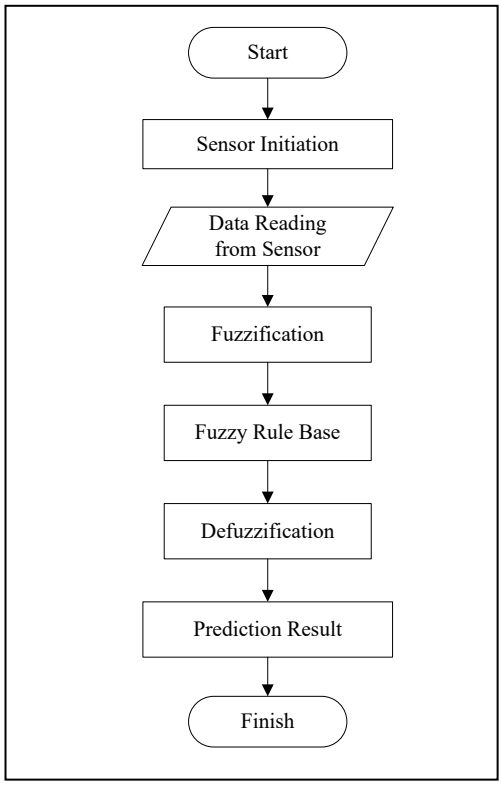

Figure 2. Software Flowchart

Prediction process using Fuzzy Logic [14]:

1. Fuzzification
   Fuzzification is a process of converting existing firm values into membership functions. In this study, 3 input variables were used, namely soil pH, soil temperature, and humidity using 8 outputs, namely Unfavorable Land, Spinach, Cayenne Pepper, Beans, Long Beans, Cucumber, Eggplant, and Tomatoo.
2. The basic rule (rule-based) on fuzzy logic control is a form of "if-then" relation rules as follows: if x is A then y is B where A and B are linguistic values defined in the range of variables X and Y, where the statement "x is A" is called the antecedent or premise, while the statement "y is B" is called the consequent or conclusion.
3. Reasoning (Inference Machine)
   The reasoning engine is a process of implication in reasoning the input value in order to determine the output value as a form of decision making. One reasoning model that is widely used is max-min reasoning. In this reasoning, the first process that is carried out is to perform the min operation of the fuzzification layer output signal which is continued with the max operation to find the output value which will then be defuzzified as an output form.
4. Defuzzification.
   The input of the defuzzification process is a fuzzy set obtained from the composition of fuzzy rules, while the resulting output is a number in the domain of the fuzzy set. Thus, if given a fuzzy set within a certain range, it must be able to take a certain crisp value.

2.3 How to Use the Tool

The following is how to operate the tool:

1. Make sure the kit is properly installed and connected to the 2000 mAH Lipo battery which has been connected to the UBEC 5A.
2. If the tool is in good condition, plug the soil pH Sensor, DS18B20 Temperature Sensor, and YL-69 Soil Moisture Sensor into the land to be checked for crop suitability (the tool's support pole can be lengthened and shortened as needed).
3. For the soil pH sensor, try to wet the soil in the area where the sensor is placed first (the soil is moist), so that the soil pH sensor can produce accurate values or measurement results.
4. If all sensors have been properly plugged into the ground, then press the ON button to turn on the tool, then

after pressing the ON button the tool will immediately turn on, the LCD will display "Power ON".
5. After turning on, the tool will automatically work and will immediately display the Prediction results on the LCD.
6. To see the results of Prediction plants that are suitable for planting, it takes approximately 1-3 minutes.
7. The prediction results are strongly influenced by the value read by the sensor, so make sure that the sensor is in good condition.
8. To disable/turn off the appliance, press the OFF button, the appliance will turn off automatically.

3. RESULTS AND DISCUSSION

3.1 Results of Reading Data from the Tool

Testing of this tool was carried out in several locations of agricultural land in the city of Palembang, where this location included agricultural land in rice fields where there was silty soil (alluvial) and humus soils as well plantation areas where there was red-yellow soil (podzolicl). The results of the data from the test were as follows:

a. Muddy Soil (Alluvial))

Table 1. Results of Data Reading on Muddy Soil (Alluvial)

pH Sensor	Soil meter	Difference	Error (%)	Temp. Sensor (◦C)	Soil Meter	Differe-nce	Error (%)	Moisture Sensor (%)	Soil Meter
5,03	5,7	0,67	11,7	33	34	1	2,94	163	WET+
5,03	5,8	0,77	13,3	31	34	3	8,82	164	WET+
4,96	5,6	0,64	11,4	34	36	2	5,71	150	WET+
Error Average			12,1				5,82		

b. Humus Soil

Table 2. The Result of Data Reading on Humus Soil

pH Sensor	Soil meter	Difference	Error (%)	Temp. Sensor (◦C)	Soil Meter	Differe-nce	Error (%)	Moisture Sensor (%)	Soil Meter
5,4	5,2	0,2	3,85	34	33	1	3,03	84	WET+
5,7	6,0	0,3	5	33	33	0	0	77	WET+
5,7	6,0	0,3	5	33	33	0	0	80	WET+
Error Average			4,62				1,01		

c. Red-Yellow Soil (Podzolic)

Table 3. The Result of Data Reading on Red-Yellow Soil (Podzolic)

Ph Sensor	Soil meter	Difference	Error (%)	Temp. Sensor (◦C)	Soil Meter	Differe-nce	Error (%)	Moisture Sensor (%)	Soil Meter
4,61	5,4	0,79	14,62	25	29	4	13,8	40	DRY
4,63	5,7	1,07	18,77	29	30	1	3,33	56	DRY
7,39	6,0	1,39	23,17	25	29	4	13,8	72	DRY
Error Average			18,85				10,31		

The Formula of Error Cacluation:

$$\text{Error (\%)} = \frac{Difference}{Reading\ of\ Measurement\ Instrument} \text{ x } 100\% \quad (1)$$

$$\text{Error Average} = \Sigma \frac{Error}{Testing} \quad (2)$$

From the table above, the average error value of the three land tests on the pH sensor is 11.86% on the

temperature sensor of 5.71%. meanwhile, the Humidity sensor obtained quite a good category value since on the soil meter 30-49% is DRY and ≥70% is WET+ [15]. The resulting value indicates that the level of accuracy of the sensors used is quite good. Data reading from this tool is used to predict plants that are suitable for planting on the land.

3.2 Prediction using Fuzzy Logic

a. Formation of a Fuzzy Set or Fuzzification

Table 4. Fuzzy Set

Fuzzy Variable	Fuzzy Set	Domain
Soil pH	Acid	[0, 5]
	Neutral	[4.5, 7.5]
	Base	[7, 14]]
Temperature (◦C)	Low	[0, 18]
	Normal	[15, 35]
	High	[32, 45]
Soil Humidity (%)	Low	[0, 40]
	Normal	[35, 90]
	High	[85, 130]

The membership function of the pH variable is represented in Figure 3 below:

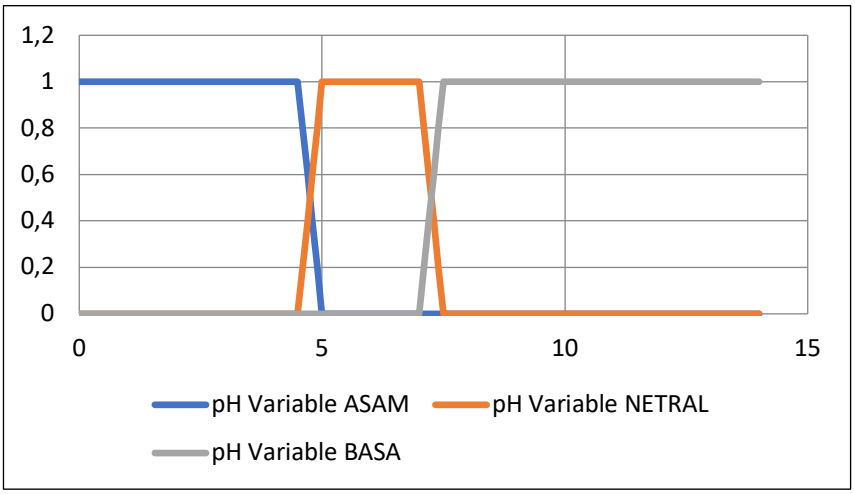

Figure 3. Membership function of pH Variable

$$\mu\text{Acid}\,(x) = \begin{cases} 1 & ;\ x \le 5 \\ \frac{(5-x)}{(5-4,5)} & ;\ 4,5 \le x \le 5 \\ 0 & ;\ x \ge 18 \end{cases} \quad (3)$$

$$\mu\text{Neutral}\,(x) = \begin{cases} 0 & ;\ x \le 4,5 \\ \frac{(x-4,5)}{(5-4,5)} & ;\ 4,5 \le x \le 5 \\ 1 & ;\ 5 \le x \le 7 \\ \frac{(7,5-x)}{(7,5-7)} & ;\ 7 \le x \le 7,5 \\ 0 & ;\ x \ge 7,5 \end{cases} \quad (4)$$

$$\mu\text{Base}\,(x) = \begin{cases} 0 & ;\ x \le 7 \\ \frac{(x-7)}{(7,5-7)} & ;\ 7 \le x \le 7,5 \\ 1 & ;\ x \ge 7,5 \end{cases} \quad (5)$$

The membership function of the Temperature variable is represented in Figure 4 below:

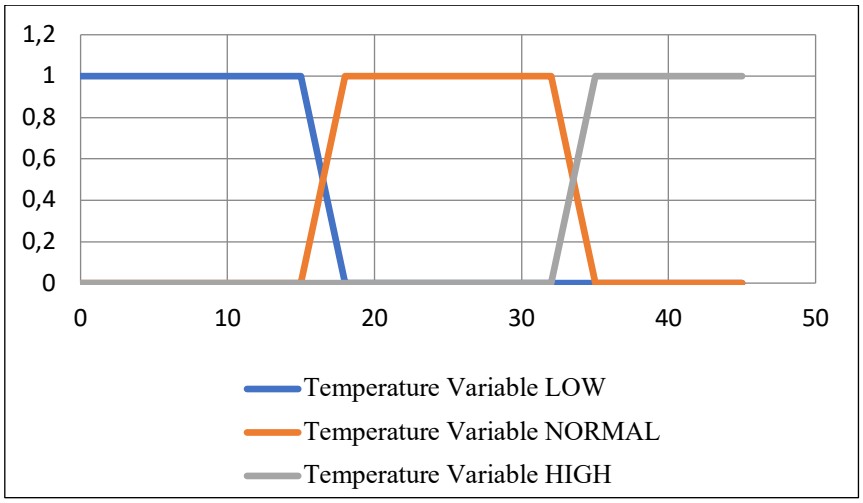

Figure 4. Membership function of Temperature Variable

$$\mu\text{Temperature Low}\,(x) = \begin{cases} 1 & ;\ x \le 15 \\ \frac{(18-x)}{(18-15)} & ;\ 15 \le x \le 18 \\ 0 & ;\ x \ge 18 \end{cases} \quad (6)$$

$$\mu\text{Temperature Normal}\,(x) = \begin{cases} 0 & ;\ x \le 15 \\ \frac{(x-15)}{(18-15)} & ;\ 15 \le x \le 18 \\ 1 & ;\ 18 \le x \le 32 \\ \frac{(35-x)}{(35-32)} & ;\ 32 \le x \le 35 \\ 0 & ;\ x \ge 35 \end{cases} \quad (7)$$

$$\mu\text{Temperature High}\,(x) = \begin{cases} 0 & ;\ x \le 15 \\ \frac{(x-32)}{(35-32)} & ;\ 32 \le x \le 35 \\ 1 & ;\ x \ge 35 \end{cases} \quad (8)$$

The Membership function of the Moisture variable is represented in Figure 5 below:

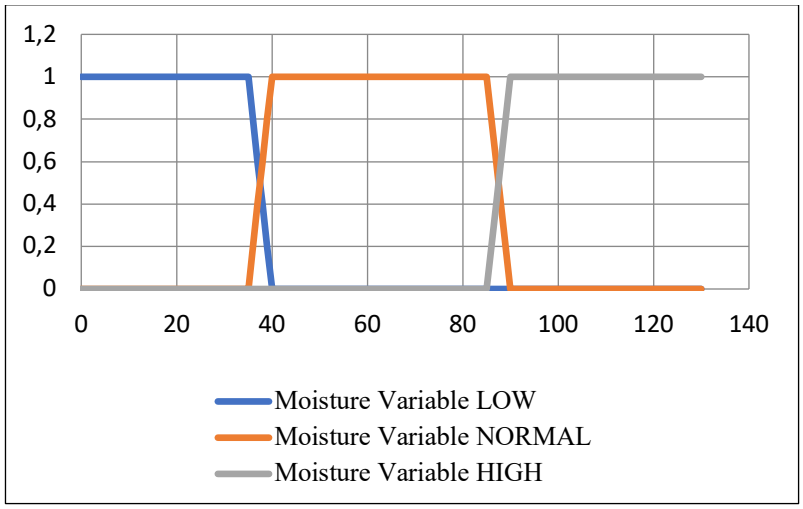

Figure 5. Membership function of Moisture Variable

$$\mu\text{Moisture Low}\,(x) = \begin{cases} 1 & ; x \leq 35 \\ \frac{(40-x)}{(40-35)} & ; 35 \leq x \leq 40 \\ 0 & ; x \geq 40 \end{cases} \quad (9)$$

$$\mu\text{Moisture Normal}\,(x) = \begin{cases} 0 & ; x \leq 35 \\ \frac{(x-35)}{(40-35)} & ; 35 \leq x \leq 40 \\ 1 & ; 40 \leq x \leq 85 \\ \frac{(90-x)}{(90-85)} & ; 85 \leq x \leq 90 \\ 0 & ; x \geq 90 \end{cases} \quad (10)$$

$$\mu\text{Moisture High}\,(x) = \begin{cases} 0 & ; x \leq 85 \\ \frac{(x-85)}{(90-85)} & ; 85 \leq x \leq 90 \\ 1 & ; x \geq 90 \end{cases} \quad (11)$$

b. Rule-Based

Fuzzy Rules were formed from three defined input variables, by analyzing the limit data of each fuzzy set on each variable. Then, 27 rules were formed according to the knowledge base that might be used in this system, with the arrangement of IF rules as follow: IF pH IS … AND Temperature IS … AND Moisture IS ... THEN Plant IS …. The results are presented in Table 5 as follows:

Table 5. Rule Based

pH	Temperature	Humudity	Plant
Acid	Low	Low	Less Good Land
Acid	Low	Normal	Less Good Land
Acid	Low	High	Less Good Land
Base	Low	Low	Less Good Land
Base	Low	Normal	Cucumber
Base	Low	High	Cucumber
Neutral	Low	Low	Less Good Land
Neutral	Low	Normal	Cucumber
Neutral	Low	High	Cucumber
Acid	Normal	Low	Less Good Land
Acid	Normal	Normal	Eggplant
Acid	Normal	High	Less Good Land
Base	Normal	Low	Spinach
Base	Normal	Normal	Spinach, Cayenne Pepper, bean, Cucumber
Base	Normal	High	Cucumber
Neutral	Normal	Low	Spinach
Neutral	Normal	Normal	Spinach, Cayenne Pepper, bean, Long Beans, Cucumber, Eggplant, Tomato
Neutral	Normal	High	Cucumber
Acid	High	Low	Less Good Land
Acid	High	Normal	Less Good Land
Acid	High	High	Less Good Land
Base	High	Low	Spinach
Base	High	Normal	Spinach
Base	High	High	Less Good Land
Neutral	High	Low	Spinach
Neutral	High	Normal	Spinach, Long Beans
Neutral	High	High	Less Good Land

c. Inference Machine

After the rules were made, the next step was to determine the membership value by using the Min implication function based on the fuzzy rules that had been made. Then next, the maximum value from the rule output was taken to obtain a fuzzy set solution, which produced an output.

3.3 Fuzzy Logic Prediction Results on the Tool

Fuzzy Logic that had been modeled was then programmed using Arduino IDE. Thus, the prediction results can be directly displayed on the LCD of the tool.

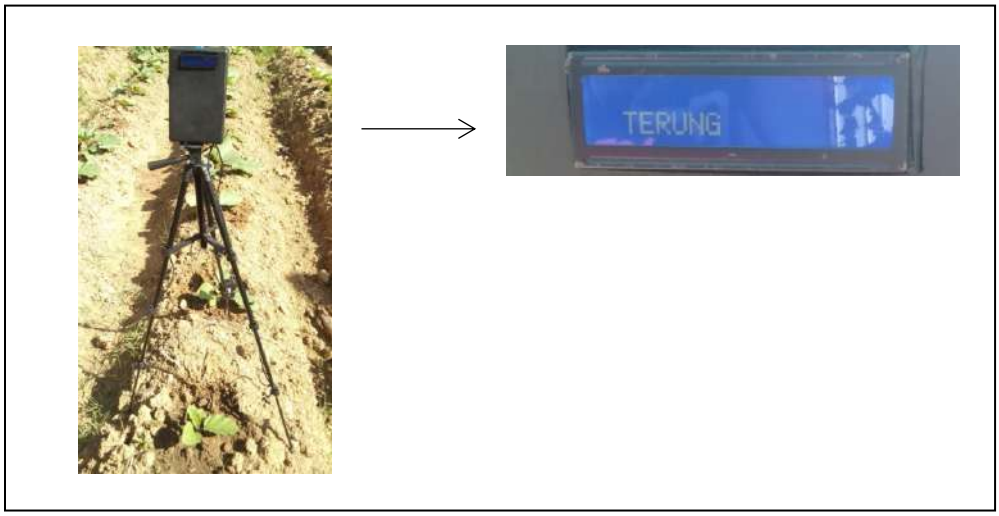

Figure 6. Results of Crop suitability Prediction

The following are the results of predictions using fuzzy logic carried out on two types of land, namely rice fields and plantations where there are three types of soil, namely alluvial, humus, and podzolic. The test carried out in this study were carried out periodically within three consecutive days at the same hour.

a. Rice Fields (Muddy Ground (Alluvial)), conducted on June 17-19, 2021 at 10.30 am (Indonesian Western Time)

Table 6. The Prediction Result on Muddy Soil (Alluvial)

Ph Sensor	Temperature Sensor	Moisture Sensor (%)	Prediction of Fuzzy Logic	Condition of Actual Data	Suitable/ Unsuitable
5,03	33	163	Cucumber	Rice/ Less Good Land	Unsuitable
5,03	31	164	Cucumber	Rice/ Less Good Land	Unsuitable
4,96	34	150	Less Good Land	Rice/ Less Good Land	Suitable

b. Rice Fields (Humus Soil), conducted on June 17-19, 2021 at 11.30 am (Indonesian Western Time)

Table 7. The Prediction Result of Humus Soil

Ph Sensor	Temperature Sensor	Moisture Sensor (%)	Prediction of Fuzzy Logic	Condition of Actual Data	Suitable/ Unsuitable
5,4	34	84	Spinach and Long Beans	Long Beans	Suitable
5,7	33	77	Spinach, Cayenne Pepper, bean, Long Beans, Cucumber, Eggplant, Tomato	Cayenne Pepper, Long Bean, Eggplant, Tomato	Suitable
5,7	33	80	Spinach, Cayenne Pepper, bean, Long Beans, Cucumber, Eggplant, Tomato	Cayenne Pepper, Long Bean, Eggplant, Tomato	Suitable

c. Plantation Land (Red-Yellow Land (Podzolic), conducted on June 1-3, 2021 at 11 am (Indonesian Western Time)

Table 8. The Prediction Result of Red-Yellow Soil (Podzolic)

Ph Sensor	Temperature Sensor	Moisture Sensor (%)	Prediction of Fuzzy Logic	Condition of Actual Data	Suitable/ Unsuitable
4,61	25	72	Eggplant	Eggplant	Suitable
4,63	29	56	Eggplant	Eggplant	Suitable
7,39	25	40	Spinach, Cayenne Pepper, Bean, Cucumber	Cayenne Pepper	Suitable

$$\text{Accuracy (\%)} = \frac{Number\ of\ Suitable\ Data}{Total\ of\ All\ Data} \text{ x } 100\%$$
$$= \frac{7}{9} \text{ x } 100\%$$
$$= 77{,}78\%$$

From the results of the calculation above, it can be seen that the accuracy of prediction of crop suitability using fuzzy logic has an accuracy of 77.78, Where the resulting value is quite good. In this study, the data read by the tool will greatly affect the prediction results, so the accuracy of the sensor must always be in good condition.

4. CONCLUSION

From the study that has been done, it can be concluded that fuzzy logic as a method used to predict crop suitability on agricultural land has a fairly good accuracy, which is above 75%. In this study, the output or predictions produced are strongly influenced by the input data from the tool. Thus, good accuracy is needed in the data generated by the sensors used in the tool.

The pH sensor has an error percentage of 11.86%, the DS18B20 sensor of 5.71%, and the YL-69 humidity sensor of a fairly good accurate value. From these results, it can be seen that the result of the percentage error on the pH sensor is quite large. Thus, in its implementation, correct measurements are required in order to produce accurate data.

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LOGIC
Journal of Engineering Design and Technology
Vol. 21 No. 3 November 2021; p. 149 – 158

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

AUCTION APPLICATION FOR BERINGKIT ANIMAL TRADITIONAL MARKET BASED ON ANDROID

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Abstract. Beringkit Animal Market is one of the large traditional animal markets in Bali which is famous for selling superior cows. In addition to selling superior cows, Beringkit Animal Market also sells dogs and various types of poultry such as chickens, ducks and roosters. However, in the midst of the COVID-19 outbreak, traditional markets are considered as the main cluster for the spread of COVID-19 due to the large number of interactions between buyers and traders. The implementation of Community Activity Restrictions (PPKM) has resulted in a lack of income for traders at the Beringkit Animal Market. This study aims to design an Android-based online animal auction application as a medium for buying and selling animals to minimize physical interaction between buyers and traders, the online auction transaction process is chosen because the auction transaction process can bring together traders and buyers in the same online media and make offers up to reach the highest agreed price. The research method applied is the DSRM method or Design Security Research Method, application development uses Android Studio to develop mobile applications, and uses Visual Studio Code to develop web-based systems. Data storage and web server management in this study using MySQL and Laravel. The results of this study are in the form of an Android-based animal auction application that can be used as a medium for transactions between buyers and traders who have gone through the blackbox testing process with the test results as expected.

Keywords : android, auction application, traditional market, animal market, covid-19

1. INTRODUCTION

Traditional markets are an important place for the survival of most people, the atmosphere of traditional markets which are often simple makes traditional markets feel more friendly to various groups of people. Both the lower middle class and the upper middle class do not feel reluctant to visit traditional markets which always survive to help meet the needs of people's lives when supermarkets and other modern markets go bankrupt. Beringkit Animal Market is one of the big traditional animal markets in Bali which is famous for selling superior cows. In addition to selling superior cows, at the Beringkit Animal Market there are also sellers of dogs and various types of poultry such as chickens, ducks and roosters [1].

Since March 2, 2020, President Joko Widodo announced that Indonesia had been tested positive for the Covid-19 outbreak [2]. As a step to suppress the positive number of Covid-19, the government, especially the Ministry of Health, issued a regulation, namely Large-Scale Social Restrictions (PSBB). Restrictions on community activities include schools and offices being closed, restrictions on activities in crowded places or public facilities. Regarding the PSBB policy, the governor of Bali issued Bali Governor Instruction number 8551 of 2020 regarding the strengthening and prevention of Covid-19 by holding Community Activity Restrictions or commonly called PPKM, namely the Enforcement of Restrictions on Community Activities [3].

In response to the Bali Governor's instructions regarding PPKM, the Head of Binmas Badung Police and the President Director of Beringkit Market imposed PPKM activities within the Beringkit Animal Market which is considered the main cluster for the spread of Covid-19 [4], the implementation of PPKM with a system of limiting the number of visitors resulted in a decrease in the income of traders [5].

Technological advances in this era of globalization allow physical buying and selling activities in the market to be minimized, by relying on the internet and applications that are connected online, the transaction process can be carried out without the need to meet face to face [6]. Utilizing technological advances, researchers designed an Android-based online animal auction application to minimize physical buying and selling activities at the Beringkit Animal Market. The reason for choosing to use online applications during the Covid-19 pandemic is because online buying and selling activities have increased during the pandemic. Based on research, the convenience factor is the main factor in increasing online buying and selling activities [7]. The selection of the auction system as a transaction method is also based on the fact that the auction system has advantages such as enthusiastic bidding activities, a fast and effective process, and high prices obtained from enthusiastic bidding activities [8].

2. METHODS

2.1 Research Method

The research method applied in this study is the DSRM (Design Science Research Method) research method which consists of the stages of problem identification, goal setting, design, case studies, evaluation and communication. [9].

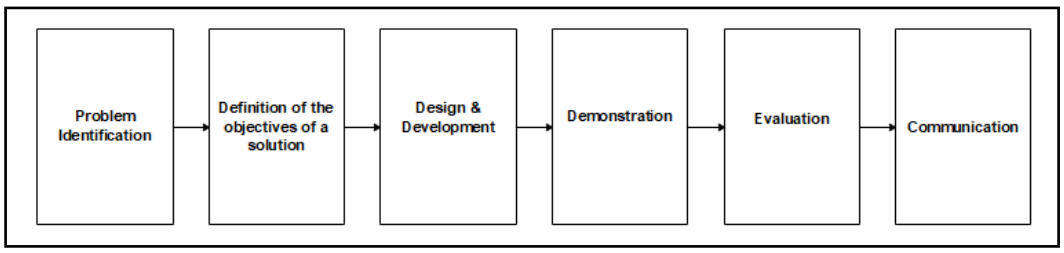

Figure 1. Design Science Research Methodology (DSRM)

a. Identify problem and motivate
The first stage is the identification of the problem, at this stage observations are made to the location to identify the problems that occur in the Beringkit Animal Market and conduct a literature study.

b. Define Objectives of a solution
The next stage is to group the problems and provide solutions to the market head and supervisor of Beringkit Animal Market.

c. Design and development
The design phase carried out is to design an overview of the system, design a system tiered chart, design a system database and web service using Laravel and MySQL, design a mobile application using Android Studio, and design a web-based system using Visual Studio Code.

d. Demonstration
The demonstration stage is carried out before carrying out the implementation, namely by conducting socialization and testing of the developed application to find out the errors contained in the application module during development. Besides, the demonstration also aims to get input from application users.

e. Evaluation
The next stage is the evaluation stage which is carried out to find out system weaknesses or system deficiencies. Is the application developed in accordance with the needs or still needs to be improved.

f. Communication
The communication stage of application development is by documenting the knowledge that is collected widely and can be discussed in the academic community in the form of seminars and scientific articles.

2.2 System Overview

An overview of the system regarding Android-Based Animal Auction Application Design for Beringkit Animal Market can be seen in Fig. 2 following.

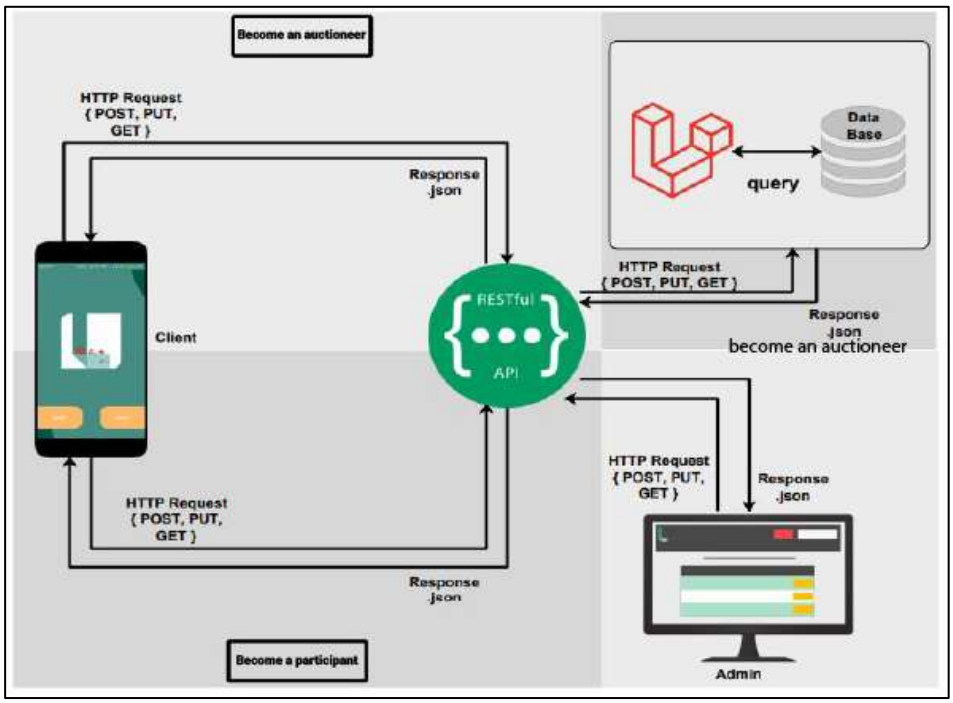

Figure 2. Animal Auction System Overview

The Beringkit Animal Market Animal Auction System has two types of users, namely clients and admins, clients can also be auctioneers or auction participants. The request sent through the client or admin is in the form of an HTTP Request, the request can be in the form of a POST, PUT, or GET method request sent to a web service. The web service on this system is built using the Laravel framework which is connected by implementing the REST architecture. The result of the HTTP Request that is query to the database will get a response in the form of JSON which will be forwarded to the client or admin.

2.3 System Tiered Chart

A tiered chart is a chart that illustrating the division function of the whole system, starting from the system into a sub-system that smaller [10]. Tiered chart of Android-Based Animal Auction Application Design for Beringkit Animal Market can be seen in Fig. 3 following.

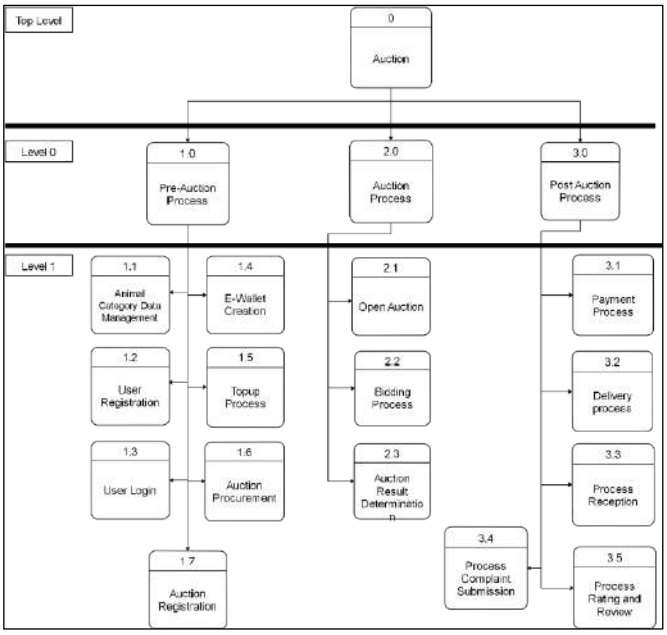

Figure 3. Animal Auction System Tiered Chart

The Beringkit Animal Market Animal Auction System is described in the form of a tiered chart and will be explained as follows.

1). Top Level consisting of the Auction Process.
2). Level 0 which consists of Pre-Auction Process, Auction Process, and Post-Auction Process.
3). Level 1 which consists of sub-processes from the three processes at level 0, namely Animal Category Data Management sub-process, User Registration sub-process, User Login sub-process, E-Wallet Creation sub-process, Topup Process sub-process, Auction Procurement sub-process, and sub-process Auction Registration process which is a sub-process of the Pre-Tender Process. Auction Opening sub-process, Bidding Process sub-process, and Auction Result Determination sub-process which are sub-processes of the Auction Process. Sub-process Payment Process, Sub-Process Delivery Process, Sub-Process Acceptance, Sub-Process Complaints Sub-process which is a sub-process of the Post-Auction Process.

3. RESULTS AND DISCUSSION

The Beringkit Animal Market Animal Auction application is an application that was built with the aim of minimizing physical buying and selling activities at the Beringkit Animal Market in the midst of the Covid-19 outbreak, the use of the auction system as a transaction method that can increase the selling value of animals through enthusiastic bidding activities is expected to increase the income of the traders at the Beringkit Animal Market.

The auction process in the Beringkit Animal Market Animal Auction Application is made using the chat room feature so that bargaining activities can be seen directly by fellow users who are online. This chat room feature allows application users to get instant messaging [11], instant messaging is obtained by users in the form of Bid Reports from every bargaining activity that occurs.

Research on mobile-based auction applications has previously been carried out by Andri and Suyanto (2020) [12], the difference in these two studies lies in the end time of the auction which in previous study the auction end time of the auction had been determined, while in this study the end time of the auction is when there is no more bidding activities.

This difference was also found in previous study conducted by Adam et al (2021) [13], in which the end time of the auction had been determined, not when there was no more bidding activity during the auction.

However, the two previous studies have similarity with this study, which is using the auction application as a medium to facilitate and streamline the transaction process between the traders and the buyers.

3.1 Implementation

The following is the result of the development of the Android-based Beringkit Animal Market Animal Auction System.

Figure 4. Application Home Menu Display

The initial menu display contains the application icon and two buttons for choice, namely the Signin button which will be directed to the Fig. 4 and the Signup button which will be directed to the Fig. 5.

Figure 5. Application Sign Up Interface Display

The Signup interface is a display for new users to register, by sending their name, email, telephone number, password and also their NIK.

Figure 6. Application Sign In Interface Display

The Signin interface is a display for users to be able to sign in, by entering their e-mail and password as a condition for signing in. Users who have successfully signed in will be directed to the interface as shown in Fig. 7.

Figure 7. Application Main Menu Interface Display

The main menu interface display is an interface that displays the "Logout" button for users who want to log out, the "Topup" button to go to the Topup menu, the "View Auction" button to go to the Auction menu, the "Check Auction Request" button to go to the Auction Request menu, button “You are the Auctioneer” and “You

are the Participant" on the Auction menu, and the "Check Auction Transaction Activity" button goes to the Auction Transaction Activity menu and also displays the user's username, user e-mail, and the user's temporary balance.

Figure 8. Auction Room Display

The Auction Room interface is a display for the auction process to occur, each participant can make a bid by selecting the BID button to secure a position as the winner of the auction and win the animal being auctioned. Each bid that occurs will be added to the value of the temporary auction price and the amount will appear on the Bid Display number display and new information will also appear about who conducted the auction, on what date and at what time the bidding was made on the Bid Report display. The user who bids and manages to survive until the time runs out will be the winner, an explanation of the auction process is also made in pseudocode as shown in Fig. 9. Pseudocode is a description of a programming algorithma computer that uses the simple structure of some programming languages but those languages only intended to be easily readable by humans [14].

```
BEGIN
Additional Time each Bid = 30 seconds
Value Up each Bid = Rp 25.000
Price Start From = Rp 50.000
        Timer CountDown Start at 05 minutes, 00 seconds (05.00)
        WHILE Timer CountDown at 04 minutes, 00 seconds (04.00)
                If ( User1 Bidding ) {
                Timer CountDown add Additional Time each Bid
                Price Start From add Value Up each Bid }
        Timer CountDown Start at 04 minutes, 30 seconds (04.30)
        Price Up to Rp 75.000
        WHILE Timer CountDown is finish (00.00)
                If (User1 = Last Bidder) {
                User1 = Winner }
END
```

Figure 9. Auction Process Pseudocode

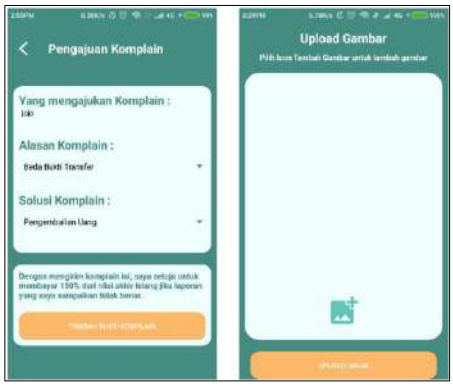

Figure 10. Complaint Submission Form Display

The interface for the Complaint Submission Form is an interface for participants who won the auction or the auctioneer can file a complaint for the incompatibility of the transaction evidence sent, participants who won the auction or the auctioneer can submit a complaint by choosing the reason for their complaint and the solution they want. The reasons that can be selected include "Different Proof of Transfer" and "Different Evidence of Animals" then for the solutions that can be selected including "Refunds" and "Replacement of Animals", the auctioneer or auction participant who has chosen the reason and solution for the complaint can select the Add Proof of Complaint button. The provisions that apply after selecting the Add Proof of Complaint button are that if the complaint submitted turns out to be incorrect or with the intention of bringing down one of the parties without clear evidence, they will be penalized by paying 150% of the transaction value.

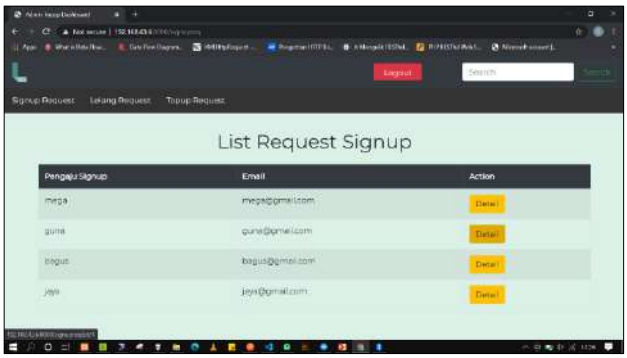

Figure 11. Display Request Signup on Admin

The interface display for the request or signup request details on the admin is a display for admins to see more complete data from prospective users who send requests for further validation of their requests The user has validated the request will be confirmed by the admin via the phone number or email that the user has provided.

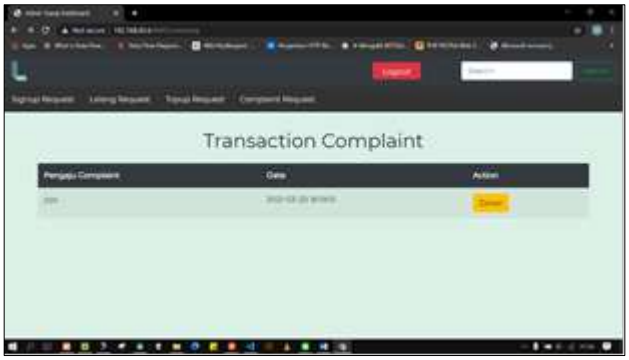

Figure 12. Display Complaint Request on Admin

The Complaint Request interface on the Admin is a display for the admin to see every complaint request from the user.

3.2 Black Box Testing

Blackbox testing is a test that is carried out by focusing on the functionality capabilities of a software, blackbox testing allows application developers to create several input conditions that will ensure the functionality and compatibility requirements of the application and make it possible to find error gaps that may exist in the application. The test aspects tested in blackbox testing are only on the input and output set using the user's point of view, blackbox testing is easy to use because the test uses a complete finished product and does not require knowledge of its construction [15].

Table 1. Black Box Testing Result

User	*Test Scenario*	*Test Conditions*	*Expected results*	*Test result*
Prospective User	Sign up with a phone number that is less than 10 characters	Name: galang Email: galang@gmail.com Telephone: 081123456 NIK:5112345640495960 Password: 12345	An error message appears "The number you entered is incorrect"	According to expectations
Prospective User	Do a re-signup with a telephone number of 10 characters or more	Name: galang Email: galang@gmail.com Telephone: 0811234569 NIK:5112345640495960 Password: 12345	Successfully signed up a new user	According to expectations
Admin	Check and submit signup data	Data that appears, Name: galang Email: galang@gmail.com Telephone: 0811234569 NIK:5112345640495960	The data that appears is in accordance with the signup input data by the prospective user and the new user data has been added	According to expectations
User	Login using email and password	Email: galang@gmail.com Password: 12345	*User has successfully logged into the application*	According to expectations
User	Newly logged in users will be taken to the create e-wallet view to create a new e-wallet as a transaction aid	New users login and don't have an e-wallet id yet	Users are taken directly to the create e-wallet screen after successfully logging in	According to expectations
User	Make a topup request to increase the e-wallet balance	Nominal: 100000	Successfully made a topup request	According to expectations
Admin	Check and submit topup request data	Data that appears, Name: galang Nominal: 100000	The data that appears is in accordance with the input data requested by the user and the user's balance has increased	According to expectations
User	Login data in accordance with the data that appears in the user information field field	Name: galang Email: galang@gmail.com Saldo: 100000	The data that appears is in accordance with the user data	According to expectations

User	*Test Scenario*	*Test Conditions*	*Expected results*	*Test result*
User	Placed a bid and successfully maintained the bid value until timeout	Last bid value: 2150000 User: jojo	Auction ends automatically when time runs out and is immediately taken to the auction results view	According to expectations
User	Make a complaint request	Name: jojo Reason for complaint: Different proof of transfer Complaint solution: Refund Application time: 2021-03-20 16:19:51	Successfully made a complaint request	According to expectations
Admin	Check the complaint request data	The data that appears Name: jojo Reason for complaint: Different proof of transfer Complaint solution: Refund Application time: 2021-03-20 16:19:51	The data that appears is in accordance with the input request data submitted by the user	According to expectations

4. CONCLUSION

After going through the field studies, field observations, design, implementation and testing of an android-based animal auction application at the Beringkit Animal Market, it can be concluded that an android-based animal auction application has been built. According to the results of the implementation, the Android-based animal auction application has succeeded in simplifying and shortening the auction of auctioneers to find buyers and minimizing the use of parking lots by cattle delivery cars to wait for the sold cows to find potential buyers.

To achieve the perfection of this application, the author conveys several suggestions if you want to do further development on this application, namely, the addition of the nearest buyer search feature.

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LOGIC
Journal of Engineering Design and Technology
Vol. 21 No.3 November 2021; p. 159 - 164

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

SOLAR POWER SYSTEM DESIGN APPLICATIONS FOR POOL WATER PUMP OPERATION AT TOURIST ACCOMODATION

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Abstract. Utilization of solar energy in Indonesia has begun to bloom. This is due to the fact that Indonesia is located at the equator where the sun is exposed all year round and is a very environmentally friendly energy. Based on this, solar energy is used as an option to meet electricity needs by using a photovoltaic (PV) system. The use of a photovoltaic system as a power provider to operate a pool water pump at a villa in Bali is an example of the application of a photovoltaic system. In this study, A Seri and Parallel photovoltaic arrays were used with a panel system that was integrated with PLN electricity. The angle of inclination and direction of placement chosen in this study is 15° with facing north, which refers to research that, has been done previously. PV designs and a series of control panels that can be accessed via the internet will be described as well.The aim in this research is investigate how photovoltaic design used as a solar power plant which applied to the module can be runing the pool water pump in the villa or tourist accommodation.

Keywords: photovoltaic, design modul, water pump

1. INTRODUCTION

Energy is one of the main needs in human life. The use of solar energy in Indonesia has very good prospects, considering that geographically as a tropical country, across the equator, the potential for solar energy is quite good. Utilization of Solar Energy through photovoltaic conversion has been widely applied, among others, the application of individual systems and hybrid systems, namely a system of combining conventional energy sources with renewable energy sources [1]-[4]. There is no denying that solar energy is a promising and clean energy sources, because there is no defilement produced during the energy alteration process, and the energy sources are highly available on earth very much. Therefore many simple module designs were introduced to utilize solar energy. [5]-[12]. Wirajati, el.al.[13]-[14] conduct research about experimental a Building Integrated Photovoltaic (PV) and showing result that photovoltaic is very eligible to be implemented in the building in Bali-Indonesia area as the tropical country, however need to be improvement in term of investment cost. In addition, Santosa et al. [15] stated that photovoltaic from building application devices energy sources are very good for the future, since energy efficiency already improved to achieve a net zero energy building.

In this study, a photovoltaic panels array with Seri and Parallel connection are used to generate electricity stored in the battery. A hardware device was built which would later be connected to the telecommunication network in order to be able to monitor the performance of PLTS remotely using phone application.

2. METHODS

This research was conducted in one of the villas located in the village of Ubud, Gianyar Regency, Bali Province. The solar power system which is installed to operate the pool pump at the villa can be seen in Figure 1.

2.1 Working Principle of System Design

A solar module (photovoltaic) is a number of solar cells that are arranged in series and parallel, to increase the voltage and current generated so that it is sufficient for the use of the load power supply system. To get the maximum output of electrical energy, the surface of the proposed system must eternally into teh sun. Figure 2 shows an application of the proposed solar system design as a driving force for a pool water pump in one of the villas in Bali.

Application of solar power in villas or tourism accommodations with the integration of solar power with the PLN electricity network source. Photovoltaic circuits use a combination of series and parallel circuits. The current and voltage coming out of the solar panel is controlled by SCC (solar charge control) for the needs of the battery charging system and direct current (DC) supply. Then direct current (DC) from the battery is converted into alternating current (AC) with an inverter that is adjusted to the voltage from PLN. In combination with PLN, an ATS (Automatic Transfer Switch) system is used which is specially designed for solar power applications, where when the battery charging is below 30% or the voltage drops below 10 V, the electricity supply will automatically switch to PLN without pause. This transfer switch is made very smooth so that operations such as air conditioning, pool pumps and refrigerators are not disturbed at all. So with the combined management of this system, it is clear that the measurement of electricity consumption from PLN and solar power is clearly separated when the utility is operational. PLN's electricity consumption will be significantly reduced and the proportion of solar power can be increased frequently with optimization developments and lower investment costs for solar installations

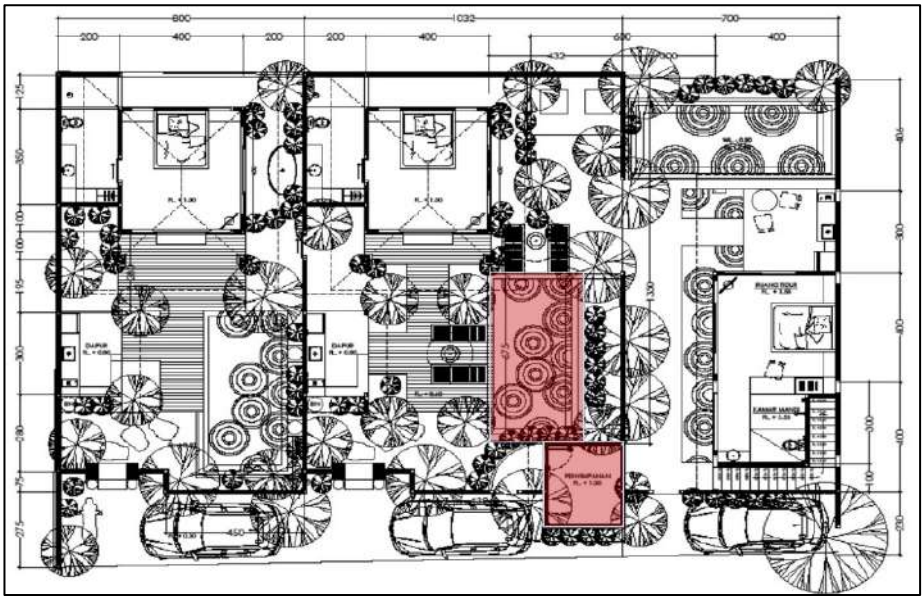

Figure 1. Research area on the villa

2.2 Design and Built System Flowchart

Figure 4 representative as a research flowchart. The research was carried out in the period from May to August 2021 The system is designed to operate the pool pump in the villa which is 12 m^2 area and depth of 1.5 m. The main component was assembly. The main components refer to all components asembled on the control panel. After the system design and main components are completed, then proceed with the installation of the system on the villa. Commisioning test and data retrieval are also proceed as well on the next day.

Table 1. Specification of PV Array

Variable	Value
Maximum power P_{max} (WP)	160
Voltage at P_{max} (V)	17.8
Current at P_{max} (A)	8.99
Open circuit voltage (V)	21.8
Short circuit current (A)	9.53
Panel size (mm)	1480 x 670 x 30
Weight (kg)	11.2
Cell type	Mono-crystalline silicon

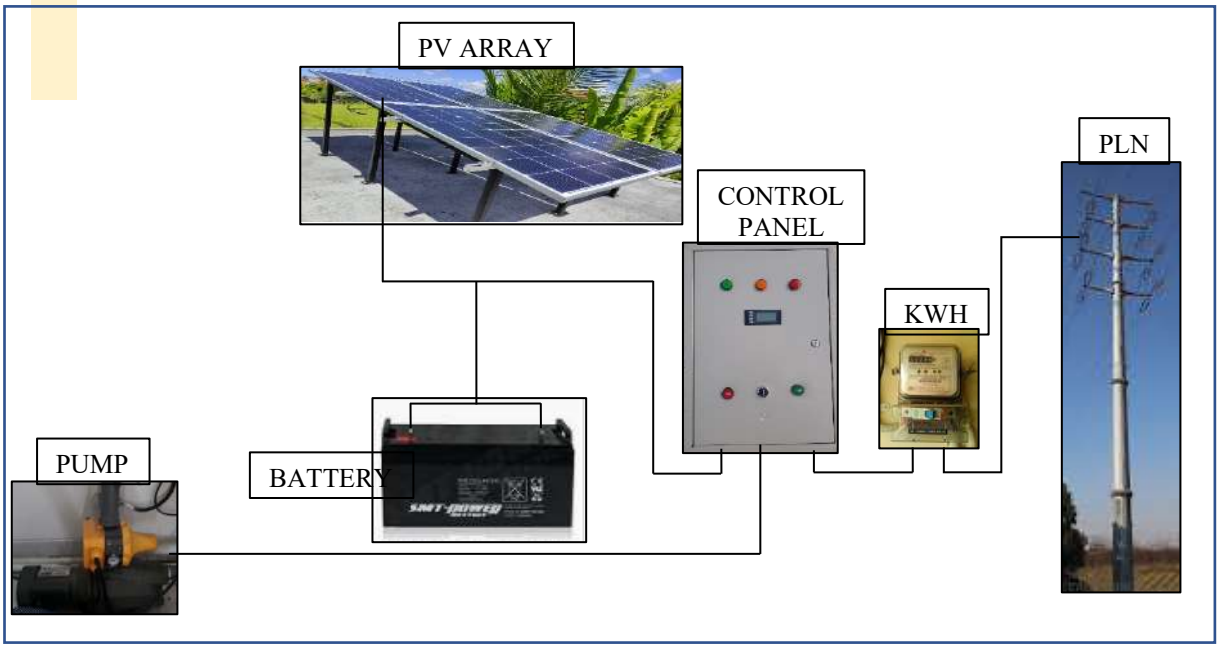

Figure 2. The Design of a Solar Power Pump for Pool Water Pumps in the Villa

Figure 3 System installation process

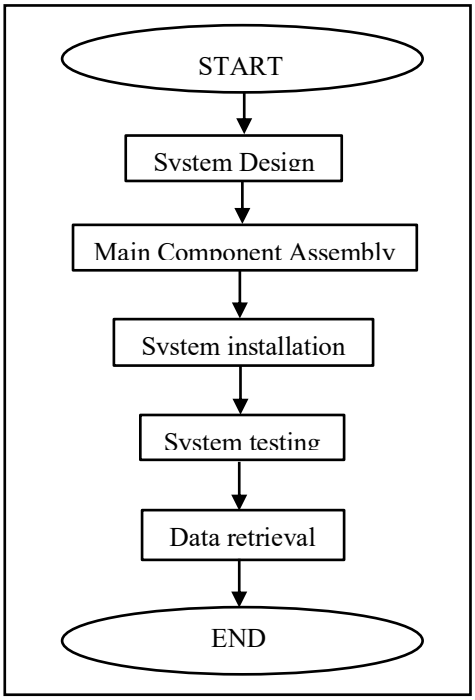

Figure 4. Research flowchart.

3. RESULTS AND DISCUSSION

3.1 System Block Diagram

Block diagram description:

a. Solar Panel
The main components of the system that can produce DC electrical energy called solar panels. Solar panels are made of semiconductor materials (usually silicon) which when exposed to sunlight can produce an electric current. The specification of PV array: peak power (P_{max}) : 160W, max power voltage (Vmp) : 17.8V, max power current (Imp) : 8.99A, open-circuit voltage(Voc) : 21.8V, short-circuit current (Isc) : 9.53A, power tolerance : +-3%, dimension(mm) : 1480x670x30mm, connector: MC4 plug type, cell BB : 12.

b. Battery
The battery or battery is a store of electrical energy when the sun is not there.
The specification of battery: Battery dry deep cycle solar panel, voltage : 12v, capacity : 100ah, dimension : 330(l) x 171(w) x 214(h) mm, terminal size : t11

c. Controller
In the controller has been assembled various equipment such as tracer solar charge controller real MPPT 40A auto 12/24V, contactor, delay timer relay + socket base 220VAC 60s, energy meter monitor LCD display with CT / Coil 0-100A, low voltage disconnect MCB DC 63A 440v 63 Ampere 2P mini circuit breaker, relay LY2N 220V 10A LY2N 220V 10A BM5, exhaust fan 120x120x38 220VAC.
It"s a device that regulates the charging of electric current from the solar panel to the battery and vice versa. When the remaining battery charge is 20% to 30%, the regulator will decide with the load. The battery regulator also regulates the overcharging of the battery and the overvoltage of the solar panels. The benefits of this tool are also to avoid full discharge and overloading and monitor battery temperature. Overvoltage and charging can reduce battery life. This controller is equipped with diode protection which prevents DC current from the battery from entering the solar panel again. There is one tool added to the controller called eBox wifi. It is a kind of serial server which can make solar controller and inverter be with wifi communication function, and carry out wireless monitoring, parameter settings, and etc. for the system only by cooperating with mobile phone APP

d. Inverter
Inverter is a device that converts DC current to AC according to the needs of the electrical equipment used. This tool converts DC current from solar panels into AC current for the needs of loads that use AC current. The specification of inverter: power inverter pure sine wave DC 12V to AC 220V 2000 watt.

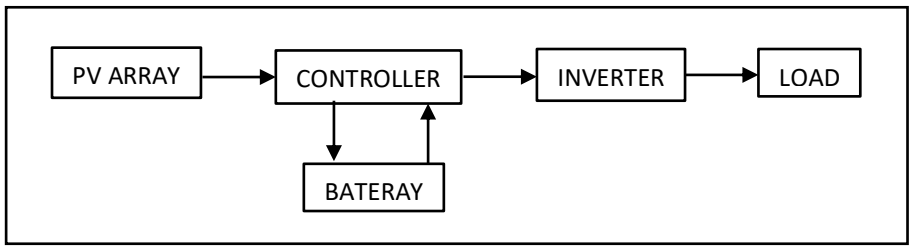

Figure 5. System Block Diagram

According to the Figure 5, the proposed model can be operated as follows: when sunshine, photovoltaic capture the radiation it produced. This pv's array is a union of various very little and flimsy solar cells arranged in series, parallel or mixed that can produce large currents and voltages as well.

How the module work is that if sunlight hits the panel then there is a transfer of an electron from N to P in the panel, and electrical energy can be generated from the terminal output on the panel. The panel will produce varying electrical energy and it depends on the number of solar cells on the panel. The result of this panel is in the form of direct current (DC) electricity whose output voltage depends on how many solar cells are installed in the panel and the amount of sunshine that flashes on the panel.

The outturn from this panel can be used properly for equipment that requires a DC voltage source with a small current usage. To be able to use it at night, the electrical energy obtained from the panel must be stored in the battery But the output from the panel cannot be directly saved to the battery. A regulator circuit is needed that contains a series of automatic battery chargers.

The purpose of this regulator is to arrange the outturn voltage of the panel and the setting current entering the battery automatically. In addition, another function of the regulator is to make the current connecting or un-connecting from the panel into the battery automatically. It also requires disconnecting the current flow from the battery when a short circuit or overload comes about. Solar panels can be used directly

without the addition of regulator circuits or batteries, but this is not carried out because it can burden the performance of the panel (due to excessive load) so that serious damage can be avoided. Furthermore, this regulator is also useful to save from the case of an overload from the panel and the panel free from damage.

The connection between the storage battery and the charge is involved in parallel to the load. if the battery is fully charged. To protect the battery from the overload or short circuit, the battery should be passed through the protection circuit before connected.

If the desired electrical output is alternating electricity (AC), the system that produces direct current (DC) must be connected to the device first called inverter. The inverter can convert electric current (DC) into alternating electric current (AC) directly. After the DC current is converted into AC current in the inverter, the AC current can be directly used to provide electrical and electronic equipment that requires alternating current. The output voltage and power connected to the load should match the capabilities of the inverter used and the size of the storage system used.

4. CONCLUSION

A PV-powered water pump has been developed to experimentally investigate the potential use of PV power supply system for pool water pump. Based on the research that has been done, it can be concluded that the concept of a PV design system installed in one of the villas can actually operate a pool pump. The provision of alternative energy sources such as solar energy through the use of photovoltaic is a promising prospect for further development, considering that the primary use of oil and natural gas is still the main energy source. In addition to being environmentally friendly, energy sources from the sun do not require special periodic maintenance, which will further reduce production costs.

5. ACKNOWLEDGEMENT

This research was supported by the Directorate of *Sumber Daya*, DIKTI, Ministry of Education, Culture and Research and Technology, Indonesian Government, Grant No. 249/E4.1/AK.04.PT/2021 and 40/PL8/PG/2021 for the in cash contribution. The author also would like to thank the Department of Mechanical Engineering - Bali State Polytechnic for the moral support that has been shown by helping the smooth running of this research so that it can be completed. The author is very grateful to colleagues and students who have helped in the completion of this research.

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LOGIC
Journal of Engineering Design and Technology
Vol. 21 No. 3 November 2021; p. 165 - 171

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

ANALYSIS OF NUMBER OF LAYERS AND VOLUME FRACTION OF FIBER AGAINST SHOCK LOAD AND COMPOSITE COMPRESSIVE STRENGTH WIND TURBINE PROPELLER

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Abstract. The manufacture of wind turbine blades has a very high risk of failure, especially in the manufacturing section or in this case the material structure. If the structure of the propeller material is not able to withstand the very high pressure and air flow, it will result in the failure of the material structure when it is in use. For this reason, the purpose of this study was to determine the composition of composite materials that have high strength and toughness properties and are suitable for wind turbine propellers. The method used in this research is experimental. The independent variables include the number of layers and the volume fraction of straw fiber. The dependent variables are shock load and compressive strength. Each compression test specimen is made with a gauge length of 100mm, a width of 25mm, and a thickness of 2.5mm. While the impact test specimens are made equal to l25mm long, l2mm wide, l2mm high, and 2mm notch. The results showed that the bending strength of the straw fiber composite with 6 layers had an increasing trend as the number of layers increased. The highest bending strength with the number of piles of 6 layers and the lowest strength with the number of piles of 2 layers. In addition, the volume fraction is very influential on the bending stress of the straw composite matrix. It can be seen that the matrix with a volume fraction of 50% has the greatest bending stress in each number of layers, both 2, 4 and 6. For the impact test, it is found that the optimal number of layers occurs in the number of 2 layers with a volume fraction of 33%. The shock load tends to decrease. Meanwhile, based on the volume fraction, the larger the volume fraction, the smaller the shock load that can be received by the straw fiber composite material.

Keywords : composite, number of layers, volume fraction, shock load, compressive strength.

1. INTRODUCTION

The increase in the need for electrical energy occurs due to high population growth, but this is not balanced with the increase in the supply of electricity, while the needs of the community continue to increase. Indonesian people depend on PLN's supply, not only for lighting needs but also to support economic activities. Power plants owned by PLN generally use non-renewable energy, to meet the ever-increasing demand for electrical energy, power plants are needed by utilizing existing resources. Geographically, Indonesia has the potential to develop renewable alternative energy power generation. One of them is wind energy that blows relatively stable throughout the year with an average speed of 5 m/second [1].

To produce wind turbine blades that have reliability in producing optimal rotation, the main aspect that needs to be considered is the structure of the turbine blades themselves. For this reason, wind turbine propellers need to be composed of material structures or materials that have high strength or toughness [2], [3]. So that the

composite material was chosen. The materials or materials commonly used in making wind turbine propellers are polyfoam, styrofoam, EPO foam, and balsa wood which have many advantages and disadvantages [4]. Because the addition of fiber to the foam will increase its mechanical properties, the weakness of this material is that it is easy to flutter [5].

The flutter phenomenon is a phenomenon of dynamic instability of a system caused by the interaction between the elements of inertia, damping, and flexibility of the structure, as well as aerodynamic loads acting on the structure. In other words, flutter is caused by a very high velocity air flow with an energy greater than the propeller structure's ability to dampen the energy (vibration), therefore vibration or flutter is one of the factors that need to be considered. Therefore, the purpose of this study was to analyze the number of layers and volume fraction of straw fiber against shock loads and compressive strength of wind turbine propeller composites.

Fiber is a type of material in the form of pieces - pieces form a network that is elongated and intact, fiber can be divided into two types, namely synthetic fibers and natural fibers. Synthetic fibers are fibers made by humans not from nature. As for natural fibers, namely fibers that come from nature. Natural fiber or you can say this natural fiber is usually obtained from plant fibers such as bamboo trees, coconut trees, banana trees and other plants that have fiber in their stems and leaves. Natural fibers derived from animals, including silk, ilama and wool [6], [7]. In composites, fiber is the main material that has a use as a reinforcement of the composite, with its use as a reinforcement in fiber composites which greatly affects the strength resulting from the composite material. Fiber composites in the industrial world began to be developed instead of using particles. In the development of processing technology, the use of fiber is now increasingly superior to the matrix material used. The fibers used can be glass fibers, carbon fibers, aramid fibers (poly aramide), natural fibers and so on. Fiber composite materials are composed of fibers bound by an interconnected matrix. The use of fiber composite materials is very efficient in receiving loads and forces that are in the direction of the fiber, on the other hand it is very weak when loaded in the direction perpendicular to the fiber [8]. Research that combines matrix and fiber must consider several factors. Long fibers can carry loads and stresses from the point of tension to other fibers. In an ideal continuous fiber structure, the fibers will be stress free or have the same stress. During fabrication, some fibers will receive high stresses and others may not be subjected to stress so the above state cannot be achieved. While short fiber composites, with the correct orientation, will produce greater strength when compared to continuous fiber. Short fiber composites can be produced with low surface defects so that their strength can reach their theoretical strength.

The shape of the fiber used for the manufacture of composites does not really affect, what affects is the fiber diameter. In general, the smaller the fiber diameter, the higher the composite strength. In addition to the shape, the fiber content also affects [9].

The matrix in the composite serves as a binding material for the fibers into a structural unit, protects against external damage, transmits or transfers external loads in the shear plane between the fiber and the matrix, so that the matrix and fiber are interconnected. The manufacture of fiber composites requires a strong surface bond between the fibers and the matrix. In addition, the matrix must also have a chemical match so that unwanted reactions do not occur on the contact surface between the two. To choose a matrix, its properties must be considered, such as resistance to heat, resistance to bad weather and resistance to shock, which are usually considered in the selection of matrix materials. There are two kinds of polymer materials used as matrix materials in composites, namely thermoplastic and thermoset.

The amount of fiber content in the composite is a matter of particular concern in fiber-reinforced composites. To obtain high-strength composites, the distribution of fibers with the matrix must be evenly distributed during the mixing process to reduce the occurrence of voids. To calculate the volume fraction, the parameters that must be known are resin density, fiber density, composite weight and fiber weight. If during the manufacture of the composite fiber and matrix mass, as well as fiber and matrix density are known, then the volume fraction and fiber mass fraction can be calculated by the equation [10],[11] .

The use of fiber in the composite aims to improve the properties and structure of the matrix that it does not have, it is also expected to be able to become a matrix reinforcement material in the composite to withstand the forces that occur. Fiber has been known since ancient times because of its strong structure, especially its tensile strength.

In addition, fiber is also the most important element, because it is the fiber that will determine the mechanical properties of the composite such as stiffness, ductility, strength and so on. Fibers are thin and long, and have sufficient characteristics in their internal structure. There are two types of fibers based on their constituent elements, the first is natural fibers, namely fibers from animals, plants and minerals, for example cotton, wool, silk, hemp and other natural fibers. The two synthetic fibers (synthetic fibers) are man-made fibers such as nylon, rayon, polyester acetates and others. In this study using natural fiber, namely straw fiber. Straw is the part of the growing stem that has been harvested with the grains of fruit (rice) together or not with the stalk reduced by the roots and the remaining part of the stem. At this time the use of straw is less efficient, usually only for livestock needs and for gardening purposes as fertilizer, even in the end it is only burned to cause pollution. So there is a lot of straw waste from rice farming. Now, with further research, it turns out that straw can also be used as a filler

material in composite materials. With this abundant availability, straw can be used as a cheap and environmentally friendly composite fiber.

According [12], [13] the matrix is the phase in the composite which has the largest (dominant) portion or volume fraction. The matrix has the function of transferring tension to the fiber, forming a coherent bond on the surface of the matrix and fiber, protecting the fiber, separating the fiber, releasing the bond, and remaining stable after the manufacturing process.

Using of synthetic fibers as composite reinforcement has a negative impact on the environment because the waste cannot be decomposed naturally and can interfere with generations. The use of natural fibers as composite reinforcement is a wise step, considering that natural fibers can decompose naturally, and there are many kinds of natural fibers available such as jute fiber, pineapple fiber, palm fiber, coconut fiber, and others [14], [15].

Composite materials generally consist of two elements, namely fiber as a reinforcing material and resin as a fiber binding material. From this mixture, a composite material will be produced which has different mechanical properties and characteristics from the constituent material [16], [17].

In its development, the fibers used are not only synthetic fibers (fiberglass) but also natural fibers (natural fiber). Natural fiber composites have other advantages when compared to glass fiber, natural fiber composites are now widely used because of their large number, more environmentally friendly because they can be degraded naturally, and the price is cheaper than glass fiber. Weaknesses of natural fibers include the size of the fiber that is not uniform, the age of the fiber greatly affects its strength [18].

The smaller the diameter of the fiber, the greater the tensile strength, because the voids in the fiber are small and the intermolecular bonds are many, so the strength is strong. The larger the diameter, the smaller the tensile strength, because the voids in the fiber are large and the molecular bonds are few, so the tensile strength is low.

The development of natural fibers as reinforcement for composite materials is very good considering the availability of natural fiber raw materials in Indonesia is quite abundant [19].

Some matrix materials can provide the required properties such as plasticity and toughness. The matrix used in the composite must be able to carry the load so that the fiber must be able to adhere to the matrix and be compatible between the fiber and the matrix, meaning that there is no disturbing reaction. In this study, the matrix used is a thermoset resin with an epoxy resin type.

2. METHODS

In the study, using straw fiber material with fiber sizes between 20 mm and 30 mm and epoxy resin as a fiber binder in the composite material, consisting of resin and hardener. The number of layers in each composite consisted of 2, 4, 6 layers with fiber volume fractions: 25%, 33% and 50%. For the bending test using the ASTM D790 standard, while the impact test using the ASTM E23 standard. Testing using Universal Testing Machine and Charpy impact machine.

3. RESULTS AND DISCUSSION

3.1 Bending Test

The bending test data that has been obtained is converted into a graphic form and accompanied by a discussion. The average bending strength of the straw fiber composite with polyester matrix is shown in Figure 1.

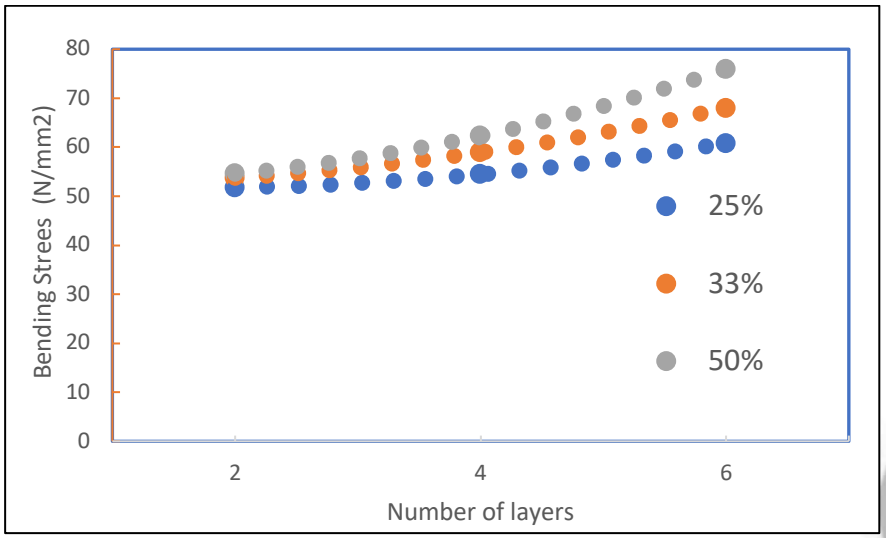

Figure 1 Relationship of Bending Stress with Number of Layers in several volume fractions.

In Figure 1 it can be seen that the bending strength of the straw fiber composite with 6 layers has an increasing trend as the number of piles increases because the matrix is able to bind straw fibers optimally as the number of piles increases. The highest bending strength with the number of piles of 6 layers and the lowest strength with the number of piles of 2 layers. In addition, the volume fraction is very influential on the bending stress of the straw composite matrix. It can be seen that the matrix with a volume fraction of 50% has the greatest bending stress in each layer, either 2, 4 or 6 layers. This is because the matrix is able to bind the fiber well, for the number of layers 4 and 6, when it reaches the highest bending stress it does not break immediately but cracks first, in addition to the straw fiber composite material with the number of layers 4 and 6, it is not easily deformed. compared to other materials. This is because the increase in the number of layers of straw fiber results in fiber density in the mold, so that the distribution of resin in the mold is more optimal and causes higher bending stresses. This means that as the number of layers increases, the composite material becomes more ductile. This can be seen in the strain graph of the straw fiber composite shown in Figure 2.

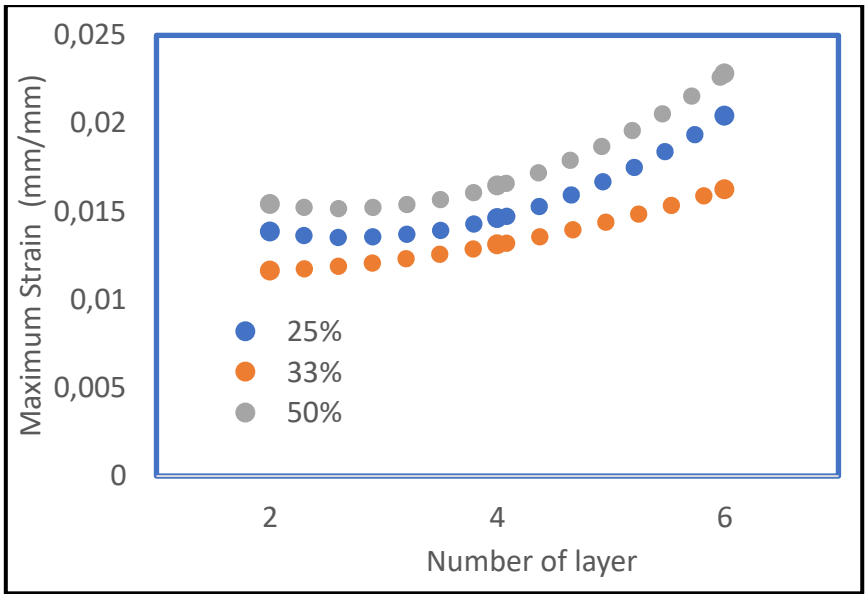

Figure 2. Relationship of maximum strain to the number of layers in several volume fraction variations.

In Figure 2 it can be seen that the highest bending strain is found in the composite of 6 layers of fiber piles, this is because the composite material is a polyester matrix that is able to bind fibers optimally which is different between the other 2 materials. This is because the increase in the number of piles results in fiber density in the mold, so that the distribution of resin in the mold is more optimal which causes higher bending strength. In addition, the composite matrix with 6 layers is more ductile and before it breaks it undergoes a cracking process.

3.2 Impact Test

Impact testing data that has been obtained is converted into graphic form and accompanied by a discussion. The average impact test of the straw fiber composite with a polyester matrix is shown in Figure 3.

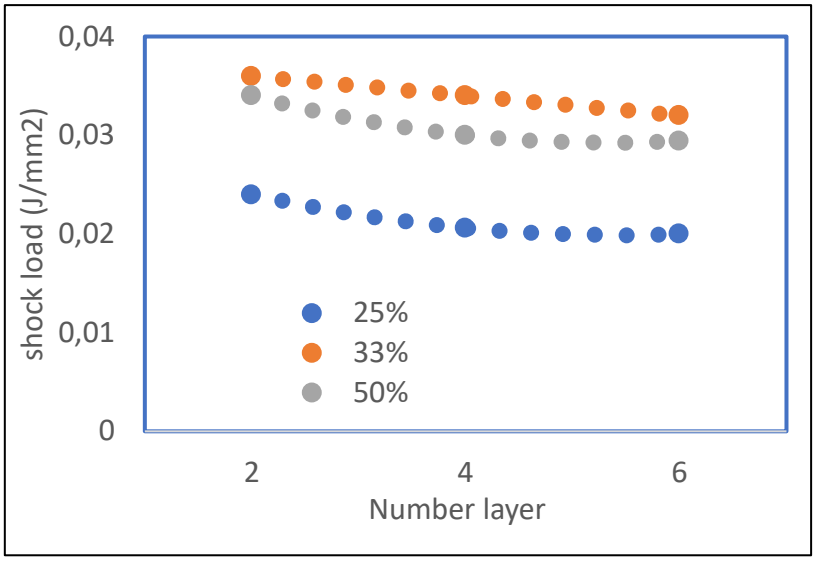

Figure 3 The relationship between the number of layers of straw fiber and the shock load in several volume fractions.

Based on Figure 3, the results of the impact test show that the optimal number of layers occurs in the number of 2 layers with a volume fraction of 33%. From the graph, it can be seen that the shock load increases from 2 layers to optimal at 4 layers and then tends to decrease. Meanwhile, based on the volume fraction, the larger the volume fraction, the smaller the shock load that this composite material can accept. According to [20], [21] that with a fixed amount of resin and more fiber or laminar fractions, the strength of the composite material will increase. This proves that the magnitude of the shock load (impact) decreases consistently with the addition of the volume fraction after 33%, while the optimal shock load occurs in the number of layers of 2 layers. This has the same tendency as the bending test, that an increase in the impact load only occurs in the volume fraction of 33%. While the decrease in the graph occurs in the volume fraction of 50% and 25%, along with the addition of the matrix composition. This phenomenon also proves that the matrix composition in this case is the ratio of resin and straw fiber gives an important role in the composite material, where the more resin composition compared to straw fiber will reduce the strength/toughness of the impact. In addition, there is a difference in the thickness of the styrofoam core with the increase in the number of layers that affect the mechanical properties of the structure of this composite material.

3.3 Structure of Fiber and Matrix Bonds

Whether or not the structure of the bond between fiber and matrix is good, one of them can be seen in the fracture results of mechanical testing.

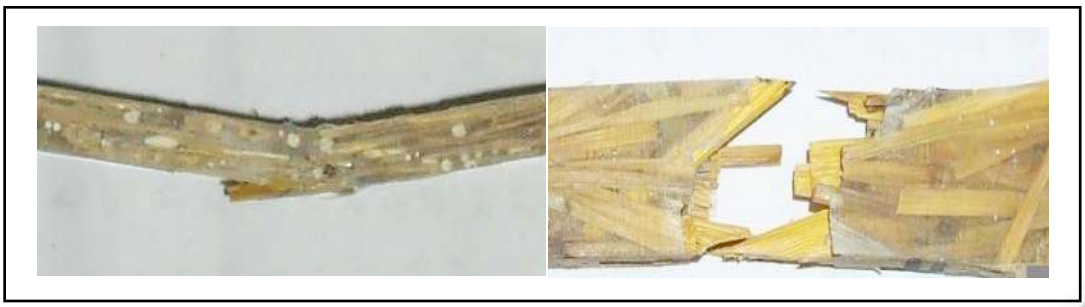

Figure 4 fracture results of mechanical testing

4. CONCLUSION

After analyzing and calculating the data and test results about the effect of variations in the length of straw fiber on the straw-epoxy composite material, it can be concluded, among others:

1. The bending strength of straw fiber composites with 6 layers has an increasing trend as the number of layers increases because the matrix is able to optimally bind straw fibers as the number of piles increases. The highest bending strength with the number of piles of 6 layers and the lowest strength with the number of piles of 2 layers.

2. In addition, the volume fraction is very influential on the bending stress of the straw composite matrix. It can be seen that the matrix with a volume fraction of 50% has the greatest bending stress for each number of layers, either 2, 4 or 6.
3. For the impact test, it was found that the optimal number of layers occurred in the number of 2 layers with a volume fraction of 33%. The shock load tends to decrease. Meanwhile, based on the volume fraction, the larger the volume fraction, the smaller the shock load that can be received by the straw fiber composite material.

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LOGIC
Journal of Engineering Design and Technology
Vol. 21 No. 3 November 2021; p. 172 - 178

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

EXPERIMENTAL STUDY OF THE EFFECT OF PLASMA CUTTING ON THE TENSILE STRENGTH OF MATERIALS "FE"

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Abstract. The cutting process in plasma cutting begins with the formation of a pilot arc between the electrode and the workpiece as a result of the electrical ionization reaction of the highly conductive cutting gas. The gas is heated by the pilot arc until its temperature rises very high then the gas will be ionized and become a conductor of electricity. When the gas stream leaves the nozzle, the gas expands rapidly carrying the molten metal so that the cutting process continues. This plasma temperature can reach 33,000°C, approximately 10 times the temperature produced by the reaction of oxygen and acetylene. If this is related to the mechanical properties of the material, where the material has been heated it will result in changes in the mechanical properties of the material in the heating area/around the cutting plane. Tensile testing is the most widely used type of test because it is able to provide representative information on the mechanical behavior of the material. Seeing an incident like this, it is necessary to test the Effect of Plasma Cutting on the Tensile Strength of 'Fe' Materials through a tensile test. Several studies have shown that torch height, amperage and cutting speed can affect material properties. The best tool parameter settings are obtained at a travel speed of 500 mm/min, 75 amperes and a torch-material distance of 3 mm, so that these settings are used as a reference in this study. In analyzing the data, the authors compare the results of plasma cutting testing with conventional cutting, in order to know the changes in mechanical properties that occur.

Keywords: plasma cutting, tensile test, strength of material

1. INTRODUCTION

The lower the torch distance used, the smaller the value of the kerf width and the resulting surface roughness [1][2]. The results show that the lower the rate of decline, the higher the hardness value and vice versa [3]. This process uses a concentrated electrical arc which melts the material through a high-temperature plasma beam. All conductive materials can be cut. Plasma cutting units with cutting currents from 20 to 1000 amperes to cut plates with inert gas, 5 to 160 mm thicknesses. Plasma gases are compressed air, nitrogen, oxygen or argon/ hydrogen to cut mild and high alloy steels, aluminum, copper and other metals and alloys [4][5]. The quality characteristics that were assessed included the surface roughness, the heat affected zone and the conicity of the cut geometry. Using design of experiments and analysis of variance, it was found that the surface roughness and the conicity are mainly affected by the cutting height, whereas the heat affected zone is mainly influenced by the cutting current [6].

The PAC parameters studied were how to have setting for the parameter such as Gas Pressure, Current flow, Cutting Speed and Arc gap of machine [7]. The plasma process is suitable for electrically conducting materials of thickness from 1 to 600 mm. The plasma cutting process may be used to cut any conductive material, including carbon steel, stainless steel, aluminum, cooper, brass, cast metals and exotic alloys [8]. The quality characteristics that were assessed included the surface roughness, the heat affected zone and the conicity of the cut geometry. Using design of experiments and analysis of variance, it was found that the surface roughness and the conicity are mainly affected by the cutting height, whereas the heat affected zone is mainly influenced by the

cutting current [9]. Plasma cutting, whether conventional or precision, is a fast, economical way to produce parts. Manufacturers should first understand the process, and then determine if this or another process produces the parts more effectively [10]. The term for advisable state of plasma arc is called stability of arc too. The stability of arc is keeping the plasma jet in desired form. It is possible to be provided by: shape of plasma torch; streaming jet; water. We must monitor these parameters: temperature and electrical conducting; density of plasma jet; diameter of plasma beam; degree of the plasma beam focusing in out put from nozzle [11]. Plasma is a thermally highly heated up, electrically conductive gas, which consists of positive and negative ions, electrons as well as of excited and neutral atoms and molecules. At the physics they often speak of the 4th state of aggregation [12]. For the cutting process first of all a pilot arc ignition by high voltage between nozzle and cathode takes place. This low-energy pilot arc prepares by ionization in parts the way between plasma torch and workpiece. When the pilot arc touches the workpiece (flying cutting, flying piercing), the main arc will start by an automatic increase in power [13].

The PAC process uses this high temperature, constricted, high velocity jet of ionized gas exiting from the constricting orifice of the torch tip to melt a much localized area and remove the molten material from the metal being cut by the force of the plasma jet. The force of the arc pushes the molten metal through the work piece and severs the material. Extremely clean and accurate cuts are possible with PAC. Because of the tightly focused heat energy, there's very little warping, even when cutting thin gauge sheet metal thickness. PAC also offers quality gouging and piercing capabilities [14].

"Torch stand-off" is the distance the outer face of the torch tip or constricting orifice nozzle is to the base metal surface. This standoff distance will be determined by the thickness of material being cut and the amperage required. Low heat build-up while cutting with less than 40 amperes may allow dragging the torch tip on the material. If a high build-up of heat is expected, a standoff distance of 1/16" to 1/8" will be required. This is easily accomplished with a Miller ICE torch with a "Drag Shield". The "Drag Shield" works with the flow dynamics of the torch to provide better cooling of the consumable parts for longer parts life. This permits the operator to drag the torch on the work piece while cutting at full output, which increases operator comfort and makes template cutting easier [15]. The treatment of the nozzle is physical condition checking, cleaning and proper testing. This test is done by Plasma temperatures can reach 33,000°C, approximately 10 times the temperature produced by the reaction of oxygen and acetylene [1]. If this is related to the mechanical properties of the material, where the material has been heated it will result in changes in the mechanical properties of the material in the heating area/around the cutting plane. Tensile testing is the most widely used type of test because it is able to provide representative information on the mechanical behavior of the material. Seeing an incident like this, it is necessary to test the Effect of Plasma Cutting on the Tensile Strength of 'Fe' Materials through a tensile test.

2. METHODS

Material with a length of 500 mm, a width of 200 mm and a thickness of 8 mm, as shown in the picture then cut with plasma cutting and manually (bandsaw) with a cut size of 200 mm long, 20 mm wide and 8 mm thick.

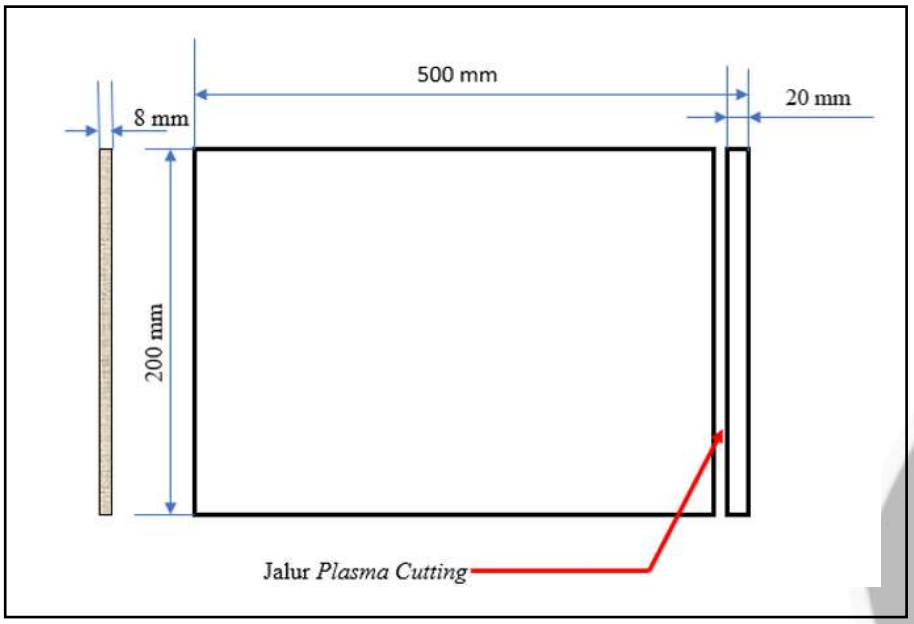

Figure 1. Test material design

Figure 2. Plasma cutter and manual cutter

Figure 3. Cutting result

After the plasma cutting process is carried out, the test object is prepared in such a way according to the test method, to fit the clamp on the tensile test equipment, then the test material is tested for tensile strength to obtain the required data. The dimensions of the test object are made 200 mm X 20 mm X 8 mm then a notch is made on the cutting results to be tested as shown in Figure 4.

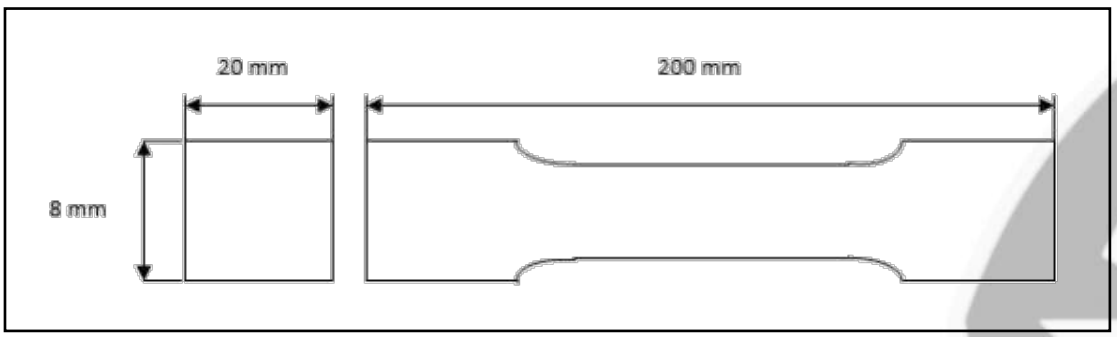

Figure 4. Tensile test object

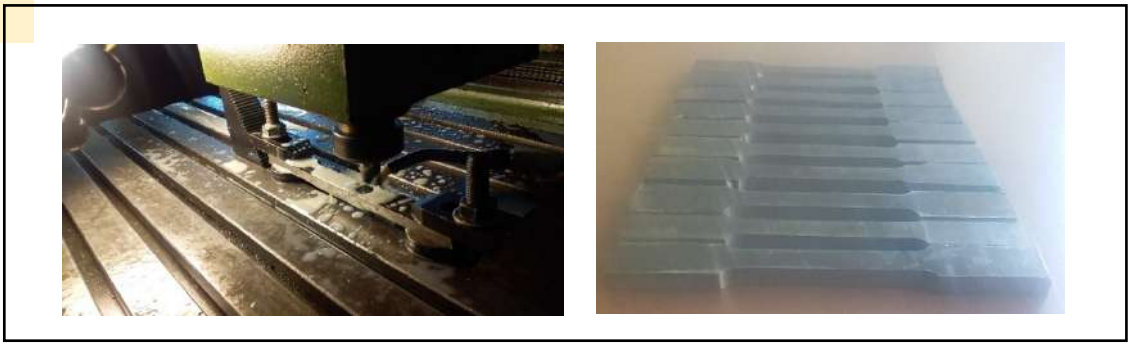

Figure 5. Formation of test object and specimens ready for test

Figure 6. Tensile strength testing process

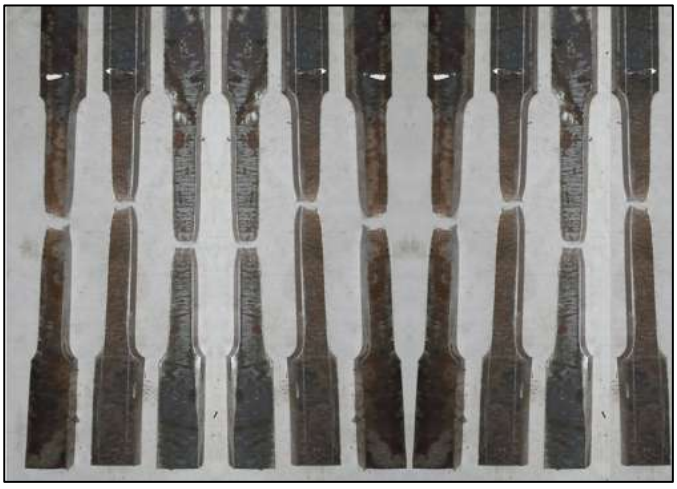

Figure 7. Tensile strength testing process

3. RESULTS AND DISCUSSION

3.1. Research data

To find out the properties of the material above, a test or evaluation must be carried out with the aim of obtaining a material that is in accordance with its classification. Tests on materials in general can be divided into two parts, namely [5]:

1.) Destructive Test This test is destructive to the workpiece, so in this test a test specimen is needed (test specimens are duplicates of workpieces derived from the same material).
Tensile Test
The purpose of conducting a mechanical test is to determine the material response of a construction, component or fabricated assembly when subjected to external loads or deformations.

2.) Non-Destructive Test This test does not damage the workpiece, so no test specimen is needed and can be directly tested on the workpiece. This is done with the aim of seeing surface defects and below the surface of the workpiece.

The process of testing the specimens was carried out at the Bali State Polytechnic Material Testing Laboratory. The test carried out is a destructive test to determine the tensile strength of the welding results. The number of samples is 10 for each variable. The test results can be seen in Table 1 below.

Table 1. Research data

Sample	Material Tensile Strength (kgf/mm²)			
	Manual cutting		Plasma Cutting	
	ST 42	Used materials	ST 42	Used materials
1	36.48	33.576	37.734	33.79
2	36.97	33.624	37.612	33.766
3	36.508	33.398	37.704	33.804
4	36.564	33.502	37.504	33.998
5	36.85	33.56	37.48	33.82
6	36.75	33.6	37.552	33.852
7	36.624	33.486	37.652	33.902
8	36.86	33.442	37.802	33.798
9	36.716	33.492	37.588	33.832
10	36.54	33.546	37.732	33.786
Average	36.69	33.52	37.64	33.83

The tendency of the material to fracture or crack more quickly if given the same stress is the brass material followed by a mixture of steel and iron. This is related to the strength of the material, where brass has a very low tensile strength when compared to alloy steel and iron. Factors that cause fracture, due to the rate of deformation and the origin of the material formed [16].

In testing iron, brass and mixed steel with a tensile test, if each material is pulled, there will be an elongation of the original length and this will cause a shrinkage of the width from the original width. This means that the percentage effect of the width shrinkage will be proportional to the percentage of the elongation of the material. This comparison is known as the Poisson ratio. The Poisson ratio for each material used is different from one another, where the Poisson ratio for iron is msteel = 0.106±0.002, brass is mbrass = 0.104±0.002 and manneal alloy steel = 0.103±0.005. The Poisson ratio for iron is greater than the Poisson ratio for brass and alloy steels. This means that the elasticity of the iron material is greater than that of brass and mixed steel, and besides that, the composition of the formation or composition of the material is also different when the tensile treatment is carried out by the force distributed to the material which also affects the strain [16].

3.2. Data processing

The test results show:

1. There is a difference in tensile strength from the results of the cuts made, where there is a change/increase in the tensile strength of both the ST 42 plate and the used plate. For the New plate with manual cutting after averaged it has a tensile strength of 36.69 kgf/mm2 and with plasma cutting after averaging the

tensile strength increases to 37.64kgf/mm2. While the used plate with manual cutting after averaged has a tensile strength of 33.52 kgf/mm2 and with plasma cutting after averaging the tensile strength increases to 33.83 kgf/mm2

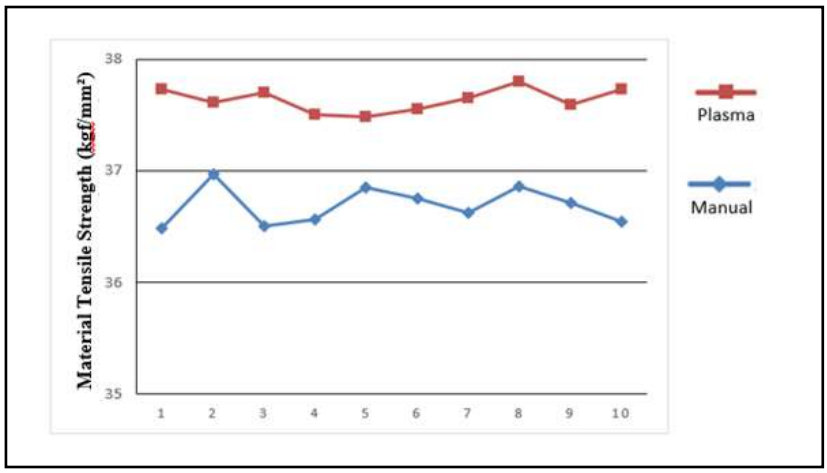

Figure 8 Graph of manual and plasma cutting results the new Plate

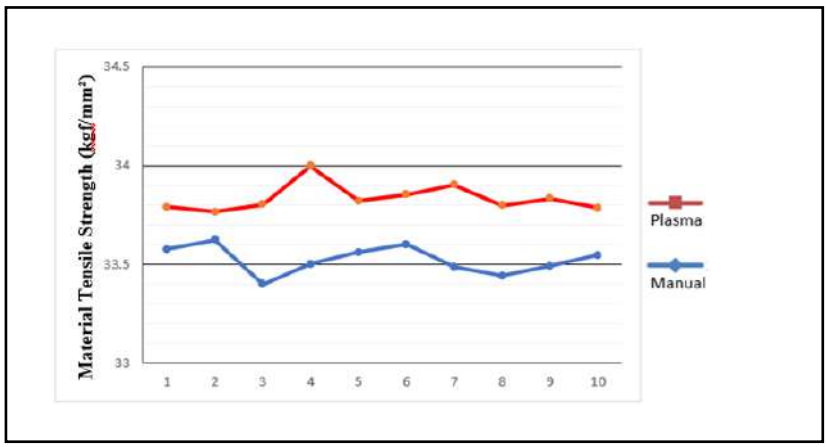

Figure 9 Graph of manual and plasma cutting results the used Plate

The increase in tensile strength is the result of the influence of cutting temperatures with high plasma cutting making structural changes in the metal so that hardening occurs. On the one hand, these changes have both good and bad effects, the good being that the material becomes stronger in accepting the load, while the bad thing is that in the next processing stage, the material requires harder tools/equipment for processing; Another effect is that with increasing hardness, it will automatically become more brittle/breakable in other words the material will have a lack of receiving vibrations.

2. Based on the data obtained, the increase in tensile strength for new materials is 2.58% while for used materials it is 0.93%, it should be noted that this value is not absolute. Corrosion due to the environment is also human error during the cutting process and specimen making.

4. CONCLUSION

There is an increase in tensile strength in the new material by 2.58% while in the used material by 0.93%.

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. 21 No.3 November 2021; p. 179 - 183

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

DESIGN AND FABRICATION OF A FIXED BED PYROLYSIS WITH LDPE PLASTIC WASTE

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Abstract.
This paper presents the design of a fixed bed reactor pyrolysis to convert plastic waste type LDPE into condensate oil. The dimensions of the batch type pyrolysis reactor are adapted to household needs and are designed to be easy to operate and transport. From the results at three different pyrolysis temperature variations; 250 °C, 275 °C and 300 °C shows that reactor yields a maximum condensate oil of 45,3wt% at temperature of 300 °C. In addition, the weight of charcoal also decreased along with the increase in operating temperature.

Keywords: design and fabrication, fixed bed pyrolysis, plastic LDPE, condensate oil

1. INTRODUCTION

Currently, the waste problem has become a common problem in various places, especially in big cities which have relatively dense population with relatively limited waste disposal sites and almost all waste disposal sites in cities in Indonesia only apply open dumping which is considered not to be appropriate as a systematic way of handling waste [1]

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. Conversion of plastic waste into fuel has several advantages, as well as being one of the main alternatives for processing plastic waste, because landfill and incineration methods have a negative impact on the environment.

Pyrolysis technology is an alternative for municipal solid waste treatment which is considered quite prospective to be developed because it has several advantages 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].

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 [3].

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]

Plastic based on its type consists of two, namely thermoplastic and thermoset plastic, thermoplastic is a plastic that has been shaped to soften by heat treatment and can be reshaped repeatedly, until it loses its constituents. Thermoset plastics are plastics that have been molded and cannot be softened by heat treatment. Excess heat will burn the constituents. 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.

Knowledge of the thermal properties of various types of plastics is very useful for the plastic recycling process which includes the thermal properties of melting point (Tm), transition temperature (Tg) and decomposition temperature. The transition temperature is the temperature when the plastic undergoes structural stretching so that there is a change from a rigid state to a more flexible state. Above the melting point, the plastic experiences an increase in volume so that the molecules move more freely which is indicated by an increase in their flexibility. The melting temperature is the temperature at which the plastic begins to soften and turn into a liquid. The decomposition temperature is the limit of the liquefaction process. If the temperature is raised above the melting temperature, the plastic will flow easily and the structure will decompose. Decomposition occurs because the thermal energy exceeds the energy binding the molecular chains.

Based on the above description it is deemed necessary to research the effect of working temperature by design of the pyrolysis system on the oil yield product.

2. MATERIALS AND METHODS

2.1 Feed stock

Plastic waste used as fuel for this experiment was collected from household production which is usually dominated by LPDE types such as plastic bags for dry-cleaning, newspapers, bread, frozen foods, fresh produce and garbage. Thus, maintaining uniform characteristics, the plastic is separated from the impurities and cropped into equal sizes.

2.2 Reactor design

The application of fixed bed pyrolysis equipment with batch reactor type is designed for household scale with a maximum capacity of 0.01 m3 which can treat crackle waste produced by households on average for 4 days. 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. Design and sign is made to carry a compact concept with m that is easy to move and operate. The preheating source comes from a heating furnace using LPG fuel. Crackle-type plastic waste can be inserted into the feeder nut located at the top of the reactor. The system pyrolysis was designed as the Fig.1 bellow

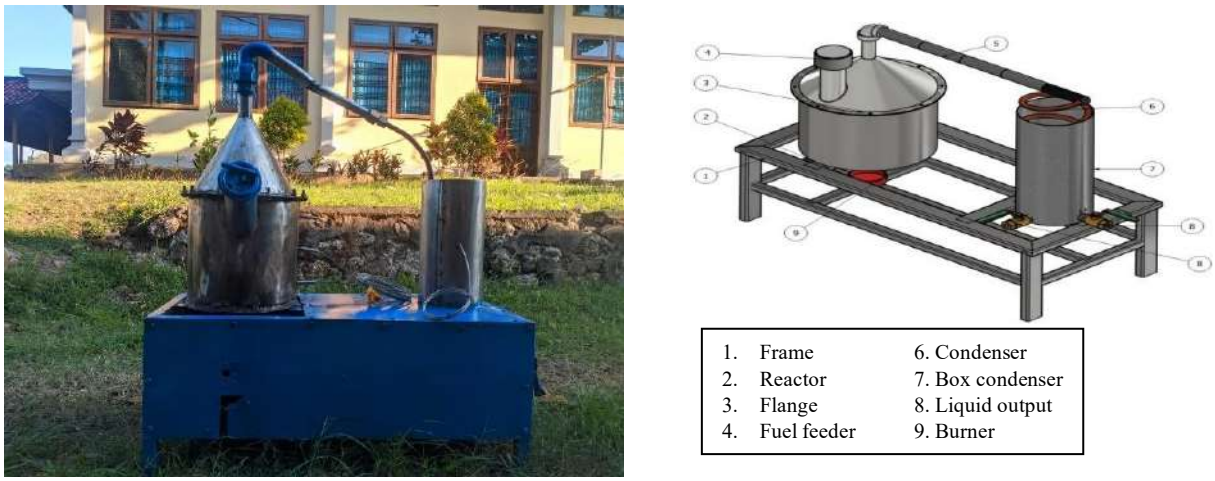

Figure1. The schematic design of fixed bed pyrolysis system

2.3 Experimental Method

A LDPE plastic waste was transfer into reactor by fuel feeder. A waste plastic to fuel production process was applied at three different temperature by 250 C, 275 C and 300 C. During fuel production process vacuum system did not apply and catalyst or extra chemical did not added. Condensation unit was setup with reactor and no water circulation system was added. Experiment was batch process fully closed system setup.

The operating temperature of the reactor will be assessed by recording the temperature measurements on the reactor. Type K thermocouple will be 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.

LDPE (700g) plastic waste is put into a fixed bed pyrolysis reactor. The reactor admires 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 C which causes the condensed gas to produce a liquid. Then the liquid is collected from the reservoir and weighed. The

product yield of condensate oil were determined by the following Eq. (1) respectively:

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

3. RESULTS AND DISCUSSION

3.1 Temperature Distribution

The temperature distribution in the pyrolysis reactor is controlled by 3 type K thermocouples mounted on the reactor with a height distance of 30mm at each point. Real time data recording using 4 channel digital temperature display. The heating rate control is done by manually adjusting the valve opening on the stove. The temperature of the cooling water in the condenser is also recorded to display the condition of the cooling water. The temperature distribution obtain by 250°C showed as Fig 2. below

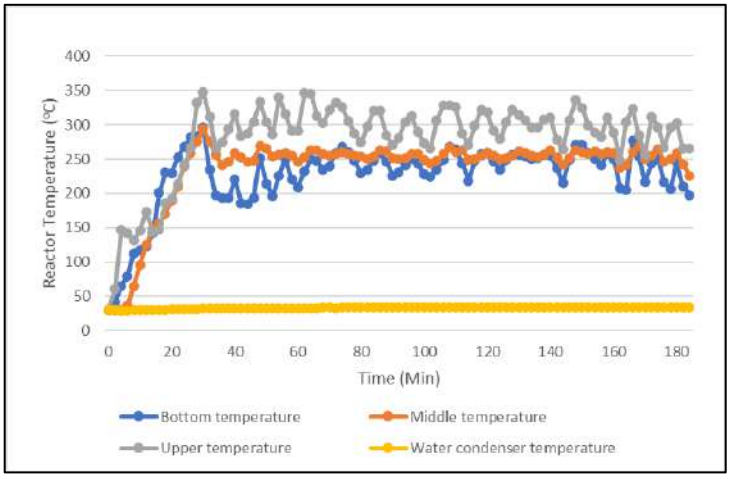

Figure 2. Temperature distribution 250°C

3.2 Condensate oil yields

The effect of reactor heating temperature on the pyrolysis process affects the amount of oil produced. Table 1 shows an increase in the volume of condensate oil production along with the increase in temperature in the reactor. At a temperature of 250°C, the volume of condensate oil produce was 182 ml, then increased to 310 ml at a temperature of 275°C and the highest volume was 526.5 ml at a temperature of 300°C.

Table 1. Pyrolysis product with different temperature

Reactor temperature (°C)	Feed mass of LDPE (gram)	Volume of condensate oil (ml)	Condensate oil yields (%wt)
250	700	182	22,4
275	700	310	35
300	700	526,5	45,3

From the results of the volume of condensate oil, it shows that the increased temperature has an effect on the increase in the volume of condensate oil. A reactor temperature of 250°C showed a volume of condensate oil of 182ml, an increase temperature to 275°C results in an increased the volume of condensate oil to 310ml and at a temperature of 300°C produced the highest condensate oil, which is 526.5ml. This is influenced by the decomposition process of the plastic that has entered the melting temperature phase (Tm) of 330°C to release the molecular bonds that form plastic into gas.

3.3 Char product

Fig. 3 shows the mass of charcoal produced during the pyrolysis process. At a temperature of 250°C, the amount of charcoal is 175 grams, an increase in temperature to 275°C indicates a decrease in the amount of charcoal, which is 122 grams and the lowest mass of charcoal is 70 grams, which is produced at a reactor

temperature of 300°C. The increase in reactor temperature will reduce the amount of charcoal produced in the pyrolysis system.

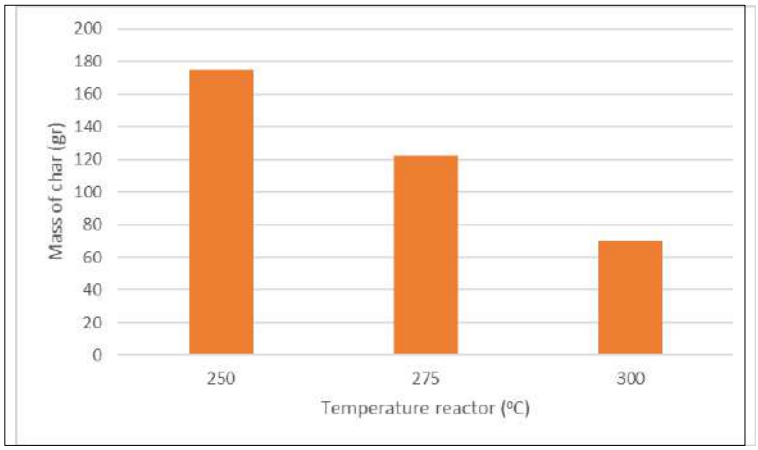

Figure 3. Char product with different temperature

4. CONCLUSION

From the results obtained, it can be concluded that the highest amount of condensate oil production is produced at a reactor temperature of 300C, which is 45.3%wt. The amount of charcoal produced decreased as the pyrolysis temperature increased.

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. 21 No. 3 November 2021; p. 184 - 189

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

THERMAL PERFORMANCE EVALUATION OF THE VARIATION OF CONDENSER DIMENSIONS FOR FOODSTUFFS TRANSPORTATION COOLING SYSTEMS

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Abstract. The process of sending food using transportation requires a refrigeration system to keep the product fresh. Unsuitable temperatures will cause the transported products to often experience damage so that they are rejected in the mark. To achieve this, it is done through testing using a condenser with several variations of dimensions for a room temperature of 5°C. The dimensions of condenser-1 are (W 23 x H 14) inch^2 x 19 mm, condenser-2 is (W 23 x H 14) inch^2 x 26 mm, and condenser-3 is (W 23 x H 14) inch^2 x 44 mm. The test results show that condenser-3 produces a faster cooling time compared to condenser-2 and condenser-1. Cooling time for condenser-3 is 1160 minutes, while condenser-2 and condenser-1 are 1560 minutes and 1860 minutes, respectively. Condenser-3 provides the lowest compression work of 42.131 kJ/kg compared to condensers 2 and 1, respectively 42.931 kJ/kg, and 46.147 kJ/kg. This has an impact on the COP value, namely condenser-3, condenser-2, and condenser-1 each of 3.437, 3.233, and 2.845. COP at condenser-3 occurs the highest. These results indicate that the largest condenser dimension gives the most optimum thermal performance results. An efficient refrigeration system has low compression work and high COP.

Keywords: condenser, thermal performance, refrigeration system, coefficient of performance.

1. INTRODUCTION

The development and application of the refrigeration system on transportation equipment have increased very rapidly. The number of transportations equipped with cooling systems aims to freshen the room air and increase comfort. Refrigeration systems are also widely applied to the preservation of food, beverages, fresh meat, ice cream, etc. This type of business requires transportation with a cooling system unit that can maintain product temperature and quality. The use of this transportation is necessary for the delivery of food from one place to another so that the quality is maintained. Inappropriate temperatures will cause products transported utilizing transportation to be damaged. This has an impact on the product or item being rejected in the market.

Cooling food aims to lower the temperature to inhibit the growth of microorganisms. It can prevent food from rotting and stale. The process of cooling food, especially those sent between places or regions, requires transportation equipped with a refrigeration system. The refrigeration system in transportation uses the vapor compression cycle. This cycle is the most widely used for refrigeration and air conditioning. Refrigeration is the process of transferring heat from a lower temperature to a higher temperature. Several studies on the application of vapor compression refrigeration systems related to foodstuffs include fishing boats; a refrigerator; a cold box for eggplant, cucumber, tomato, and beer [1][2][3]. The principle of vapor compression refrigeration consists of four main components that are interconnected, namely the compressor, condenser, expansion valve, and evaporator. The cooling fluid is called refrigerant which circulates in the refrigeration unit to absorb room heat and release it into the environment. This process of absorption and release of heat occurs due to the temperature

difference between the air and the refrigerant. So the condition of the refrigerant will affect the performance of the cooling system itself. The ideal vapor-compression refrigeration cycle is shown in Figure 1.

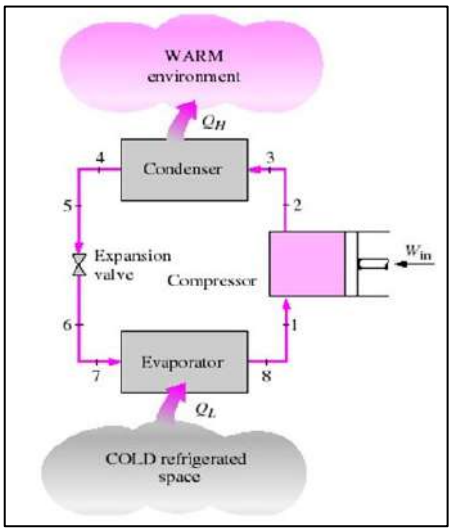

Figure 1. Ideal vapor-compression refrigeration cycle [4]

The compressor functions to suck the low-pressure refrigerant vapor that comes out of the evaporator. In the compressor, the pressure of the steam is increased so that it turns into superheated vapor. Superheated vapor flows into the condenser and undergoes a condensation process. This result is then followed to the expansion valve for the process of lowering the pressure to facilitate the evaporation process in the evaporator. The heat transfer process occurs in the evaporator and condenser. The evaporator absorbs heat from the cooling components and the heat is transferred to the condenser to be released into the environment. The condenser is an important component of the refrigeration system so a lot of research has been done regarding this component. Condensers are used to evaluate materials and refrigerants to analyze heat transfer processes; liquid smoke distillation apparatus through the cooling setting in the condenser [5][6]. The condenser is a heat exchanger unit that functions to condense a substance from a gaseous state to a liquid state [7]. The main function of the condenser is to receive steam from the compressor and condense it. The condenser is a very important component because it has a role in maximizing the efficiency of the refrigeration system.

The condenser is a heat exchanger with the type commonly used is shell and tube. A heat exchanger is the implementation of heat transfer between two fluids with different temperatures and is separated by walls and without mixing the fluids [8][9]. The fluid flow system in the condenser can be in the form of refrigerant in the pipe while gas outside the pipe or vice versa. The rate of heat transfer that occurs in the condenser is a function of the refrigeration capacity, evaporation temperature, and condensation temperature [10]. The condenser must be able to release the energy absorbed by the evaporator and the heat of compression provided by the compressor. In research [11] explained that the increase in the rate of heat release of the high stage condenser has an impact on increasing the coefficient of performance in the cascade system. The condenser is an important component of Air Conditioning (AC) which functions as a heat exchanger and the amount of heat generated by the condenser can affect comfort [12]. The distribution of refrigerant through the condenser has an impact on refrigerant mass, heat transfer, pressure drop, and temperature in each tube [13]. The refrigerant distributed to the condenser is most sensitive to operating conditions and the total refrigerant cost [14].

In connection with the above, the effect of adding condenser dimensions on the thermal performance of the transport refrigeration system will be studied for a room temperature of 5°C. By increasing the capacity of the condenser, it has implications for the process of releasing heat to the environment which affects the process of absorption of heat from the cooled space that occurs in the evaporator.

2. METHODS

The research uses materials in the form of refrigerant 134a (R134a) and refrigeration oil. The equipment used includes a manifold gauge, digital thermometer, digital tachometer, digital scale, vacuum machine, and three units of condenser dimensions (W 23 x H 14) inch^2 with a thickness of 19 mm (condenser-1), 26 mm (condenser-2), and 44 mm (condenser-3). The research was carried out on a truck refrigerator unit installed on a transportation device with a vapor compression system. Experiments using R134a cooling fluid were carried out for a constant room temperature of 5°C and a constant refrigeration load of 2,000 Watt. The variables measured in this study were the refrigerant pressure and temperature at the compressor suction pipe (P_1 and T_1), the refrigerant pressure

at the condenser inlet (P_2 and T_2), and the refrigerant temperature at the condenser outlet pipe (T_3). The research scheme is shown in Figure 2.

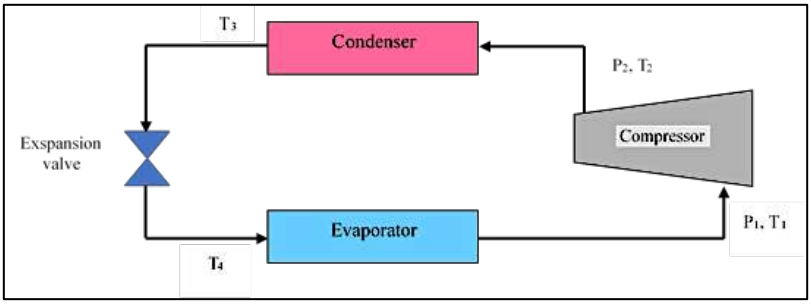

Figure 2. Schematic of research data measurement

The calculation uses the average value of each repetition and is converted from units of measurement to absolute units with the following Equation.

$$P_{abs} = P_{gauge} + P_{atm} \quad (1)$$

P_{abs} is absolute pressure (kPa), P_{gauge} is measurement pressure (Psig), and P_{atm} is atmospheric pressure (kPa) = 101.325 kPa. After obtaining the absolute average pressure, then look for the average temperature value on each digital thermometer. After the pressure and temperature values are obtained, the enthalpy can be found at each point by using table R134a. From the enthalpy value, thermal performance is calculated based on compression work (W_c), mass flow rate ($\dot{m}$), refrigeration effect (q_r), and coefficient of performance (COP) as follows.

$$W_c = h_1 - h_2 \quad (2)$$

W_c is the work of compression (kJ/kg), ($\dot{m}$)is the mass flow rate (kg/s), h_1 is the initial enthalpy of compression (kJ/kg), and h_2 is the final enthalpy of compression (kJ/kg).

Refrigeration effect (q_r) is the heat absorbed in the evaporator in processes 4-1 as shown in Equation 3.

$$q_r = h_1 - h_4 \quad (3)$$

q_r is the refrigeration effect (kJ/kg), h_1 is the initial enthalpy of compression (kJ/kg), and h_4 is the final enthalpy of expansion (kJ/kg).

The coefficient of performance (COP) of a standard vapor compression cycle is the refrigeration effect divided by the compression work.

$$COP = \frac{q_r}{W_c} = \frac{h_1 - h_4}{h_2 - h_1} \quad (4)$$

3. RESULTS AND DISCUSSION

The dimensions of the condenser influence the time of cold as shown in Figure 3.

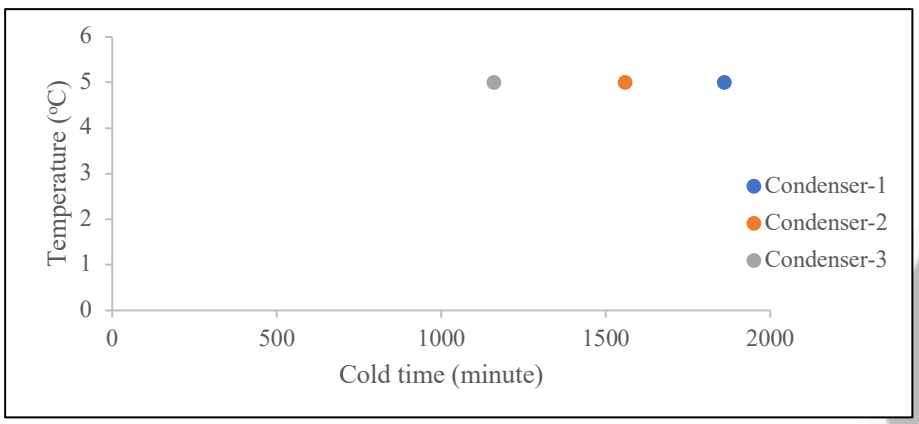

Figure 3. Distribution of cold time at a temperature of 5°C

Condenser-3 with dimensions (W 23 x H 14) inch^2 x 44 mm has a faster cooling time compared to condenser-2 (W 23 x H 14) inch^2 x 23 mm and condenser-1 (W 23 x H 14) inch^2 x 19 mm. Cooling time for condenser-3 is 1,160 minutes, while condenser-2 and condenser-1 are 1,560 minutes and 1,860 minutes, respectively. Faster cool downtime as a result of lower pressure on condenser-3 so compressor work is also lower. The lower the compressor work causes the amount of heat released (q_{out}) by condenser-3 to be greater than that of condensers-2 and 1. The lower the temperature conditioned by each condenser dimension, the longer it takes to cool down. This affects the heat transferred or absorbed by the evaporator is getting bigger.

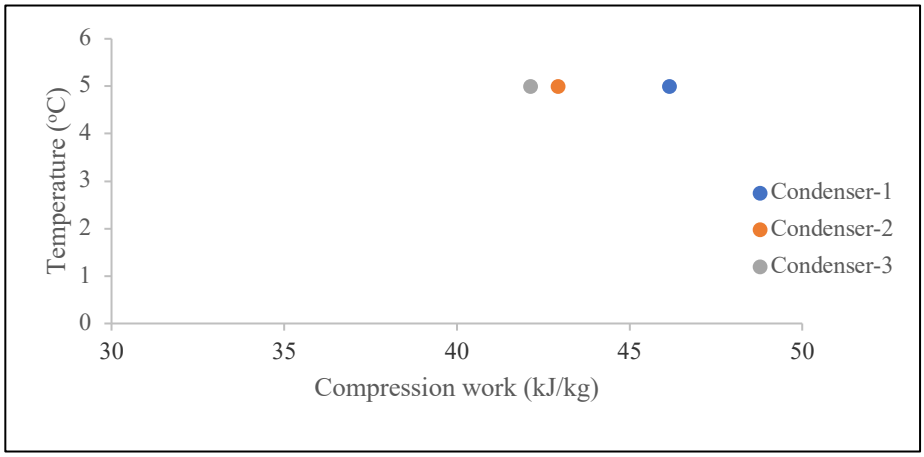

Figure 4. Distribution of compression work at a temperature of 5°C

The dimensions of the condenser affect the compression work which has an impact on the room temperature. The relationship between compression work and room temperature is shown in Figure 4. At room temperature 5°C shows that the lowest compression work occurs in the condenser with the largest dimensions (condenser-3). While the highest compression work occurs at the smallest condenser dimension (condenser-1). Condenser-3, condenser-2, and condenser-1 have compression work of 42.131 kJ/kg, 42.931 kJ/kg, and 46.147 kJ/kg, respectively. This condition is caused because the compressor outlet pressure is inversely proportional to the dimensions of the condenser. The larger the dimension of the condenser, the lower the compressor outlet pressure.

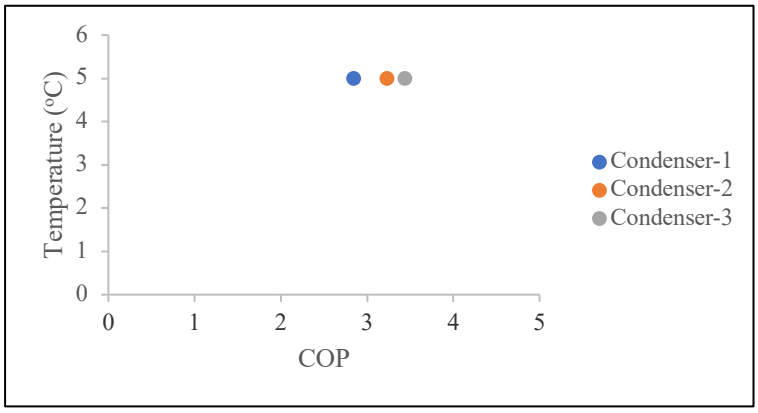

Figure 5. Distribution of coefficient of performance (COP) at a temperature of 5°C

Figure 5 shows the relationship between 5°C room temperature and the coefficient of performance (COP). Condenser-3 has a higher COP value than condenser-2 and 1. This is because the compression work on the cooling system influences the COP. The lower compression work has an impact on the higher COP, and vice versa. The lowest compression work occurs in condenser-3 as shown in Figure 4. COP on condenser-3, condenser-2, and condenser-1 were 3.437 each, 3.233, and 2.845. COP is inversely proportional to the work of compression and directly proportional to the dimensions of the condenser. Compression work affects the COP as shown in Figure 6.

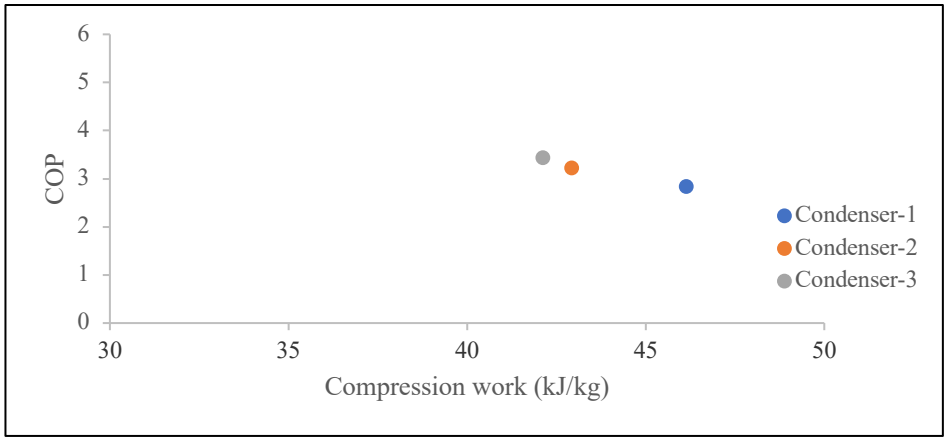

Figure 6. Relationship coefficient of performance (COP) with compression work at a temperature of 5ºC

The lower the compression work, the higher the COP. This occurs in the use of condenser-3 for the refrigeration system. Compression work required for refrigeration is inversely proportional to COP. An efficient refrigeration system has low compression work and high COP. The results of this study are in line with [15] that the longer the condenser causes the more effective heat transfer because the fluid mechanism process is getting shorter to return the fluid from the condenser to the evaporator.

4. CONCLUSION

Refrigeration systems are important for food preservation in the process of storage and shipping. In this study, an evaluation of the thermal performance of the use of condenser dimensions for the transportation refrigeration system was carried out. The largest condenser dimension provides optimum thermal performance. This can be seen from the results of the study, namely, the largest condenser dimension produces the lowest compression work, faster cooling time, and higher COP.

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LOGIC
Journal of Engineering Design and Technology
Vol. 21 No. 3 November 2021; p. 190 - 196

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

ANALYSIS OF DISPLAY CABINET DESIGN WITH COMMISSIONING TEST FOR FRESH SEA FOOD

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Abstract. This research is a design of a display cabinet cooling system with integrated energy from PLN electricity and solar power. This equipment is used for displaying marine fish and other fresh sea food in restaurants or cafes in support of Balinese culinary specialties, namely grilled fish and seafood which are very well known and can be a very extraordinary carrying capacity for Bali tourism. This cooling system is designed to be able to maintain the temperature of the cooling room (cabin) up to -5 ^{o}C. This is in accordance with the standards for storing fresh sea fish and sea food in a temperature range of -2^{o}C to 2^{o}C, where fish and sea food are still in a very fresh condition for an average of 1 week. Other standards to maintain product freshness also require room humidity between RH 90% – RH 95%. Furthermore, data collection on system performance is carried out using the commissioning test method to determine the initial performance achievement of the tool so that its shortcomings can be evaluated which will be developed and corrected in further research. From the research, it is found that the temperature achievement is very good, the solar and PLN integration system with the Automatic Transfer Switch (ATS) control system has also worked well where the switch occurs when the battery charging condition is below 30% or below 10V. However, something that has not been achieved is the humidity in this system, the average relative humidity (RH) is 50% so that the final condition of the product becomes dry on the surface of the fish. This relatively low humidity is due to the fact that it still relies on the humidity increase system by opening the cooler cabin door. In the next development, the right humidifier system will be designed for this display cabinet system.

Keywords : Integrated energy, display cabinet, sea food, humidifier.

1. INTRODUCTION

At this time cooling in the display cabinet is done by adding ice to the meat or fish, when the ice starts to melt, the product will be submerged at a temperature of 0^{o}C or more. This condition is not suitable for the storage of meat and fish, so that there will be rapid spoilage of meat and fish which results in very low product quality and hygiene. On the other hand, the operation of the display cabinet still requires a lot of electrical energy so that the operational costs are relatively expensive. Because of the existing design, the display cabinet requires a relatively larger cooling load because of the high infiltration of the open display system. Another condition is that the electricity tariff (PLN) is quite expensive and in the future, it will be more expensive in line with the depleting supply of fossil energy. So, to maintain sustainability, as a tropical country, solar energy is a renewable energy for the future.

As a tropical country with abundant sunlight throughout the year with high intensity, solar power has the potential to be developed as one of the most effective renewable energies to be applied in various regions throughout Indonesia. On the other hand, electrical energy is getting more expensive than conventional generators

from fossil energy. Meanwhile, the need for a cooling system for the storage of food ingredients, both fresh meat and fish, is urgent because of the abundant production. Thus, for the need for cooling engine propulsion, there has been much research on increasing the effectiveness and sustainability of solar power compared to conventional electrical energy. Santosa et.al [1] stated that Indonesia as a tropical country really needs a cold chain system for abundant horticultural and fishery products. Besides that, the cooling system (refrigeration) is very suitable for using solar energy as a very brilliant alternative energy. However, to maintain the quality of the stored product, it can remain fresh for a certain period, it is necessary to maintain a certain temperature and humidity with good refrigeration and humidifier technology. Chaomuang et al. [2] investigated the effects of operating conditions, including door opening frequency, ambient air temperature and product occupied volume, on the distribution of air and product temperatures in closed refrigerated display cabinets. Air infiltration due to door opening causes an increase in product temperature at the front and a decrease in temperature at the rear. At higher door opening frequencies (over 60 openings per hour per door), product temperature at the front center shelf level is most affected. The position of the product in the cabinet is a determining factor for its temperature: high temperatures are observed at the front, especially at the top of the cabinet, and low temperatures are observed at the rear. Both ambient temperature and filled volume also affect product temperature variations in closed display cabinets. Manson et al. [3] reviewed the modeling and optimization of supermarket refrigeration systems to food safety and customer modeling. It was found that the wastage of energy in the supermarket refrigeration system was caused by the frequency with which the display cabinet doors opened and other refrigerator systems. Li and Wang [4] stated that solar power is more appropriate to be developed for small capacity cooling systems that can be used as cold chains in remote areas. The system can be connected to the network or not depending on the condition of the existence of the network. At this time Photovoltaic (PV) has been applied to various cooling system capacities from a few kilowatts to several thousand kilowatts. As for the large capacity cooling system, it is better to use a power source from the state electricity network because the electricity output from photovoltaic fluctuates greatly. Gupta et al. [5] developed a stand-alone solar panel as an energy source for the refrigerator system and analyzed the appropriate solar panel design for a certain refrigerator capacity and found that solar power is very suitable for the refrigerator system. Bilgili [6], Modi et al. [7], Su et al [8] and Daffalah [9] state that a minimum initial subsidy of 15% is required to obtain a financial repayment period from the current system to the project's assumed life of 24 years and the system cannot survive economically without initial financial incentives or government subsidies, or a substantial reduction in the cost of more expensive components and a DC refrigeration system is more efficient than an AC system if it uses solar energy. Santosa et al [10] researched to improve the performance of the refrigerator system by improving the type of heat exchanger used and with better performance, the energy consumption of the ending system will also be lower.

To improve energy efficiency dan reduce energy losses especially as an effect infiltration and defrost, which freezing is the most damaging phenomenon to the efficiency. Frost accumulation blocks airflow, worsening cooling capacity and performance coefficient [11]. The thermal entrainment factor cannot be used randomly, although its use is suitable for designing better cabinets under the same climatic class conditions [12]. Installing doors on open-air refrigerated display cabinets is a simple and effective way to improve cabinet performance because it can reduce air entry warm and moist into the cupboard. Large unstable eddies develop in the mixing layer, thereby increasing the infiltration of larger external air. The model is then used to predict the effect of air infiltration through the door gap on the performance of closed display cabinets in both thermal and energy aspects. Applications in supermarkets were also observed that door opening is the main energy loss in display cabinets and in supermarkets a lot of waste is needed because many display cabinets are open [13,14,15]. In addition, Manson et al. [16] conducted an experimental study on the effects of operating conditions, including door opening frequency, ambient air temperature and product occupied volume, on the distribution of air and product temperatures in closed refrigerated display cabinets and obtained that this kind of operation cause significant energy loss.

From the above review, research on refrigeration systems with energy sources from solar energy is very important to conduct research in order to develop this system more efficient in future.

2. METHODS

This research is an experimental study on a prototype display cabinet system for storing fresh meat or fish with an integrated energy source from solar power. The design is based on the standard temperature for refrigerator storage (not frozen) to store fish and seafood at a temperature of -2.2 ^{o}C to 2.2 ^{o}C and a humidity of 90% -98% RH [17]. Thus the prototype is designed to be able to work up to -5 ^{o}C. The main components that are the focus of the design include:

1) Solar power system.
2) Solar and national *PLN* grid integration control system with automatic transfer switch method.
3) Display cabinet refrigeration system.

The calculation and analysis of system and component planning is assisted by on-line computer programs, namely: EES, Cool pack, PVSyst and Dancap. The commissioning test was carried out broadly, namely with the

product load in the form of fresh fish which was stored for 6 days. In this commissioning test, the procedure consists of:

1) Test the characteristics of the temperature inside the cabin,
2) Temperature gain test and compressor on-off control
3) Achievement of air humidity (RH%).
4) Automatic transfer Switch (ATS) system performance and
5) Testing the characteristics of temperature and load quality of fresh fish products.

Measurements were made with a data logger system and temperature measurements with a precision of +-0.3 ºC, humidity measurements +-3% RH. while the performance data of each component of the support system is checked in a check list based on the design and planning that is planned for the operation of this system. The solar power system used is an integrated system with the national *PLN* grid. Product quality data was collected by measuring the temperature (T) and humidity (RH) of the cooling room. Overall analysis will be carried out to obtain system performance and product quality assisted by the @EES (Equation Engineering Solver) program, the @CoolPack program, and the spread sheet program. The results of the analysis will be shown with graphs and tables.

3. RESULTS AND DISCUSSION

Sea food storage needs for display cabinets on display for restaurants or cafes, especially for Balinese tourism supporters with the support of Balinese culinary specialties, spicy and fresh from quality seafood. Storage of fresh sea food ranges from -2.2 ºC to 2 ºC. From the results of the design, commissioning test and analysis analysis carried out, the following results were obtained.

3.1 Solar Power System (Photovoltaic) Design

Figure 1 shows a solar-photovoltaic power system consisting of a series and parallel photovoltaic circuit, Solar Charge Control (SCC), DC/AC Inverter and Batteries. In this system the output of solar energy is AC and DC current and can directly drive the display cabinet cooling system with AC current. The design of the solar power system begins with a simulation of the calculation of the capacity sizing of the components to be used, namely: solar panels (photovoltaic array), solar charge controller (SCC), batteries and DC/AC inverters. The balance of the capacity of each component is simulated with @spread sheet (excel) and the simulation is also assisted by the @PVSys software program. The simulation also considers the configuration of the solar panel arrangement, for example series, parallel or series-parallel combination and alternative battery voltage systems (e.g., 12V or 24V) to be implemented including the type and size of cable required.

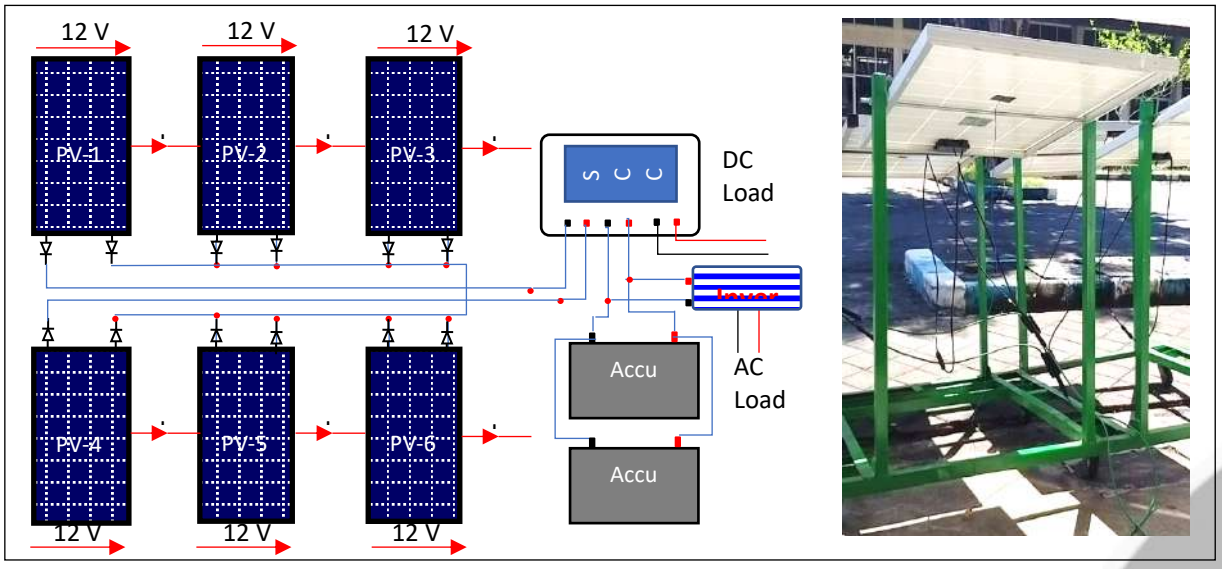

Figure 1. Photovoltaic array design

Photovoltaic arrays can be simulated according to the needs and the desired optimization. A combination of parallel, series, or parallel and series combinations of photovoltaic to obtain the desired current or voltage. Figure 1 also shows a photovoltaic designed to meet the electrical energy load of a prototype display cabinet. Meanwhile, the PVSyst software can be used to simulate off-grid PV mini-grid systems with a database of components such as solar panels, batteries, and SCC. The calculation results of component specifications are shown in Table 1 below.

Table 1. Summary of specification solar energy system

Components	Spesification	Amount	Capacity
Photovoltaic (PV)	- Rated Maximum Power(P_m) : 100W - Tolerance : +/-3% - Cell Efficiency : 16.93% - Voltage at Pmax (V_{mp}) : 17.8V - Current at Pmax (I_{mp}) : 5.62A - Open-Circuit Voltage (V_{oc}) : 21.8V - Short-Circuit Current (I_{sc}) : 6.05A - Series Fuse Rating(A) : 12 - Number of bypass diode : 2 - Dimension(mm) : 1000x670x30mm	6	600 WP
Solar Charge Control (SCC)	Minimum capacity 47,2 A	1	30 A
Inverter	Minimum capacity = 912,6 W	1	1000 W
Batterei	Minimum capacity 198 Ah	2 @100Ah	200Ah

The design of the photovoltaic system is designed to meet the experimental test results for the development of a display cabinet cooling system prototype. The photovoltaic design is an integrated system between the solar power system and the PLN electricity network with an Automatic Transfer Switch (ATS) mechanism that will switch automatically if the battery voltage in the solar power circuit drops to 10V or charging below 30%.

3.2 Display Cabinet Prototype Design

For the design of the display cabinet system, the main components have been designed which consist of determining compressor specifications, condenser capacity, evaporator capacity, capillary tube dimensions, cooling room volume which are designed to be tested continuously to get the best temperature and humidity conditions. Based on the specifications and capacity of the compressor, other major components are planned on the basis and assumptions as shown in Table 2 below.

Table 2. Data base of refrigeration design calculation

Database design	Base Value
Condesing temperature	45°C
Evaporating temperature	-15°C
Sub-cooled degree	2K
Super-heat degree	8K
Compressor	½ HP

By using the Engineering Equation Solver (EES), @Coolpack, and Dancap computer programs, the capacity of the main components is planned and adjusted to the capacity on the market, so that the specifications for the main components are obtained as shown in Table 3 as follows.

Table 3. Calculation result of refrigeration main component

Main Components	Capacity
Capacity of Condenser	144 W
Capacity of Evaporator	100 W
Capillary tube	Length: 1,85 m, diameter : 0,61 mm
Volume of Cabin	1,2 m x 0,40 m x 0,40 m
Compressor	½ HP

3.3 Prototype and Commissioning Test of Display Cabinet

The results of the prototype display cabinet design are shown in Figure 2. The body display cabinet is transparent and slightly open so that the products on display are very clearly visible. The main components of this prototype consist of a display cabinet cooling system and a control panel consisting of a solar panel control and

control for ATS (automatic transfer switch) which is also equipped with instrumentation for measuring current, voltage and power.

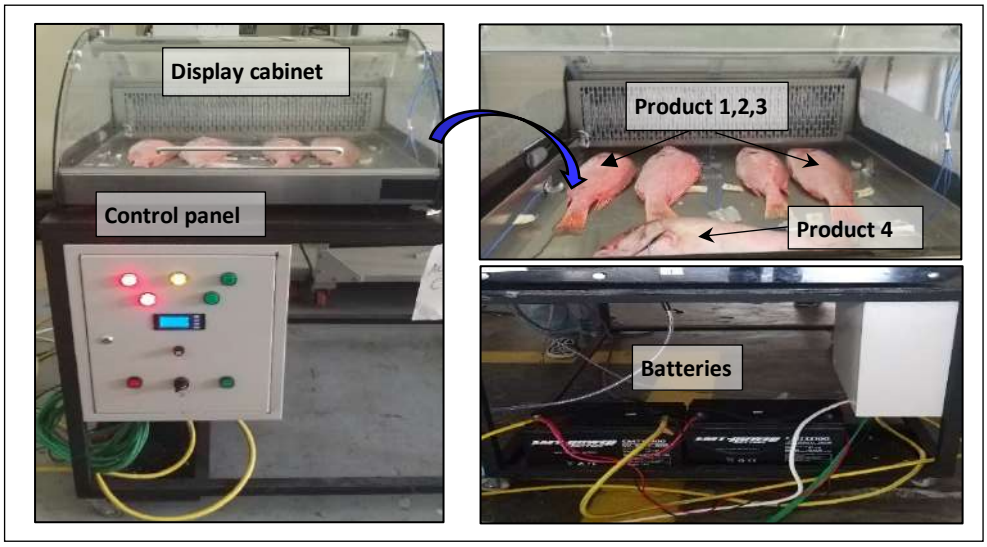

Figure 2. Prototype of display cabinet

The prototype was tested with high-pressure instruments such as a thermocouple with a precision of +-0.5K and a data logger that can retrieve data every 2 seconds. In the display cabinet cooling system, the temperature of each point in the system is measured, namely: point 1 at the compressor entry condition, point 2 to the compressor exit condition, point 3 to exit the condenser, point 4 to enter the capillary tube, point 5 to exit the capillary tube or enter the evaporator, and point 6 is evaporator exit condition. Where the temperature conditions of the commissioning test results are shown in Figure 3 below.

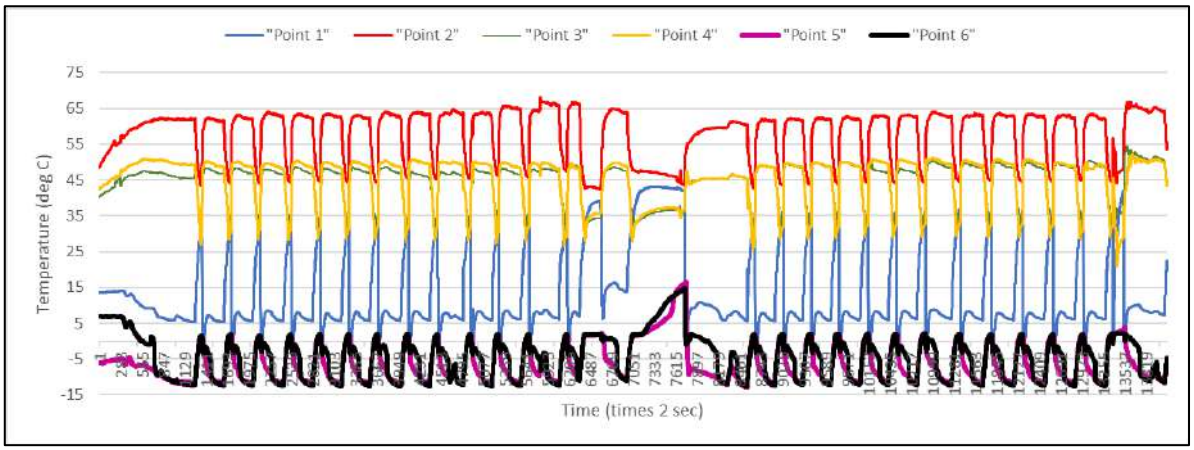

Figure 3. Temperature characteristics of refrigeration system

From the commissioning test results on the temperature of the display cabinet cooling system in Figure 3 above, it can be evaluated that the temperature has been achieved properly with continuous and stable compressor on and off conditions. Defrost occurs at the 4th hour operation (point 7333), during defrost it can be seen that there is an increase in temperature at point 5 and point 6 (temperature evaporator) up to 12^{o}C. While the temperature conditions in the condenser are still stable. It can be evaluated that the temperature gain performance of the display cabinet system is very good.

Testing the temperature of the product and the space stored in the form of fresh fish is shown in Figure 4. The commissioning temperature test data (T) of fish while it is stored in a display cabinet is placed in four positions, namely product 1, product 2 and product 3 in a lined position near the evaporator and product 4 in a position further ahead of the evaporator (see Figure 2). Product 1 to product 3 gets the same temperature while product 4 experiences a temperature of approximately 5^{o}C higher. While the display cabinet cooling room was measured in two positions, that is side 1 and side 2, where position 1 was closer to the evaporator and obtained a different temperature of approximately 3^{o}C. The relative humidity (RH) of the cooling room was measured separately with

a special hygrometer and the average humidity in the cooling room was 50% even though the display cabinet door was opened periodically every 1 hour for 10 seconds. And from the evaluation with this method has not been able to get the desired humidity of at least 90%.

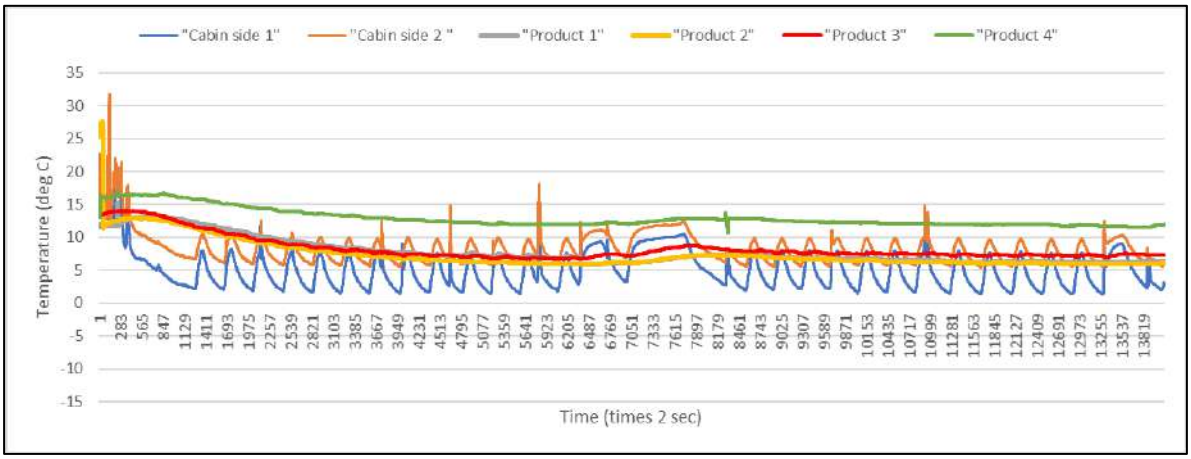

Figure 4. Temperature characteristic of cabin and products

From the analysis of fish products stored for 6 days in a display cabinet in general, it can be seen that the fish is still fresh with good quality (from the color of the gills, the smell and the suppleness of the meat). However, the upper fish skin is a little dry because of the lack of moisture in the display cabinet cooling chamber. This will be the focus of attention in further research, namely by developing a humidifier system that is suitable for display cabinets for storing fresh fish.

4. CONCLUSION

Based on the standard cold storage conditions in the display cabinet, it was stated that the conditions for displaying fresh fish were carried out at a temperature of -0.6 ºC and 95% humidity to be stored for 1 week. From the results of this design, the temperature has been achieved very well but the optimal humidity has not been achieved, where the humidity achieved has only reached an average of 50%RH. From the results of the analysis found that the natural way alone has not been able to produce the desired moisture. From the results of the analysis of the product (fresh fish) stored in this prototype display cabinet, the conditions were hygienic and there was no spoilage during cold storage in the display cabinet. However, the product in dry conditions is less gentle on the upper skin surface. In future research, this weakness will be improved by adding a humidifier system. Meanwhile, the ATS system for the integration of solar and electricity from PLN has worked well and resulted in an excellent integration of energy sources to be developed in tropical countries, such as Indonesia.

5. ACKNOWLEDGEMENT

This research was supported by the Directorate of Sumber Daya, DIKTI, Ministry of Education , Culture and Research Technology, Indonesian Government, Grant No: 249/E4.1/AK.04.PT/2021 and 41/PL8/PG/2021 for the in cash contribution. The authors wish to acknowledge the contributions of The Mechanical Engineering Department -Bali State Polytechnic for the in-kind contributions. Also, Centre for Research and Community Service (P3M-PNB) for all administrative support.

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LOGIC
Journal of Engineering Design and Technology
Vol. 21 No. 3 November 2021; p. 197 - 204

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

THE EFFECT OF MATERIAL CONVEYANCES ON WORKLOAD, MUSCULOSKELETAL DISORDERS, PRODUCTIVITY AND PERFORMANCE IN THE PROCESS OF PLATE CUTTING

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Abstract. The use of material conveyances that are not in accordance with the concept of ergonomics harm the human body. Repair of work brushes by applying ergonomics to material conveyances can reduce the risk category. The purpose of this study was to determine the effect of material conveyance on reducing workload, musculoskeletal disorders, increasing productivity and performance. The study was conducted using the same subject design method with a sample of 16 workers. The data were analyzed by paired t-test with a significant level of $p<0.05$. The results of the analysis showed that the PO workload data was 104.4 beats per minute, P1 was 93.5 beats per minute there was a decrease of 10.9 beats per minute or 10.4%, PO musculoskeletal complaints were 80.1 scores, P1 was 70.0 the scores were decreased by 10.1 or 12.6%, PO productivity of 0.201, P1 of 0.355, an increase of 0.154 or 43.4%. The conclusion is that the use of material conveyances means a decrease in workload, musculoskeletal disorders, an increase in productivity and performance. It is recommended to workers to use material conveyances equipment in carrying out transport and material transport activities.

Keywords: ergonomic, material conveyance, plate cutting process.

1. INTRODUCTION

Material conveyance is a tool used to carry out the work of lifting and transporting materials carried out by workers to move loads from an origin location to a destination location [1]. The materials conveyance used manually. The reason for using it manually with human labor in this material transfer activity is because there are several advantages that can be obtained, namely more flexibility in moving materials at irregular work sites, cheaper and easier to do for light loads.

The activity of lifting and transporting the eser plate is carried out by four workers without using a load carrying tool, carried out not ergonomically, namely with an unnatural attitude or an attitude of forced labor. This condition can increase the workload, cause various disorders in the musculoskeletal system, quickly cause fatigue and be followed by a decrease in productivity [2].

The process of lifting and transporting the eser plate needs to be improved with the following provisions: (1) the load that is lifted and transported for men is 20 kg, while for women 15 kg, (2) the method of lifting and transporting needs to be done correctly, for example both hands, arms, and the whole body plays a role, (3) both shoulders and body are burdened evenly [1].

Every effort to repair a work station should be simple, inexpensive, can and easy to do, can reduce workload, musculoskeletal disorders and increase productivity [3][4]. Especially regarding human resources (workers) must be empowered as optimally as possible, to achieve this goal, every worker must be provided with comfortable, safe, efficient work facilities. Work facilities include: work station facilities and work facilities, work

environment, and work organization that must be in accordance with the abilities, abilities and limits of workers with the hope of achieving the highest productivity [5][6].

Starting from these problems, improvements were made to the lifting and transporting process of the eser plate, in an effort to overcome the problems that arise, namely by using material conveyance, with the hope that the workload, musculoskeletal disorders can be reduced, so productivity and performance can be increased.

The problem that focuses on research on the plate positioning device, with indicators in the form of workload, musculoskeletal disorders, productivity and performance in lifting and transporting plates, the following problems can be described: (a) whether the use of material conveyances in lifting and transporting eser plates can reduce the workload on workers, (b) whether the use of material conveyances in lifting and transporting eser plates can reduce musculoskeletal disorders in workers, (c) whether the use of material conveyances in lifting and transporting eser plates can increase the productivity and performance of workers.

The general objective to be achieved in this study is to determine the means of conveying materials in lifting and transporting eser plates to decrease workload, musculoskeletal complaints and increase productivity and worker performance. The specific objectives to be achieved in the research are as follows: (a) knowing the use of conveying materials in lifting and transporting activities can be a workload on workers, (b) knowing that the use of conveying materials in lifting and transporting activities can decrease workload on workers, (c) knowing the use of material conveyances in lifting and transporting activities can increase worker productivity and performance. The practical function expected in this study are: (a) useful for researchers using the means of transporting materials to refer to the ergonomic aspects, (b) beneficial for workers in the use of material conveyances in lifting and transporting activities so that it refers to the ergonomic aspect. The theoretical functions expected in this study are: (a) the results of this study are expected to contribute ideas in the development of science and technology related to ergonomics, (b) the results of this study are expected to be used as a reference by other researchers in conducting similar research, (c) the results of this study are expected to be a reference for workers in lifting and transporting activities to reduce fatigue, and disorders of musculoskeletal.

2. METHODS

2.1 Research Design

This research is an experimental study using the same subject design method. In this study, a washing out is needed which is useful for eliminating the effects of previous treatments so as not to leave an effect or response (residual effect), [4]. The design of this research can be seen in Figure 1.

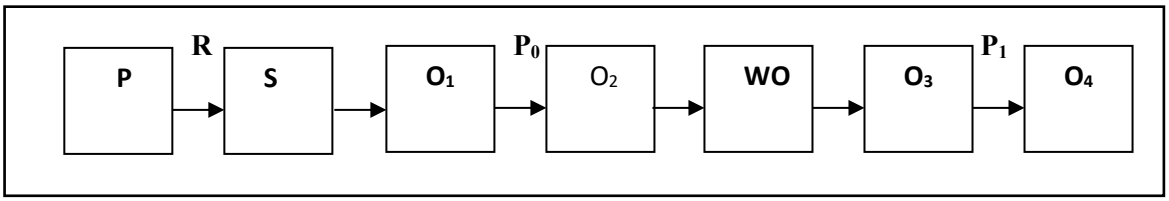

Figure 1. Treatment by Subjects Design

Description:
P : Population
R : Randomization
S : Samples that meet the inclusion criteria
P_0 : Treatment without material conveyance
P_1 : Treatment without material conveyance
O_1 : Initial observation of treatment without material conveyance
O_2 : Final observation of treatment without material conveyance
O_3 : Initial observation of treatment with material conveyance
O_4 : Final observation of treatment without material conveyance
WO : Wash out to remove the carry over effects given for one day

The research was carried out at Politeknik Negeri Bali Mechanical Technology Workshop. The research was conducted in June 2021. The scope of this research is in the field of Work Physiology Ergonomics which is focused on workload, musculoskeletal disorders, productivity, and performance, on lifting and carrying activities of eser plates.

2.2 Sampling Technique

The sampling technique for this study was random sampling [7]. The total population of lifting and transporting large plates that enter the inclusion criteria is 28 people. The 28 people in charge of lifting and transporting the eser plate were carried out by simple randomization using a random number table so that 16 people were obtained as research samples.

2.3 Research Instrument

The instruments or measuring instruments used in this study are as follows:

a. Stop Watch brand Casio made in Japan is used to record the time and count the pulse.
b. Super brand anthropometry Made in Japan to measure the anthropometry of the worker's body.
c. Kodak digital camera made in Japan to document the work attitude.
d. The Nordic Body Map questionnaire with four Likert scales was used to interpret the musculoskeletal disorders
e. The Detecto Medic Scale brand made in Japan is used to measure body weight.

2.4 Research Procedure

To avoid errors in data collection, research procedures were made, namely making a schedule for giving treatment and taking data, which can be shown in Table 1.

Table 1. Schedule of Treatment

Period I.		Period II.	
Day	Subject	Day	Subject
1	Treatment before using material conveyance on lifting and transporting plates of eser (PO)	1	Rest (16 people did not do the treatment)
2	WO	3	Treatment after using material conveyance on lifting and transporting eser plates (P1)

Description:
PO : Treatment without material conveyance on lifting and transporting eser plates.
WO : Washing Out.
P1 : Treatment with material conveyance on lifting and transporting eser plates.

2.5 Data Analysis

The steps of data analysis are as follows:

a. The data that has been obtained is then processed and analyzed with the help of the SPSS (Statistical Package for The Social Science) version 15.00 program. Statistical tests are determined with the following stages:
b. Descriptive analysis in order to obtain the mean, standard deviation, and range of the research variables.
c. Significance test to determine the difference in the mean of the control (PO) and treatment (P1) groups with the t test paired if the data is normally distributed with a significance level of 5% ($\alpha = 0.05$).
d. Abnormal data were tested by nonparametric statistical tests, namely the Wilcoxon test.

3. RESULTS AND DISCUSSION

3.1 Test Data

The number of workers who were the subjects in this study were 16 men, with two types of treatment in the lifting and transporting activities of the eser plate, namely before using the material conveyance and after using the material conveyance. Subject characteristics included age, height, weight, and body mass index (BMI). The average characteristics of the subjects can be shown in Table 2.

Table 2 Subject Characteristics

Variable	Mean	Standard Deviation	Range
Age	18,8	0,9	18,0 – 20.,0
Weight (kg)	57,0	2,4	55,0 – 65,5
Height (cm)	165,6	1,0	163,0 – 167,0
Body mass index	20,8	0,8	20,2 – 23,6

In Table 2 it can be seen that the average age of the subjects in this study was 18.8 ± 0.9 years. Age, weight, and height are included in the normal category, while the body mass index is in the normal category.

a. Subject Anthropometry Data

Subject anthropometry measured in this study included eye height, shoulder height, elbow height, and waist height. The subject's anthropometric measurements are related to the means of transporting materials. Subject anthropometric data can be shown in Table 3.

Table 3. Subject Anthropometry Data

Variable	5th Percentile	95th Persentile	Mean	Standart Deviation
Height	164,5	167,0	165,8	0,8
Eye Height	154,5	157,0	155,8	0,9
Shoulder Height	136,5	139,5	137,8	0,8
Elbow Height	83,5	86,0	83,8	0,8
Waist Height	95,0	98,0	95,9	1,3

In Table 3 it can be seen that the average standing elbow height of the subjects in this study was 83.8 ± 0.8 cm, the 5th percentile of elbow height was 83.5 cm, used as the basis for calculating the handle of the material conveyance.

Manuaba [8] state for manual work that requires space for tools and materials with a workbench surface height of 10 to 20 below elbow height in a standing position. Can be shown in the picture of the means of materials conveyance Figure 3, Picture before treatment (PO) Figure 4, Picture after treatment (P1) Figure 5.

Figure 3. Materials Conveyance

Figure 4. Before Treatment (PO)

Figure 5. After Treatment (P1)

b. Workload

The workload is calculated based on the difference between the pulse at work and the resting pulse. The pulse rate at work is measured immediately after completing the work, while the resting pulse rate is calculated before starting the work. The data obtained were analyzed for significance by using the paired t-test. The difference in the average workload in the treatment before using the material conveyance (PO) and after using the material conveyance (P1). The results of the analysis of significance with the paired t-test can be shown in Table 3.

Table 3. t-test – Paired Average Subject Workload between Treatments

Subject Group	N	Average Working Pulse (dpm)	Standard Deviation	Mean Difference	t	p
PO	16	104,4	4,5	10,9	8,117	0,000
P1	16	93,5	4,2			

The analysis of significance in table 3.2 using the t - paired test showed significantly different results ($p< 0.05$) with $t = 8.117$ and $p = 0.000$. This means that the use of materials conveyances in lifting and transporting plates can reduce the workload on workers.

c. Musculoskeletal disorders

The average value of musculoskeletal disorders was calculated based on the value of disorders after lifting and transporting the eser plate minus the disorders value before lifting and carrying the eser plate for each treatment. The data obtained were analyzed for significance by using the t-paired test. The difference in the mean of musculoskeletal disorders in the treatment before the use of materials conveyances (PO) and after the use of materials conveyances (P1). The results of the analysis of significance with the t - paired test can be shown in Table 4.

Table 4 Paired t-test Mean differences in Musculoskeletal Disorders Subjects between treatments

Subject Group	N	Mean Musculoskeletal Disorders Score	Standart Deviation	Mean Difference	t	p
PO	16	80,09	1,74	-10,08	-15,428	0,000
P1	16	70,01	1,99			

Table 3.3 shows that with the paired t-test analysis the results were significantly different ($p<0.05$) with $t = -15.428$ and $p = 0.000$. This shows that there is a difference between P0 and P1. Therefore, it can be stated that the use of material conveyances in lifting and carrying eser plates can reduce musculoskeletal disorders in workers.

a. Eser Plate Cutting Production

The production of eser plate cutting is carried out on a plate cutting machine, namely; cutting the eser plate before using the material conveyances (PO), and cutting the eser plate after using the material conveyance (P1). Cutting production data is calculated in one working hour with the same accuracy between (PO) and (P1). The

production results between P0 and P1 were carried out by using the t-paired test, the results of the analysis of significance can be shown in table 5.

Table 5. T-test – Paired Average Production

Subject Group	N	Average Production (cuts/hour)	Standart Devation	Mean Difference	t	p
PO	16	20,96	3,23			
				- 12,13	-5,597	0,000
P1	16	33,09	9,95			

From table 3.4, the analysis of significance with the t-paired test shows that there is a significant difference in production results between PO and P1 with p <0.05 and t = - 5.597 and p = 0.000. This means that the use of material conveyances can increase production, as shown in Figure 3.

Work productivity is the ratio between the average production yield of cutting plates per hour and workload for each treatment. The analysis of the significance of the productivity results between PO and P1 was carried out using the paired t test, which can be shown in Table 6.

Table 6. t-paired test of work productivity mean

Subject Group	N	Average Productivity	Standart Deviation	Mean Difference	t	p
PO	16	0,201	0,031			
				-0,154	-6,542	0,000
P1	16	0,355	0,109			

Table 6 shows that there is a significant difference (p <0.05) with t = -6.542 and p = 0.000 on work productivity between PO and P1. This means that it shows that the use of material conveyances can increase work productivity.

3.2 DISCUSSION

a. Subject Conditions

The subjects in this study were male workers whose characteristics discussed were age, weight, height and body mass index. The age of the subjects in this study was between 18 – 20 years with a mean of 18.8 ± 0.9 years. In this age range the subject can perform activities with optimal physical strength. A person's physical capacity is directly proportional to some extent with age, and reaches its peak at the age of 25 years (Manuaba, 1990). The average body weight of the subjects was 57.0 ± 2.4 kg, while the average height of the subjects was 165.6 ± 1.0 cm, and the average body mass index was 20.8 ± 0.8 years. Adiputra [9] stated the ideal body weight with the formula height minus 100 ± (reduction multiplied by 10%). The normal body mass index (BMI) for Indonesians is 18-25 [3].

Anthropometric data of the subjects as shown in table 3.2 shows that the average standing elbow height of the subjects in this study was 83.8 ± 0.8 cm. This elbow height is used as the basis for making material conveyances for lifting and transporting large plates. The height of the material conveyances must be below the subject's elbow height of 10 cm, adjusted to the size of the eser plate cutting machine, namely; machine table height 90 cm, width 60 cm, length 240 cm.

b. Workload

In this study, ergonomic intervention was carried out on the lifting and transporting activities of the eser plate using a materialconveyances, in fact a significant difference (p <0.05) was obtained compared to before using a materials conveyance on the workload of workers. The results of the analysis show that before using the material conveyance (PO) the average worker load is 104.4 beats per minute, while after using the material conveyance (P1) it is 93.5 beats per minute. This means that there is a decrease of 10.9 beats per minute or a decrease of 10.4%. According to Grandjean [2] and Adiputra [1], the working pulse is between 100 – 125 beats per minute, including the moderate category. So the work pulse before using the material conveyance is in the medium category, while after the ergonomic intervention using the material conveyance is included in the light category.

c. Musculoskeletal Disorders

Musculoskeletal disorders experienced by workers often occur in the upper and lower neck, back, waist, both upper arms, as well as both knees and calves. Unnatural work attitudes or forced attitudes experienced by workers cause reactions in the form of complaints in the musculoskeletal system [10][11]. The results of the analysis showed that after using the material conveyance there was a significant difference (p <0.05) and a decrease

in musculoskeletal disorders from an average score of 80.1 to 70.0. This means that it experienced a large decrease of 10.1 or 12.6%.

d. Work productivity

The occurrence of a decrease in workload and a decrease in musculoskeletal disorders in lifting and transport activities directly increases work productivity. The analysis shows that productivity before treatment (PO) is 0.201 while after treatment (P1) is 0.355. This means an increase of 0.154 or 43.4%. Ergonomic intervention on equipment that is suitable for anthropometry will be able to reduce workload, and musculoskeletal disorders and can increase work productivity [12] [13]. A decrease in workload, and musculoskeletal disorders, as well as an increase in work productivity can increase work time efficiency. The increase in productivity also means an increase in the work efficiency [14][15].

4. CONCLUSION

4.1 Conclusion

Starting from the results of the analysis and discussion, it can be concluded as follows:

a. Material conveyance in lifting and transporting large plates can reduce workload workers in plate cutting.
b. Material conveyance in lifting and transporting ice plates can reduce worker musculoskeletal disorders in the plate cutting process.
c. Material conveyance in lifting and transporting eser plates can increase worker productivity and performance in the plate cutting process.

4.2 Suggestions

a. To workers in carrying out lifting and transporting eser plates using material conveyance avoid musculoskeletal disorders.
b. To the policy makers to pay attention to the condition of the tools and facilities in order to increase productivity and performance.

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LOGIC
Journal of Engineering Design and Technology
Vol. 21 No. 3 November 2021; p. 205 - 211

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

EFFECT OF MATERIAL TYPE AND MINIMUM DIAMETER OF SPECIMENS ON THE FATIGUE LIFE

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Abstract. The obstacle faced during the fatigue test is the waiting time which is quite long and inefficient, especially for test specimens made of ductile metal with waiting times of up to several days. The research method includes reducing the specimen radius to obtain a flexural stress approaching 400 MPa which was originally 229 MPa from a radius of 254 mm to 240 mm with the results of turning the original specimen obtained a minimum diameter of 8.6 mm is reduced to 7.3 mm at a maximum loading of 10 kg. Results of the research are brass specimens C3604BD type with a minimum diameter of 8.6 mm at a flexural stress of 298 MPa showing a fatigue life of 2455546 cycles with a test duration of 1754 minutes and a minimum specimen diameter of 7.3 mm at a flexural stress of 299 MPa showing a fatigue life of 684311 cycles with a test duration of 489 minutes which means that with a minimum specimen diameter of 7.3 mm the fatigue life is 3.59 times shorter than a minimum specimen diameter of 8.6 mm. Meanwhile, for aluminium AA1101 type with a minimum specimen diameter of 7.3 mm at a flexural stress of 182 MPa, the fatigue life is 422117 cycles with a test duration of 278 minutes and with a minimum specimen diameter of 8.6 mm at a flexural stress of 183 MPa, the fatigue life is 389232 cycles with a test duration of 302 minutes which means that with a minimum specimen diameter of 7.3 mm the fatigue life is 1.05 times shorter than the minimum specimen diameter of 8.6 mm or almost the same.

Keywords: fatigue test, rotating bending, C3604BD brass, AA1101 aluminum, copy lathe, specimen profile radius, testing time

1. INTRODUCTION

Research on fatigue life has been carried out on 2 types of specimens, namely brass C3604BD type and AA1101 type with an analysis of the difference in profile radius of standard fatigue test specimens tested on an integrated rotating bending fatigue test machine equipped with a copy lathe on the machine. The reduction of the profile radius on standard fatigue test specimens in order to increase the efficiency of the test time previously there were obstacles that fatigue testing took a long time to several days, especially for materials that were quite ductile such as brass.

Fatigue test of brass specimens with 3 different treatment conditions resulted in fatigue life at flexure strength (S) of 98.95 MPa under normal conditions of 1200000 cycles, at annealing conditions of 380^{o}C worth 800000 cycles, under conditions of making a 1 mm deep groove worth 692000 cycles, and being corroded in solution of NaCl at pH 6.6 and concentration of 38% obtained 1110000 cycles [1]. State of the art of the fatigue properties was reviewed [2] for the corrosion resistance of mechanical components. Fatigue tests on steel alloys increase the fatigue life by 5 to 30%, except for Ti alloys, the fatigue life decreases by 12 to 14%. The difference between fatigue testing using Ultrasonic at 20 kHz reaches a fatigue life of 10^7 cycles for 9 minutes, but with the conventional method at 100 Hz it is achieved for 1 day which results in a drastic reduction in fatigue testing time and costs [3]. The results of the A356 automotive wheel specimen cut at the bottom inner corner of the wheel

spokes which were tested for fatigue at S 120 MPa broken at a fatigue life of 380000 cycles showed a decrease in the value of the specimen cut exactly on the inner rim bar, the fatigue test at S 120 MPa broke at fatigue life 360000 cycles [4]. Different treatments on fatigue test specimens resulted in different fatigue life of specimens treated with annealing, giving grooves and corroding can reduce fatigue life than the untreated condition. For specimen material AA of 7075 because it does not show an endurance limit, then in the fatigue test it was stopped at 100 MPa [5]. Fatigue life on the aluminium alloy specimen, AA 6063-TF with a coarse surface obtained fatigue life at 1102472 cycles and on a smooth surface obtained fatigue life at 1281945 cycles which means the fatigue life of a specimen with a smooth surface is 16.3% longer than the fatigue life of specimens with a coarser surface [6]. Fatigue life of specimen AA 2219-T852 as a result of longitudinal forging with a thickness of 8" and 12" shows that the increase in the lowest stress level for sectioned in the longitudinal direction of 12" and short transverse of 8" is lower in fatigue life than short transverse 12" [7]. The average fatigue life of the sectioned AA 1100 specimen in the longitudinal direction of the rolling direction (RD) is 10685087 cycles and for the AA 1050 specimen material is 10171184 cycles. The two values of fatigue life are greater than the fatigue life in the transverse direction of RD which is 8814385 cycles for AA 1100 material and 8596266 cycles for AA 1050 material [8]. The fatigue test specimen material from Aluminium had no fatigue limit, but on steel [9] showed fatigue limit values. The fatigue-tested AA6063 T6 material with a mini-specimen size with an area of 5.5 mm^2 (1.58 mm thickness and 3.5 mm width) sectioned from a complex rectangular profile 45 mm x 45 mm at a maximum stress of 220 MPa resulted in fatigue life at 48011 cycles [10]. The integrated rotating bending fatigue test machine has not only been used in fatigue tests for brass and aluminium but is also used for fatigue tests on cast iron and nylon [11]. The fatigue life of AA 2219-T852 forged longitudinally with a thickness of 12" and a transverse direction of 8" thickness shows an increase from its lowest stress level for a thickness of 12" in the transverse direction [12]. Material AA 6082-T6 was corroded in the salt spray corrosion chamber referring to the ASTM B117 standard. The comparison of all fatigue tests with the same fatigue life was 2 x 10^6 cycles for different S at 98 MPa for 1 month of corrosion, at 91 MPa for 2 months of corrosion, at 68 MPa for 3-month corrosion, and 131 MPa for non-corroded material [13]. AA 6063 with spray coating with sand blasting increased fatigue life from 4182 cycles to 5585 cycles at a load of 9.34 kN, and anodizing with sand blasting increased fatigue life from 3890 cycles to 4200 cycles at a load of 9.34 kN [14]. Specimen AA 7075-T6 which was tested for fatigue at 24 ^oC had a lower S-N curve than 160 ^oC, both of which were lower than the S-N curve at 20 4oC [15]. The fatigue resistance of aluminium A356-T6 which is cast into sand molds is highly dependent on the presence of casting defects and its microstructural characteristics which in cast results often have porosity and oxides that dominate fatigue performance [16]. Glass polyester composites that were tested for fatigue obtained a fatigue life of 512 cycles at a maximum S of 340 MPa and a fatigue life of 506823 cycles at a minimum S of 140 MPa, while AA2024-T4 obtained a fatigue life of 4783 cycles at a maximum S of 340 MPa and a fatigue life of 16812322 cycles at a minimum S of 140 MPa [17]. The fatigue life of AA2024-T4 is higher than that of Glass polyester composites.

2. METHODS

Fatigue test research was carried out on 2 types of specimens from material C3604BD type and AA1101 type with variable type of material and profile radius of standard fatigue test specimens at a radius of 254 mm and 240 mm as an improvement effort to increase the flexure stress to close to 400 MPa which is desired so that fatigue testing can save shorter test times, which is a problem for ductile metal materials requiring a test time of up to several days for just a single specimen. The fatigue test is carried out on an integrated rotating bending fatigue test machine equipped with a patented copy lathe device. The copy lathe device installed on the integrated rotating bending fatigue testing machine has been submitted for patent registration to the Ministry of Law and Human Rights of the Republic of Indonesia with Number of Application is S00201910197 on November 8, 2019 for claims: the turning can be adjusted at a speed according to the type of specimen material through DC motor and manual actuation of the symmetrical profile lathe tool in a stepwise forward iteration followed by left side movement and then forward movement followed by right side movement until the minimum diameter (final size) of the specimen is achieved.

Fatigue life data is obtained through recording on the computer of the integrated rotating bending fatigue test machine which is equipped with application software that can store operator name, mobile phone number or operator's mobile phone number, the selected loading level, the installed encoder can calculate the amount rotation until the fatigue test specimen breaks when it reaches its fatigue life, the speed that is being applied to the machine is displayed on the monitor screen, and the fatigue test machine can send a short message (sms/short message service) when the machine is started and send sms back when the specimen becomes disconnected or the power source from the electricity source/PLN (state electricity company) is broken. The fatigue testing machine has been equipped with close circuit television (CCTV), so that when the internet network source is still connected, the

fatigue testing machine can be monitored remotely online to ensure the specimen has failed or the power source is disconnected. The results of the fatigue life recording can be recorded on the machine monitor screen in the form of the number of revolutions achieved until the specimen breaks and the level of loading applied in kg. The flexure stress is calculated using Formulas (1) to (3).

$$S = M.c/I \quad (1)$$

$$M = (F/2)\ (L/2) \quad (2)$$

$$I = \pi d^4/64 \quad (3)$$

where:
S: Flexure strength (MPa),
M: Flexure moment (Nm),
c: Outer fiber distance or radius of specimen (m),
F: Load (N), in the range of 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 kg.
L: Horizontal distance between bearings load, fixed for the machine is 285 mm,
I: Inertia moment (m^4), and
d: Minimum diameter in the center of of fatigue specimen length (mm).

The concept of fatigue test method R.R. Moore's machine construction and specimen bending illustration is shown in Figure 1.

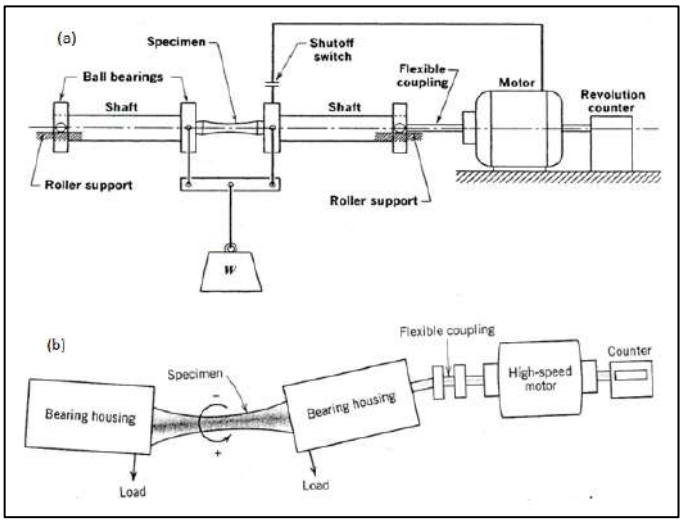

Figure 1. Rotary rod fatigue testing machine by R.R. Moore: (a) Machine construction [18], and (b) Specimen bending [19]

The shape and dimensions of the standard fatigue test specimen with 2 kinds of specimen radii or can also be expressed with a minimum diameter in the middle of the length of the rod are shown in Figure 2.

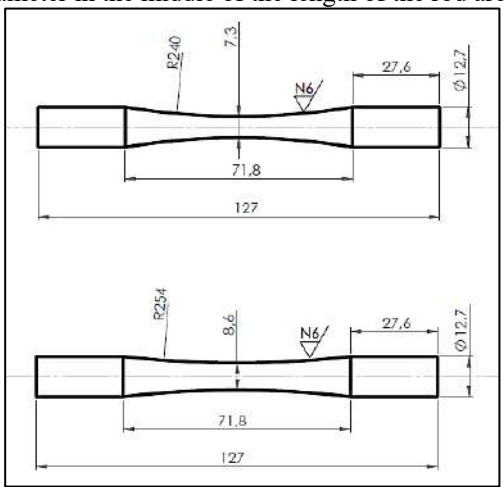

Figure 2. Shape and dimensions of standard fatigue test specimens with 2 kinds of radius on 254 mm and 240 mm

The turning of the brass specimen and the aluminium specimen is shown in Figure 3.

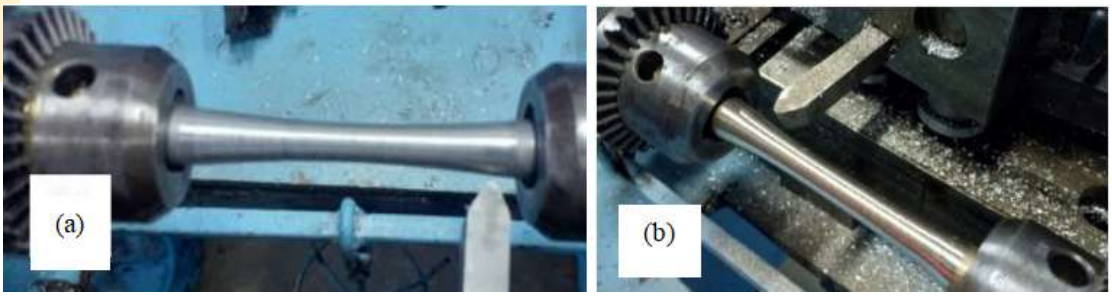

Figure 3. Specimen turning: (a) Brass, and (b) Aluminium

The construction of the integrated rotating bending fatigue test machine front view and rear view are shown in Figure 4.

Figure 4. Construction of the integrated rotating bending fatigue test machine: (a) Front view, and (b) Rear view

The brass and aluminium specimens prior to fatigue testing are shown in Figure 5.

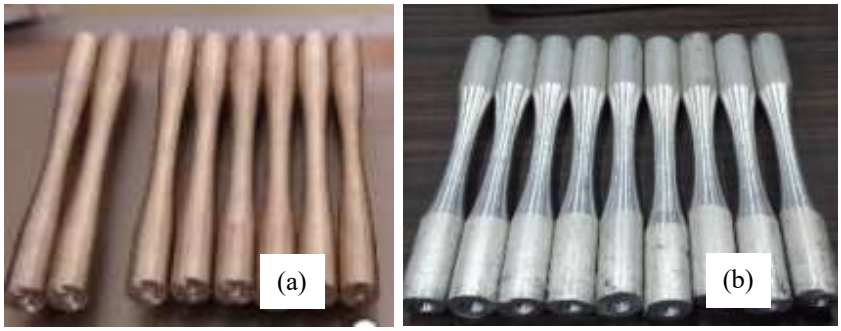

Figure 5. Specimens before fatigue test: (a) Brass and (b) Aluminium

The brass and aluminium specimens after fatigue testing are shown in Figure 6.

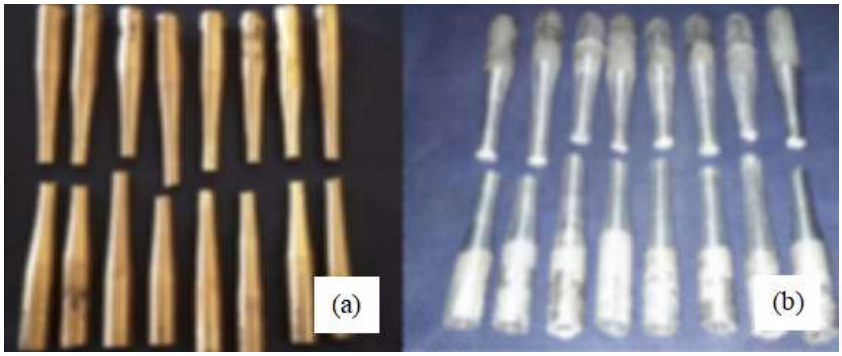

Figure 6. Specimens after fatigue testing: (a) Brass, and (b) Aluminium

The results of fatigue life in the form of the number of rotations of the specimen until it breaks and the flexure stress from the serial data is plotted into an S-N curve which is compared between the data with various test conditions including differences in specimen material and specimen radius profile.

3. RESULTS AND DISCUSSION

The fatigue life of brass C3604BD with different specimen profile radii at 240 mm and 254 mm resulting in a minimum specimen diameter of 7.3 mm and 8.6 mm is shown in Table 1 and Figure 7.

Table 1. Fatigue life of brass C3604BD with minimum specimen diameter of 7.3 mm and 8.6 mm

No.	Brass C3604BD			
	ϕ 7.3 mm		ϕ8.6 mm	
	S (MPa)	N (Cycles)	S (MPa)	N (Cycles)
1	395	201513	298	2455546
2	329	498000	275	2889076
3	299	684311	252	3625736
4	269	1072145	229	4848366
5	240	1783948	201	9385424
6	211	2533160	183	14234556
7	182	4212535	165	18988907
8	153	9731510	147	31322458

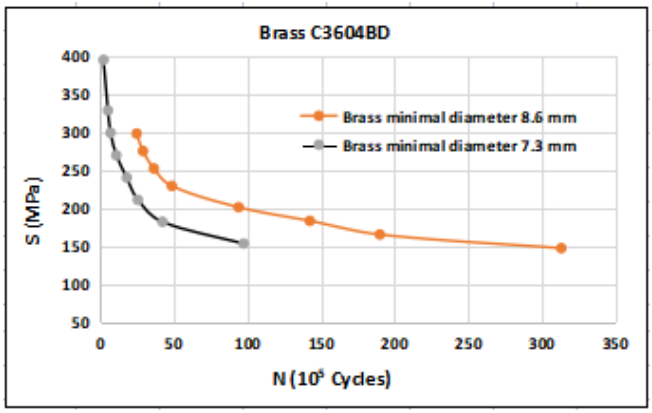

Figure 7. Fatigue life of brass C3604BD minimum specimen diameter of 7.3 mm and 8.6 mm

The fatigue life of AA 1101 with minimum specimen diameter of 7.3 mm and 8.6 mm is shown in Table 2 and Figure 8.

Table 2. Fatigue life of AA 1101 with minimum specimen diameter of 7.3 mm and 8.6 mm

No.	AA 1101					
	ϕ 7.3 mm			ϕ 8.6 mm		
	S (MPa)	N (Cycles)	Duration (minute)	S (MPa)	N (Cycles)	Duration (minute)
1	395	36161	26	229	102444	73
2	329	53553	38	201	174235	124
3	299	65321	47	183	389232	278
4	269	78599	56	165	784704	561
5	240	102651	73	147	1167834	834
6	211	158439	113	129	1960328	1400
7	182	422117	302	111	3841875	2744
8	153	1053240	752	94	8364557	5975

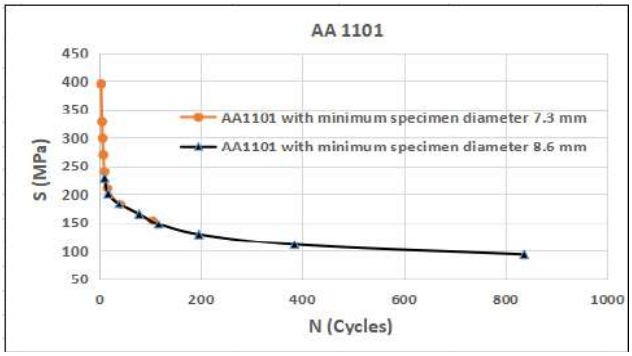

Figure 8. Fatigue life of AA 1101 with minimum specimen diameter of 7.3 mm and 8.6 mm

Brass specimens C3604BD type from the Table 1 with a minimum diameter of 8.6 mm at a flexural stress (S) of 298 MPa showing a fatigue life of 2455546 cycles with a test duration of 1754 minutes and a minimum specimen diameter of 7.3 mm at S of 299 MPa showing a fatigue life of 684311 cycles with a test duration of 489 minutes which means that with a minimum specimen diameter of 7.3 mm the fatigue life is 3.59 times shorter than a minimum specimen diameter of 8.6 mm or save the testing time of 1265 minutes or 21 hours.

Aluminium AA1101 type from the Table 2 with a minimum specimen diameter of 7.3 mm at S of 182 MPa, the fatigue life is 422117 cycles with a test duration of 278 minutes and with a minimum specimen diameter of 8.6 mm at S of 183 MPa, the fatigue life is 389232 cycles with a test duration of 302 minutes which means that with a minimum specimen diameter of 7.3 mm the fatigue life is 1.05 times shorter than the minimum specimen diameter of 8.6 mm or save the testing time 24 minutes what can be said by almost the same.

4. CONCLUSION

Conclusions that can be drawn from the fatigue life research of brass materials C3604BD type and AA1101 type include:

1) The brass specimen type C3604BD with a minimum specimen diameter of 7.3 mm has a fatigue life of 3.59 times shorter than the minimum specimen diameter of 8.6 mm, which means that the testing time is reduced to 1265 minutes or approximately 21 hours, and
2) Aluminium type AA1101 with a minimum specimen diameter of 7.3 mm has a fatigue life of 1.05 times shorter than the minimum specimen diameter of 8.6 mm, which means that the testing time is 24 minutes more efficient or almost the same.

5. ACKNOWLEDGEMENT

The authors are grateful to Hendri Irwanto Prabowo for his cooperation in the manufacture of copy lathe profile rails on an integrated rotating bending fatigue testing machine at the Laboratory of Materials Testing, Department of Mechanical Engineering, State Polytechnic of Malang.

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LOGIC
Journal of Engineering Design and Technology
Vol. 21 No. 3 November 2021; p. 212 - 217

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

THE INFLUENCE OF PARKING ATTENDANT AND PARKING FACILITIES ON USER SATISFACTION OF CAR PARKING ON NGURAH RAI STREET GIANYAR CITY

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Abstract. Driver satisfaction in making a trip is influenced by the quality of parking services. The purpose of this study was to analyze the effect of parking attendants and parking facilities on the satisfaction of car park users on Jalan Ngurah Rai, in Gianyar City, which is currently working on revitalizing traditional markets with modern concepts. Research using survey methods, distributing questionnaires to obtain 100 sheets of parking service user perception data. The results of the analysis show that the regression equation obtained is Y = 2.354 + 0.281 X1 + 0.672 X2. The parking attendant and parking facilities variables both partially and simultaneously have a significant positive effect on the user satisfaction variable. Value of Sig. variable parking attendant and parking facilities respectively 0.000 < 0.05. The value of tcount for parking attendants and parking facilities are 9,500 and 20.921, respectively > ttable = 1.9872. Fcount = 312.296 > 0.025324. The ability of the parking attendant and parking facilities variable in influencing the user satisfaction variable is quite large, as indicated by the coefficient value. determination (R2) of 86.3%.

Keywords: parking attendant, parking facilities, user satisfaction, regression model

1. INTRODUCTION

Parking is an important component of the urban transportation system. With the continuous increase of uncontrolled car ownership and limited availability of infrastructure and land resources, parking problems become a formidable challenge for transportation managers [1]. The increase in car ownership and car use gives rise to a growing conflict between demand and availability of parking spaces [2]

The limited land available for adequate parking areas in office and shopping centers causes consumers to park their vehicles on the road, which results in disruption of traffic flow [3]. The high demand for on-street parking poses a major challenge to transportation management, which has also received great attention from researchers. A large number of studies have been carried out to improve on-street parking management, from either a survey-based or a modeling-based perspective [4]

On-street parking is one of the most frequently seen prototypes of parking, both paid and unpaid, which causes vehicles moving on the road to share width with parked vehicles [5]. On-street parking has several natural contributions to the economy and safety of road users. But this of course, has some negative effects, such as reduction of road capacity, frequent occurrence of accidents on main roads [6]. However, previous studies have found a positive relationship between public parking provision and household car ownership and use [7] [8].

In practice, parking policies are often opportunistic. In low-density areas with segregated housing, parking policies may not have much effect due to the large amount of land available for parking facilities, while in high-density neighborhoods conflicts of interest between car owners and non-owners over land are common [9]. Especially in inner-city areas that serve as destinations for travel, shopping and recreation as well as in residential neighborhoods with high population density and land use [10].

Driver satisfaction in traveling is influenced by the ease of getting parking attendant parking facilities, rates, security and comfort. Driving satisfaction decreases when the driver is difficult to get parking facilities [11]. This study focuses on the satisfaction of parking service users on the quality of the service itself, namely parking attendants and parking facilities, while parking rates are easily affordable. User satisfaction is an important indicator to evaluate services. Studies on parking satisfaction mostly focus on the service itself where parking is a part of travel satisfaction.

The city of Gianyar, this year is working to revitalize the traditional market with a modern concept [12]. The research was conducted on Jalan Ngurah Rai which is the main and most populous road in Gianyar City, precisely at the intersection of Jalan Ksatrian - Jalan Captain Dipta intersection, 420 m long, type 2/2U road, 15.40 m wide. The car park slots are 79 SRP, with a size of 4.6 x 3.30 m2, forming an angle of 450 taking the road (on-street parking) north of the road. Meanwhile, motorbike parking is provided on off-street parking for 100 m to the north of the road with a width of 6.5 m.

2. METHODS

This study is an observational survey method, taking a sample of 100 respondents, using a questionnaire as an instrument to collect data from the population of car park users on Jalan Ngurah Rai in Gianyar City. The measurement is the perception of parking service users, where the analysis is the parking interpreter and parking facilities. Parking attendants are people/officers who provide services, while parking facilities are places/slots for car parking in the SRP. Data analysis used multiple linear regression statistical method with SPSS ver.26 software.

The measurement scale used is a Likert scale with a score of 1 – 5, as shown in Table 1.

Table 1. Perception and Score

No	Perception	Score
1	Strongly disagree	1
2	Do not agree	2
3	Somewhat agree	3
4	Agree	4
5	Strongly agree	5

2.1 Validity and Reliability Test

Validity and reliability tests were carried out by analyzing the perception data of 30 respondents. The validity test method used is Pearson Product Moment, where if the correlation value is 0.3, then the instrument is declared valid [13]. The reliability test method is the Cronbach's Alpha coefficient method, because the research instrument is in the form of a questionnaire. Cronbach's Alpha coefficient value must be 0.6 so that the instrument can be declared reliable [14].

2.2 Multiple Linear Regression Model

In this study, the multiple linear analysis method was used to predict the state of the dependent variable, if two or more independent variables as predictors changed. The linear regression equation can be formulated as equation 2.1 [15]:

$$Y = a+b_1X_1+ b_2X_2 \quad \text{..... (1)}$$

Where:

Y = parking user satisfaction level
a = constant
b1, b2 = regression coefficient
X1 = parking attendant attitude
X2 = parking lot condition

2.3 Test t, F, dan R^2

t test is used to test the effect of each independent variable individually or partially on the dependent variable. This test is done by comparing the value of tcount > ttable, and the value of Sig. less than = 0.05, then the independent variable has a significant effect [14].

The F test is used to simultaneously test the effect of the independent variable on the dependent variable. This test is carried out by comparing the significance of the value of Fcount > Ftable, then the formulated model has met. If the value of Fcount > Ftable, it can be interpreted as a joint effect, with a determined significance level of 0.05 ($\alpha = 0.05$) [14].

The coefficient of determination (R2) test is used to measure how far the model's ability to explain the variation of the dependent variable is. The value of the coefficient of determination (R2) is between 0 and 1. A value of R2 that is close to 0 means that the ability of the independent variable to explain the variation of the dependent variable is small, whereas the value of R2 that is close to 1 means that the ability of the independent variable to explain the variation of the dependent variable is large [14].

2.4 Research Model Schematic

In this study, two independent variables were used to explain one dependent variable. Parking interpreter variable (X1) and parking facility (X2), as independent variables, and user satisfaction variable (Y) as dependent variable. Figure 1 shows the schematic of the research model.

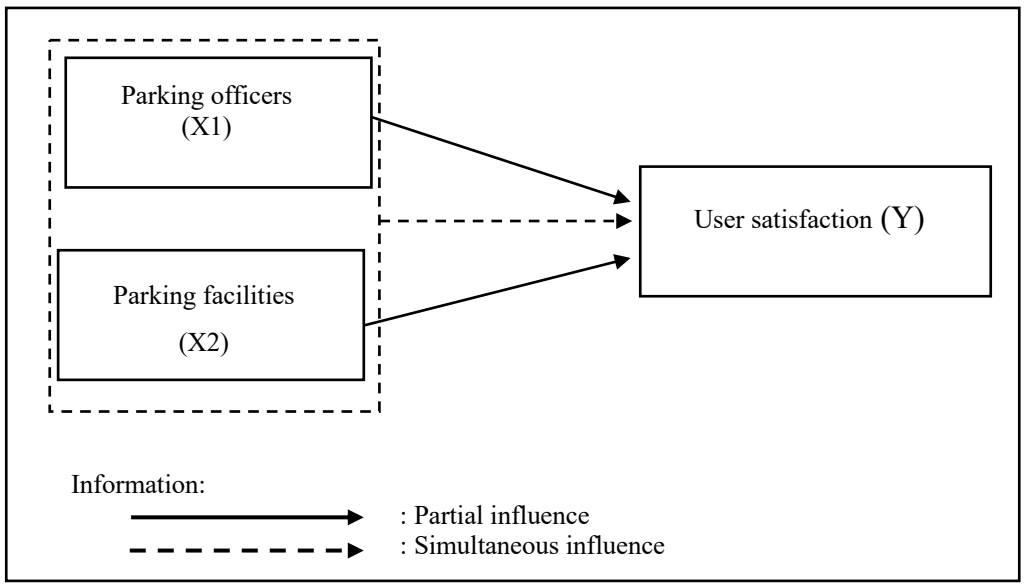

Figure 1. Research Model Schematic

3. RESULTS AND DISCUSSION

3.1 Validity and reliability test

Of the 30 questionnaires that have been distributed to test the validity and reliability, the results obtained, as shown in Table 2.

Table 2. Validity and Reliability Test Results

Variable	Corected item-Total Correlation	Cronbach's Alpha if Item Deleted
X11	0,839	0,753
X12	0,655	0,814
X13	0,593	0,825
X14	0,488	0,850
X15	0,706	0,797
X21	0,763	0,817
X22	0,636	0,850
X23	0,670	0,841
X24	0,710	0,831
X25	0,657	0,845
Y1	0,499	0,728
Y2	0,751	0,634
Y3	0,551	0,711
Y4	0,379	0,764
Y5	0,488	0,733

Table 2 shows the Corrected Item-Total Correlation of all indicators. All indicators meet the requirements of 0.3. The smallest value is owned by the Y4 indicator 0.379 and the largest indicator X11 with a value of 0.839. Meanwhile, in Cronbach's Alpha if Item Deleted column, it can be seen that all indicator values meet the requirements of 0.6. The smallest value on the Y2 indicator is 0.634, the largest on the indicator but still meets the requirements > 0.6. Thus the instrument is declared valid and reliable.

3.2 Multiple Linear Regression Model

Based on the results of the analysis of 100 questionnaires that have been distributed, the regression equation coefficient and t-test value (partial), as shown in Table 3.

$$Y = 2{,}354 + 0{,}281\ X1 + 0{,}672\ X2 \quad \text{..... (2)}$$

Table 3. Coefficient of Regression Equation and t Test Value (partial)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2,354	0,704		3,343	0,001
	Parking attendant (X1)	0,281	0,030	0,360	9,500	0,000
	Parking Facility (X2)	0,672	0,032	0,793	20,921	0,000

a. Dependent Variable: Usage satisfaction (Y)

From Table 3, the constant value is 2.354, the parking attendant variable coefficient (X1) is 0.281, the parking facility variable coefficient (X2) is 0.672, so that the regression equation (2) is obtained. The regression equation shows the relationship between the parking attendant variable (X1), Parking Facilities (X2) as the independent variable, and User Satisfaction (Y) as the dependent variable. From the regression model can be seen:

1. The value of the constant is 2.354, meaning that if there is no change in the value of the independent variable parking attendant and parking facilities (X1 and X2 values are 0) then the dependent variable User Satisfaction (Y) is 2.354 units.
2. Coef value. parking attendant regression (X1) is 0.281, meaning that if the parking attendant variable (X1) increases by 1% with the assumption that the parking facility variable (X2) and constant (a) is 0 (zero), then the User Satisfaction variable increases by 0.281. Parking attendant variable (X1) contributes positively to User Satisfaction (Y).
3. Coef value. Parking Facility regression (X2) is 0.672, meaning that if the Parking Facility variable (X2) increases by 1%, assuming the parking attendant variable value (X1) and constant is 0, then User Satisfaction increases by 0.672.

3.3 T-Test Results (Partial)

Based on Table 3, taking into account the rows of columns t and sig, it can be explained as follows:

1. Parking attendant variable (X1) has a positive and significant effect on User Satisfaction (Y). This can be seen from the significance value of the parking attendant (X1) 0.000 < 0.05. Then the value of ttable = (α/2; n-k-1) = (0.025;100-2-1) = (0.025;97) = 1.9872. It means that the value of tcount = 9.500 > ttable = 1.9872. Thus, the hypothesis which states: "Parking attendant (X1) has an effect on User Satisfaction (Y)", is partially accepted. The ttable value can be searched from Excel with the formula: "=T.INV(probabilit;deg_freedom1).
2. Parking Facility Variable (X2) has a positive and significant effect on User Satisfaction (Y). This can be seen from the significance value of Parking Facilities (X2) 0.000 < 0.05. Then the value of ttable = (α/2; n-k-1) = (0.025;100-2-1) = (0.025;97) = 1.9872. It means that the value of tcount = 20,921 > ttable = 1.9872. Thus, the hypothesis which states: "Parking Facilities (X1) has an effect on User Satisfaction (Y)", is partially accepted.

3.4 F Test Results (Simultaneous)

Table 4 shows the magnitude of the influence of the parking attendant (X1) and parking facilities (X2) variables together (sumultaneously) on the User Satisfaction variable (Y).

Table 4. F Test Value (Simultaneous)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	421,457	2	210,729	312,296	.000[b]
	Residual	65,453	97	0,675		
	Total	486,910	99			

a. Dependent Variable: Kepuasan Pengguna (Y)

b. Predictors: (Constant), Juru Parkir (X1), Fasilitas Parkir (X2)

From Table 4, it can be seen that the value of Sig. 0.000 < 0.05, and the value of Fcount = 312.296. Ftable value = (α/2; k;n-k) = (0.025;2;100-2); (0.025;2;98), then Ftable = 0.025324. Meanwhile, Fcount = 312.295 > Ftable = 0.025324. Thus, it can be concluded that the parking attendant variable (X1) and Parking Facility (X2) have a significant or simultaneous effect on the independent variable User Satisfaction (Y). This Ftable value can be obtained from Excel software calculations with the formula "=F.INV(probability;deg_freedom1;deg_Freedom2)"

3.5 Coef Test Results. Determination (R2)

Table 5 shows the coefficients. determination (R2) a measuring tool used to describe how much variation is described in the model.

Table 5 Coef Value. Determination (R2)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.930[a]	0,866	0,863	0,821

a. Predictors: (Constant), Juru Parkir (X1), Fasilitas Parkir (X2)

From Table 5 it can be seen that the value of the coefficient. determination (R2) is found in the Adjusted R Square value, which is 0.863. This shows the ability of the independent variable to explain the dependent variable is 86.3%, the remaining 13.7% is explained by other variables not discussed in this study.

4. CONCLUSION

Parking attendants and parking facilities greatly determine the level of satisfaction of parking users in the City of Gianyar. This is evidenced by the results of the analysis, namely:

1. The regression equation obtained is Y = 2.354 + 0.281 X1 + 0.672 X2.
2. The variable parking attendant and parking facilities partially have a positive significant effect on the variable user satisfaction. The parking attendant variable has a value of Sig. = 0.000 < 0.05, thiutng = 9.500 > t table = 1.9872. The Parking Facility variable has a value of Sig. = 0.000 < 0.05, thiutng = 20.921 > t table = 1.9872.
3. The variable parking attendant and parking facilities, together (simultaneously) have a significant positive effect on the User Satisfaction variable, with a value of Sig. = 0.000 < 0.05, and the value of Fcount = 312.296 > Ftable = 0.025324.
4. The ability of the parking attendants and parking facilities to influence the User Satisfaction variable is quite large, namely the value of Adjusted R Square = 86.3%. The rest is influenced by other variables not discussed in this study.

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LOGIC
Journal of Engineering Design and Technology
Vol. 21 No.3 November 2021; p. 218 – 224

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

EFFECT OF TEMPERATURE VARIATION OF STATIC THERMAL TENSIONING ON ANGULAR DISTORTION AND MICROSTRUCTURE BEHAVIOR OF GMAW WELDED SUS 304 STAINLESS STEEL PLATE

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Abstract. Due to its rust resistance properties, the use of stainless steels, especially SUS304 for industrial equipment is increasing. The manufacturing process that is often used is GMAW welding. One of the disadvantages of SUS304 is the occurrence of distortion and sensitization when welded. In this study, the effect of temperature variations of Static Thermal Tensioning on angle distortion and microstructure behavior due to GMAW welding of SUS 304 T-joint plates was studied. Heating by electric heater is given to both parts of the base metal plate SUS 304 5mm thick with temperature variations of 200 ºC, 250 ºC and 300 ºC. Cooling water with a temperature of 24 ºC is provided on the back side of the welded track. Welding using filler ER 304 with a diameter of 0.8 mm with welding parameters such as welding current, voltage, gas flow and travel speed controlled at 75 A, 22 V, 10 l/min and 8 mm/s, respectively. Angular distortion of welding results for each treatment temperature variation was measured using a bevel protractor, and perform metallographic test to knowing the microstructural behavior. The results of the measurement of the average angular distortion of three repetitions show that at a temperature of 250 C static thermal tensioning produces the smallest angular distortion of 3º70', compared to other temperature variations which produce angular distortion 4º45’ at 200 ºC and 3º86' at temperature 300 ºC. The findings of the largest Cr (carbide) deposits due to sensitization were found at a temperature of 300 ºC at 16,49% and the lowest at a temperature of 200 ºC at 7,05%

Keywords: static thermal tensioning,sensitization, SUS 304,GMAW, angular distortion.

1. INTRODUCTION

Stainless steels are an important class of engineering materials that have been used widely in a variety of industries and environments due to their high corrosion and oxidation resistance property [1]. Due to its rust resistance properties, the use of stainless steels, especially SUS304 for industrial equipment is increasing. Austenitic stainless steels are used in the pressure vessels, chemical, transportation, medical industry due to their superior mechanical properties [2]. The manufacturing process that is often used is GMAW welding. However, this technology in its traditional form has disadvantages because the high temperature involved generates thermal expansion, shrinkage, and microstructural transformations [3]. The most concerned of the disadvantages of SUS304 is the occurrence of distortion and sensitization when welded.

Non-uniform heating and cooling during welding results in non-uniform expansion and contraction of the weld base and its surroundings, which results in residual stresses and unwanted deformations in the welded joint [4]. In the process of welding SUS 304 material, the thermal expansion and contraction produced is very large so that it can cause defects or failures in welding. Additional works such as post weld heat treatment and welding repairs need to be done to correct distortions and reduce the residual stresses [5]

[6] has done optimization of welding parameter relationship with distortion angle and weld depth. The results show the smallest angle distortion value of 0.139 [radian] and penetration depth of 2.77 [mm] can be achieved with a variable welding using a plate length of 355.75 [mm], with a current of 250 [A] and a welding speed of 30 [cm/min].

Thermal tensioning is a welding method by adding active cooling that moves behind the welding torch and a heater that is placed next to the welding line. The residual stress that occurs in the weld area also decreases and bends distortion that often occurs in conventional plate welding can become almost flat when using this method [7].

One of the Thermal Tensioning methods is Static thermal tensioning (STT), where the working principle of this method is in the form of thermal tensioning to against thermal stress due to welding. Static thermal tensioning (STT) method can minimize the distortion that occurs in the AA5083 aluminum plate with a thickness of 3mm where the optimal distortion reduction occurs at a heating temperature of 200 ^{o}C [8].

Angular distortion can occur in the welding of T joints. This distortion is even greater if the welding material used is stainless steel, because in austenitic stainless steels thermal expansion is high and heat conduction is low [9,10]. Effect of heat input can influence both detrimental and beneficial effect on the material microstructure which is then directly influencing corrosion resistance of materials [11]. The heat input of welding will cause sensitization (formation of Cr precipitation at grain boundaries) in the HAZ; acceleration of localized attack in the presence of chloride ions [12, 13]. Sensitization it self leads to degradation of corrosion resistance as well as the mechanical properties [14]. then Further research is needed to overcome the problem of angular distortion and sensitization phenomenon in stainless plate welding, especially SUS 304, considering its very wide use in industry.

2. METHODS

2.1 Specimen and Equipment Preparation

The welding specimen is a SUS 304 plate with dimensions of 170 mm in length, 130 mm in width and 5 mm in thickness. Before tackweld to form a T joint, the plate is drilled with a diameter of 2 mm in several positions as a place for installing several thermocouples as shown in Figure 1. below:

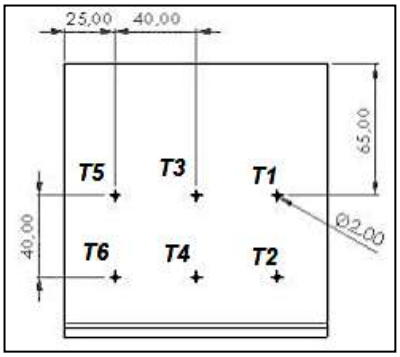


Figure 1. Thermocouple hole position

Tack weld the specimen at an angle of 90^{o} which is then measured using a bevel protractor to ensure that it is correct. Then to record the temperature distribution during the welding process, several thermocouples are installed As shown in Figure 2. below:

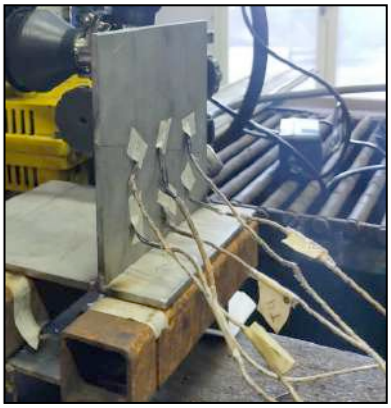


Figure 2. Tackwelded Specimens and Installed Thermocouples

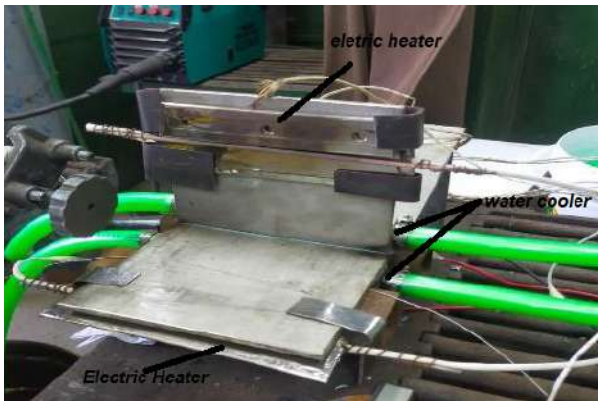


Figure 3. Instaled Electric Heater and Water Cooler

The flat electric heater is mounted on the back side of the base metal plate. While the water cooler is installed on the back side of the welding line as shown in figure 3. To keep the travel speed constant, the welding gun is mounted on a gas cutting machine that can move in a straight line with adjustable speed, as seen in Figure 4.

Figure 4. Gas Cutting Machine for Constant Travel Speed

2.2 Method of Collecting Data

GMAW welding is performed on specimens with three repetitions for each temperature variation of static thermal tensioning, namely at temperatures of 200 ^{o}C, 250 ^{o}C and 300 ^{o}C. Welding parameters as travel speed, current, gas flow and voltage are controled, respectively at 8 mm/s, 75 A, 10 l/min and 22 volt. Welding temperature distribution on each installed thermocouple recorded every second on the data logger. Angular distortion measured by bevel protractor, and perform metallographic tests to see the microstructural behavior that occurs. the results were compared between treatments.

3. RESULTS AND DISCUSSION

3.1 Angular Distortion

The results of the measurement of angular distortion on the SUS 304 plate from GMAW welding with T joints are presented in Table 1.

Table 1. Angular Distortion of Static Thermal Tensioning Treatment with Temperature Variation

Repeatation	Distorsion (°)		
	Temperature 200 °C	Temperature 250 °C	Temperature 300 °C
1	4.73	2.8	3.97
2	4.93	2.6	3.9
3	3.7	2.95	3.7
Mean	4.45	2.78	3.86

The comparison graph of the average angular distortion is shown in Figure 5. From the graph it can be seen that there are differences in angular distortion due to temperature variations in the static thermal tensioning treatment given to the plate when welding. The average angular distortion that occurs at the static thermal tensioning temperature of 200 °C is 4.45° while at the temperature of 250 °C and 300 °C, it is 2.78° and 3.86°, respectively. It appears that the thermal static tensioning temperature of 250 °C produces the lowest angular distortion compared to 200 °C and 300 °C.

3.2. Temperature Distribution

The temperature distribution during welding with static thermal tensioning treatment with temperatures of 200 C, 250 C and 300 C can be described in graphical form as shown in Figure 6.

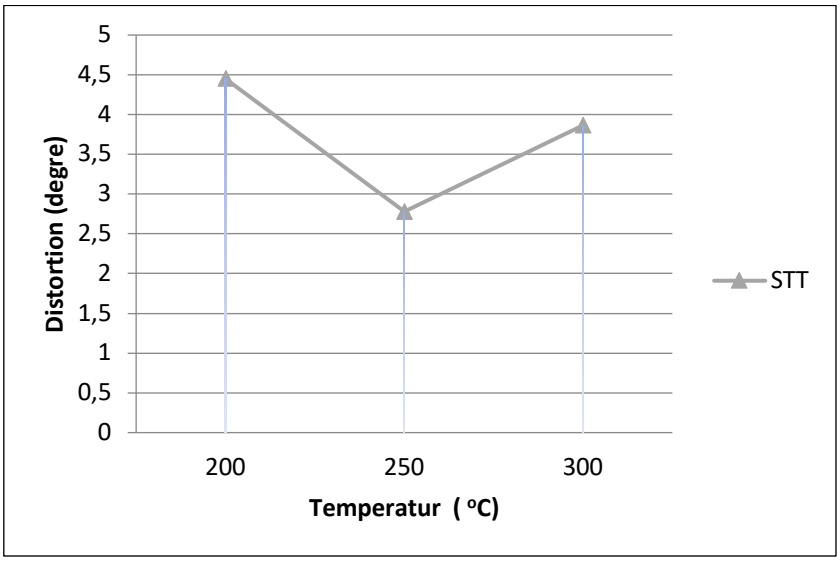
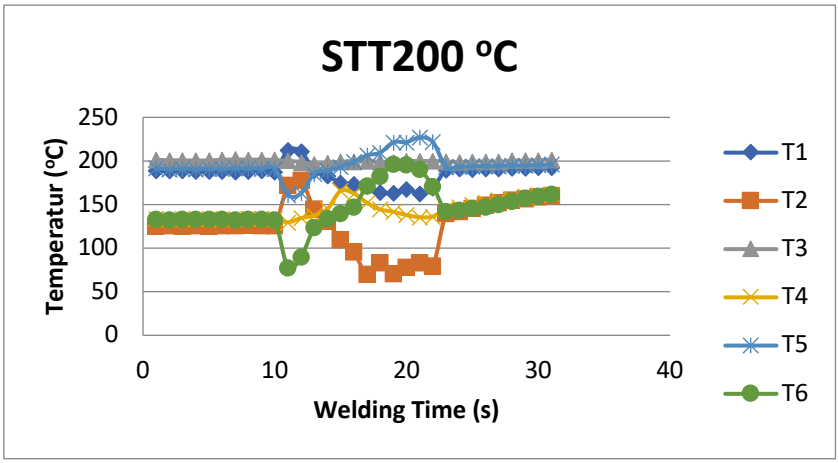
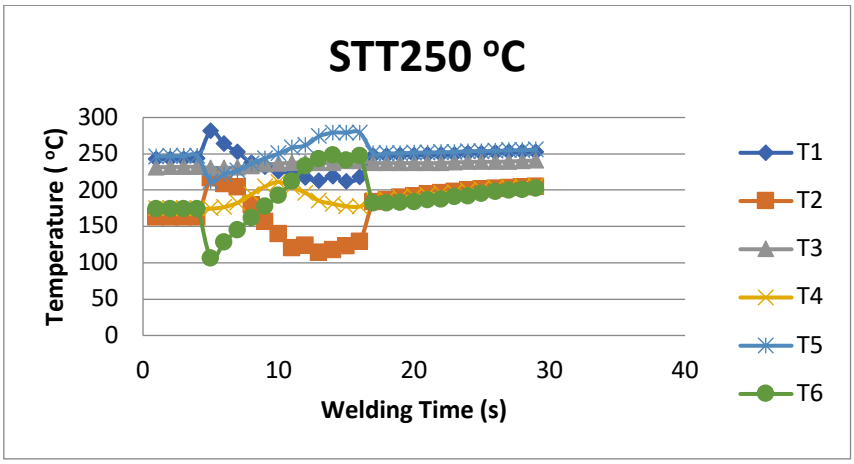


Figure 5. Comparison graph of angular distortion that occurs at several treatment temperatures



a



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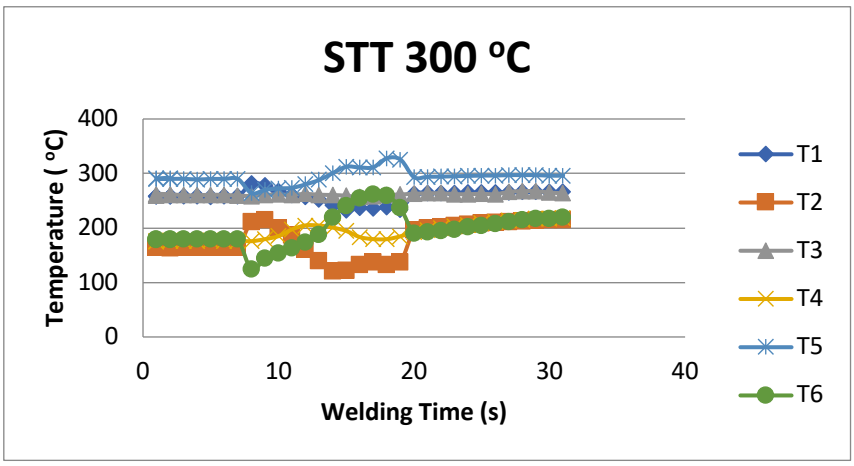

c

Figure 6. (a,b,c) Temperature distribution During welding

According to figure 6 (b), the Static Thermal Tensioning treatment has a relatively low angle distortion of 2°78' at a temperature of 250 C, in this treatment the temperature on the base metal is more evenly distributed and on the welding line the cooling occurs more efficiently, so that the temperature on the welding line decreases and the resulting distortion is lower.

3.3 Microstructure

Optical micrographs of weld metal are as shown in Figure 7 below

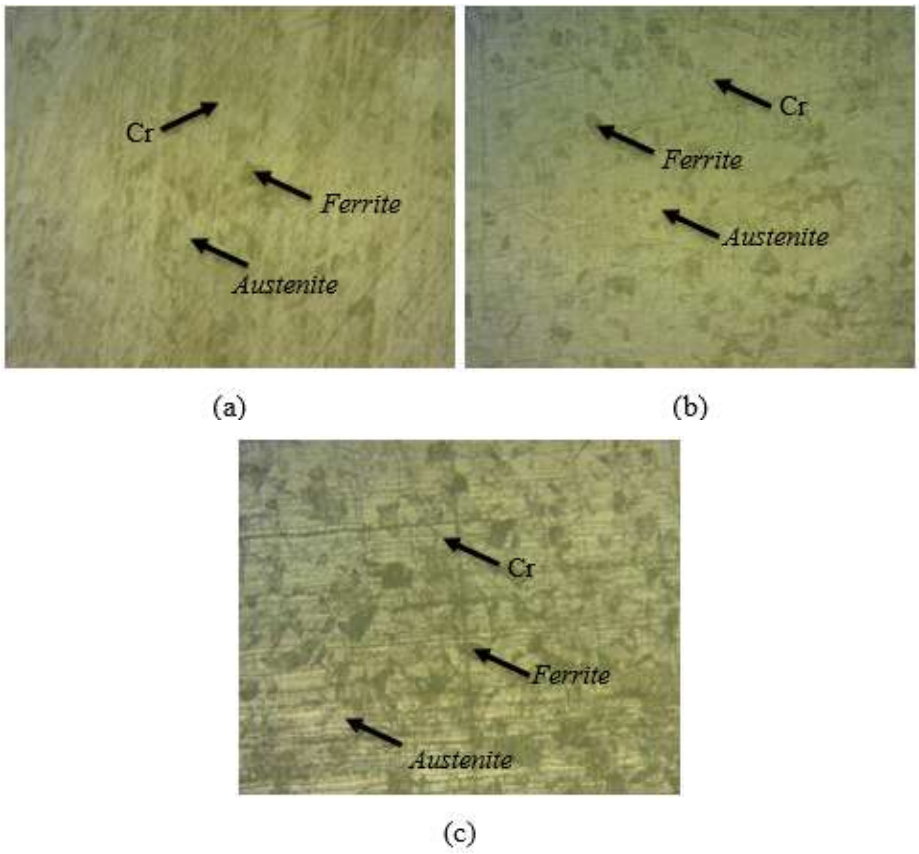

Figure 7. Optical micrographs of weld metal (a) 200 °C, (b) 250 °C, and (c) 300 °C

Fig 7 (a),(b) and (c) show the microstructure of the HAZ on the Static Thermal Tensioning 200°C, 250°C, 300°C treatment method. From the micro photos taken, the structure consists of 3 phases, Ferrite, Austenite and Cr. Ferrite structure is dark in color and austenite is light in color and Cr deposits are in the form of ditch around the grain boundaries.

Table 2. Recapitulation of sensitization percentage of Static Thermal Tensioning treatment

Sensitization *STT*					
200°C		250°C		300°C	
Pixel	Percentage (%)	Pixel	Percentage (%)	Pixel	Percentage (%)
53480	7,05%	71156	9,38%	123195	16,49%

The higher the STT treatment temperature, it can be seen in the figure that the denser the grains are in the HAZ area. Also followed by Cr (Carbide) deposits in each treatment, as high as the temperature treatment given, it can be seen in the Table 2. that the more Cr deposits at the grain boundaries that arise, means when the sensitization time and temperature increased carbide precipitation at grain boundary also increased [15]. The highest percentage of Cr was 16.24% in the STT treatment at 300°C.

4. CONCLUSION

Referring to the discusion of this study can be concluded as follows:

a. The optimal static thermal tensioning temperature to obtain the smallest angular distortion in the welding of the 5 mm thick SUS304 T plate joint with the GMAW process is 250 °C. where at this temperature the angular distortion value that occurs is 2° 78'.

b. The most even temperature distribution on the SUS 304 plate welded by the GMAW process is in the Static thermal tensioning treatment with a temperature of 250 ºC
c. The optimal static thermal tensioning temperature to obtain the lowest sensitization effect in the welding of the 5 mm thick SUS304 T plate joint with the GMAW process is 200 ºC. where at this temperature the percentage of carbide deposition is 7,05 %.

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LOGIC
Journal of Engineering Design and Technology
Vol. 21 No. 3 November 2021; p. 225 - 231

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

EFFECT OF FORGING DEFORMATION AND COOLING ON MECHANICAL PROPERTIES OF MARTENSITIC STAINLESS STEEL

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Abstract. Stainless steel has good mechanical properties compared to other materials for strength and hardness, usually it will increase in hardness after hardening or forging. The purpose of this study was to obtain information about: The value of hardness and tensile strength of martensitic stainless steel forging with various deformations and cooling. The research method used is an experimental method, namely by forging on martensitic stainless steel with variations in deformation and cooling rate. Variations of forging deformation used are 25%, 50%, and 75%. The cooling media used are water, oil and air. The results of forgings with various cooling media were tested for tensile strength and tested for hardness using the Rockwell C (HRC) method. It was found that the higher the value of forging deformation, the higher the value of strength and hardness of martensitic stainless steel. This is because more and more martensite structures are recrystallized. In addition, it was also found that water and air cooling media gave an increase in the hardness of martensitic stainless steels. This is influenced by the cooling rate, where the higher the cooling rate, the more martensite structures formed, thus increasing the hardness value. The increase in hardness value is proportional to the increase in yield strength and tensile strength..

Keywords : martensitic stainless steel, forging deformation, cooling rate, tensile strength, hardness, yield strength, elongation.

1. INTRODUCTION

Martensitic stainless steel is widely used as a material for machine components, both transmission components and cutting tools.[1] This type of steel is a stainless steel that has good hardenability, which is easy to harden to a fairly high hardness value of 60-70 HRC.[2]

In the forging process it will go through a heating and cooling process, so that the material will undergo a heat treatment process.[3] Because the martensitic type has good hardenability, after the forging process it tends to increase in strength and hardness so that the material properties will turn out to be strong and hard.[4] With the increase of the forging pressure, the strength increased, the hardening capacity and strain hardening exponent decreased.[5] The hot forging technique was found to remove defects from the additive manufacturing material, resulting in enhanced mechanical strength, ductility, and isotropy.[6] This is necessary for engine components that require frictional resistance. Various cooling processes will have different cooling rates depending on the type of cooling medium.[7] The cooling media commonly used are: air, water, oil or other cooling media.[8] In addition to the cooling medium, different cooling methods will also produce different levels of hardness.[9] The hardness of the material increased due to combination of strain hardening and Hall-petch strengthening.[10] The good ductility benefits from the continous strain induced martensitic transformation with continous tensile deformation.[11] Maximum forging force are 100 tons, upper the value can decrease hardness.[12]

Based on this brief description, it is necessary to research the forging process on martensitic stainless steels with variations in cooling rates, so that they can determine the maximum strength and hardness properties..

2. METHODS

2.1 Research Design

In this study, 30 specimens were used of martensitic stainless steel with dimensions of 6x12x220 mm. Furthermore, martensitic stainless steel with these dimensions is forged with variations in forging deformation of 25%, 50%, and 75%. Shortly after being forged and then immersed in a different cooling medium, namely: water, air, and oil. Wait until the test specimen has cooled completely. Furthermore, the test specimens were tested for hardness on a hard test machine and also tested on a tensile machine. The aim is to obtain data on the value of hardness, elongation, tensile strength, and yield strength. Furthermore, the data is processed using a two-way analysis of variance (Two Way ANOVA) to analyze the effect of the magnitude of the deformation of the forging and the cooling medium on its mechanical properties which include hardness, elongation, tensile strength, and yield strength.

Figure 1. Martensitic Stainless Steel Specimen and test specimen

2.2 Research Flow Chart

The research design that has been described as follows:

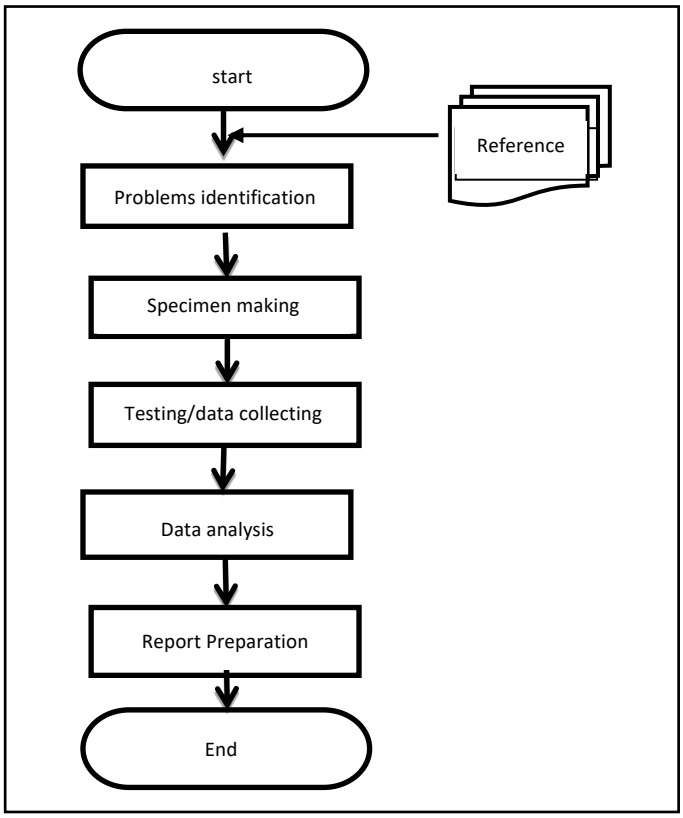

Figure 2. Design Flow Chart

3. RESULTS AND DISCUSSION

After forging with variations of forging deformation 25%, 50%, and 75% and variations of water, air, and oil cooling media. Then tested on the hard test machine and tensile testing machine. The results are as follows:

Table 1. Hardness (HRC)

Forging Deformation (%)	Cooling Media		
	Air	Oil	Water
75% (t = 1 mm)	79.8	77.6	78.3
	74.8	73.3	79.5
	74.8	75.3	79.7
Average	76.5	75.1	79.17
50% (t = 2 mm)	74.4	70.7	78.2
	74.4	69.4	78.8
	75.8	70.8	78.5
Average	74.8	70.3	78.5
25% (t = 3 mm)	74.6	65.3	78.2
	75.6	66.2	77.8
	77.3	65.7	78.2
Average	75.6	65.7	78.07

Table 2. Elongation (%)

Forging Deformation (%)	Cooling Media		
	Air	Oil	Water
75% (t = 1 mm)	20.8	20.8	16.7
	22.9	21.8	19.8
	20.8	22.9	20.8
Average	21.5	21.1	19.1
50% (t = 2 mm)	22.9	23	20.8
	22.9	22.9	20.8
	23	23	23
Average	22.93	22.96	21.53
25% (t = 3 mm)	24.3	24.3	22.8
	24.3	25	22.8
	23	23	23
Average	23.87	24.1	22.87

Table 3. Tensile Strength (Kg/mm^2)

Forging Deformation (%)	Cooling Media		
	Air	Oil	Water
75% (t = 1 mm)	93.4	84.4	91.3
	90.6	91.3	92.6
	90.2	86.2	93.3
Average	91.4	87.9	92.4
50% (t = 2 mm)	82.8	76.5	90.6
	80.3	78.4	88.5
	81.1	80.3	88.1
Average	81.4	78.4	89.1
25% (t = 3 mm)	76.3	68.6	79
	77.4	69.3	82.1
	78.2	70.3	79.8
Average	77.3	69.4	80.3

Table 4. Yield Strength (Kg/mm^2)

Forging Deformation (%)	Cooling Media		
	Air	Oil	Water
75% (t = 1 mm)	78.4	74.6	79.3
	74.2	73.5	78.4
	73.9	74.2	74.5
Average	75.5	74.1	77.4
50% (t = 2 mm)	71.5	65.5	68.6
	70.4	67	72.3
	69.3	70.4	70.9
Average	70.4	67.6	70.6
25% (t = 3 mm)	59.8	58.5	68.6
	58.2	60.6	69.3
	74.8	62.4	67.3
Average	64.2	60.5	68.4

3.1 Effect of Cooling Media Variation and Forging Deformation on Hardness

The interaction of cooling medium variation and forging deformation on hardness is shown in Figure 3. It was found that the 25%, 50%, and 75% forging deformations had the same characteristics of hardness values. The highest hardness values were equally obtained in water cooling media, followed by air cooling media, and the lowest hardness values were equally obtained in oil cooling media. This is influenced by the higher the cooling rate, the higher the hardness value. However, the oil cooling medium may react with the martensitic stainless steel structure, thereby eroding the carbon element in the martensitic stainless steel which causes the lowest hardness value compared to air and water cooling media. Furthermore, it was found that the higher the value of forging deformation, the higher the hardness value because the more martensitic stainless steel structures increased in hardness due to recrystallization. Lower processing temperatures increased strength, decreased ductility but decreased within-part property variation [13].

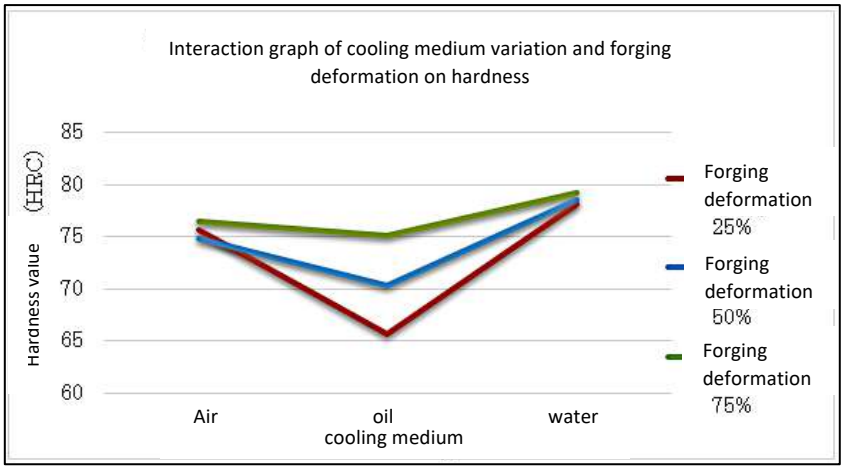

Figure 3. Interaction of Cooling Medium Variation And Forging Deformation On Hardness

3.2 Effect of Cooling Media Variation and Forging Deformation on Elongation

The elongation of forged steel with variations in cooling medium and forging deformation is shown in Figure 4. The highest elongation value is for forged steel with a forged deformation value of 25%, followed by forged steel with a forged deformation value of 50%, and the lowest deformation value is steel. forging with 75% forging deformation. At 25% forging deformation, the mechanical properties of martensitic stainless steel still have elastic or ductile properties. When the forging deformation is increased to 50%, the mechanical properties of the martensitic stainless steel change to become more plastic, until the 75% forging deformation results in the martensitic stainless steel having the dominant property of being plastic.

Variations in cooling media have a significant effect on water cooling media. Where the steel forged with water cooling media experienced a drastic decrease in the elongation value at 75% forging deformation. It is different with 25% and 50% forging deformation which has the highest elongation value in the oil cooling medium,

75% forging deformation has the highest elongation value in the air cooling medium. This indicates that the higher the value of forging deformation will have a significant impact on the effect of the cooling medium used in relation to the increase in the hardness of martensitic stainless steel.

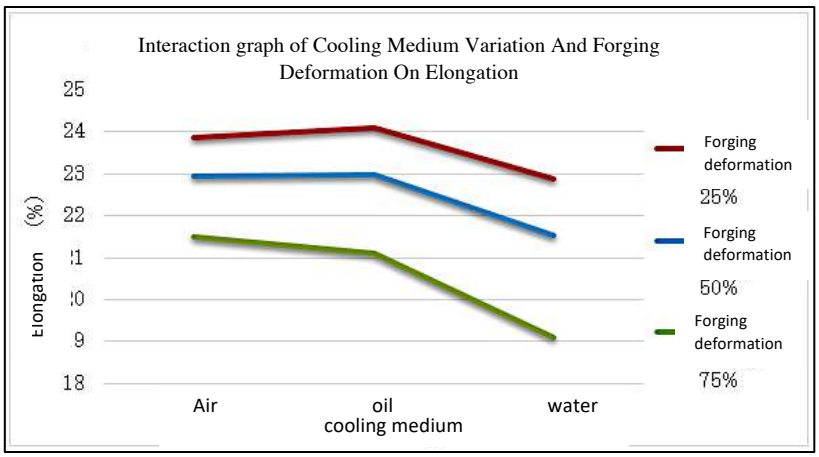

Figure 4. Interaction of Cooling Medium Variation And Forging Deformation On Elongation

3.3 Effect of Variation of Cooling Media and Forging Deformation on Tensile Strength Max.

Interaction of cooling medium variation and forging deformation on the max. shown in Figure 5. It was found that the forging deformations of 25%, 50%, and 75% had a characteristic tensile strength value of max. the same one. The value of tensile strength max. The highest values were found in the water cooling medium, followed by the air cooling medium, and the tensile strength value of max. The lowest values were equally found in the oil cooling medium. This is influenced by the higher the cooling rate, the higher the tensile strength value. also getting higher. However, the oil cooling medium may react with the martensitic stainless steel structure, thereby eroding the carbon element in the martensitic stainless steel which causes the maximum tensile strength value. lowest compared to air and water cooling media. Furthermore, it was found that the higher the value of forging deformation, the higher the hardness value because more and more of the martensitic stainless steel structure recrystallized and increased the value of the tensile strength max. Otherwise, the grain size does not increase with increasing the forging temperature, which results from the occurence of dynamic recrystallization caused by deformation.[14]

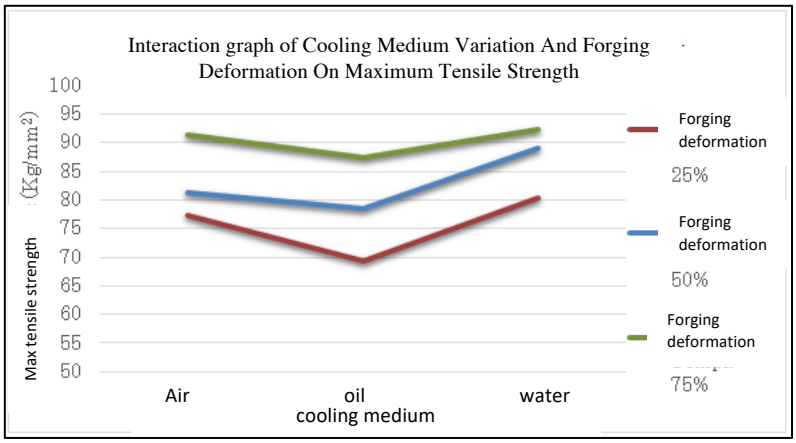

Figure 5. Interaction of Cooling Medium Variation And Forging Deformation On Maximum Tensile Strength

3.4 Effect of Cooling Median Variation and Forging Deformation on Yield Strength

The interaction of cooling medium variation and forging deformation on yield strength values is shown in Figure 6. It was found that the 25%, 50%, and 75% forging deformations had the same characteristic yield strength values. The highest yield strength values were equally obtained in water cooling media, followed by air cooling media, and the lowest yield strength values were equally obtained in oil cooling media. This is influenced by the higher the cooling rate, the higher the yield strength value. However, the oil cooling medium may react with the martensitic stainless steel structure[15], thereby eroding the carbon element in the martensitic stainless steel which

causes the lowest yield strength value compared to air and water cooling media. Furthermore, it was found that the higher the value of forging deformation, the higher the hardness value because more and more martensitic stainless steel structures recrystallized and increased the yield strength value.

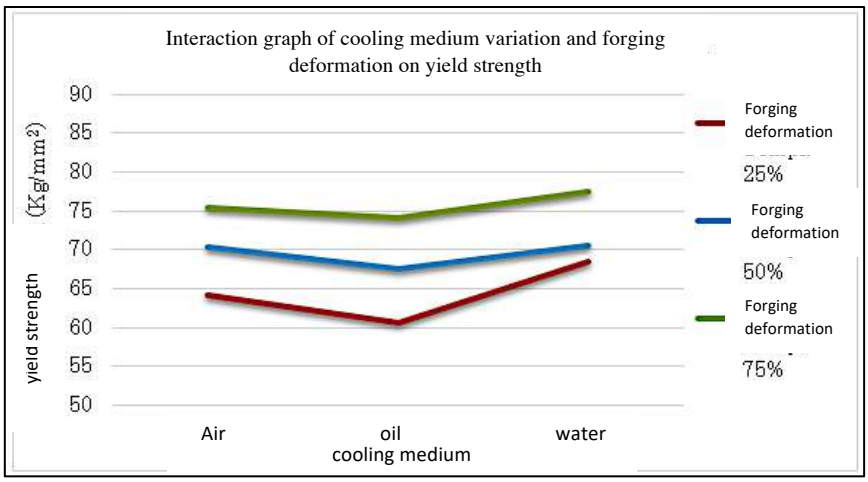

Figure 6. Interaction of cooling medium variation and forging deformation on yield strength

4. CONCLUSION

Based on this discussion, it can be concluded that the higher the value of forging deformation, the higher the value of strength and hardness of martensitic stainless steel. This is because more and more martensite structures are recrystallized. In addition, it was also found that water and air cooling media gave an increase in the hardness of martensitic stainless steels. This is influenced by the cooling rate, where the higher the cooling rate, the more martensite structures formed, thus increasing the hardness value. The increase in hardness value is proportional to the increase in yield strength and tensile strength.

5. ACKNOWLEDGEMENT

The author would like to thank all those who have helped financially or morally so that the researcher can complete this research article. The author hopes that the results of this research can contribute to the development of science and technology and can be applied to industries engaged in the material sector.

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LOGIC
Journal of Engineering Design and Technology
Vol. 21 No. 3 November 2021; p. 232 - 239

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

DESIGNING OF WORK FACILITY FOR ECOBRICK MATERIAL USING ERGONOMIC INTERVENTION TO REDUCE MUSCOLOSKELETAL DISORDER

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Abstrak.
Kamulyan waste bank is a place to collect the waste from the household around Lowanu Village, Brontokusuman, Mergangsan, Yogyakarta. This waste is distributed to garbage collectors and sorted. Plastic waste that cannot be recycled is used as material for making ecobricks. Ecobricks are materials made from used plastic bottles filled with plastic sachets, plastic bags, and similar materials that are compressed. In making ecobricks, workers perform activities in a sitting position on the floor with both legs folded in and a slightly bent posture. This work attitude causes muscle complaints in the upper and lower neck, upper arm, right elbow, left wrist, and left hand. The purpose of the study was to improve work attitudes to reduce muscle complaints in body parts by designing ergonomic work facilities. This research was conducted with ergonomics intervention on the design of ecobrick plastic compaction work facilities with the Nordic Body Map-VAS Modified Questionnaire. The muscle complaints of the workers' body parts were determined using the Nordic Body Map questionnaire. The results of the study provide a design for compaction of ecobrick plastic materials with dimensions of table length 134.44 cm, table width 66.39 cm, table height 71.63 cm, length of seat mat 41.41 cm, width of seat mat 43.49 cm, height seat 44.51 cm, backrest height 55.5 cm, and backrest width 45.88 cm. Based on the NBM-VAS questionnaire, it shows that the initial condition of pain or pain in the upper neck and lower neck with a moderate pain value is aimed at a scale of 6.5 cm and 7.3 cm to mild pain with a scale of 4.2 cm and 4.3 cm. . Moderate pain in the left wrist and left hand with a scale of 6.1 cm, respectively, to no pain on a scale of 3.1 cm and 3 cm.

Keywords: ecobrick, ergonomic design, nordic body map questionnaire

1. INTRODUCTION

Plastic is a non-organic material that is very difficult to decompose. It takes tens to hundreds of years to decompose with nature. The demand for plastic in Indonesia has increased by an average of 200 tons per year. In 2010, the demand for plastic was 2.4 million tons, and in 2011 it increased to 2.6 million tons [1]. Handling plastic waste can be done in various ways, ranging from household scale to factory scale. The government with the 3R program (Reduce, Reuse, Recycle) waste can be reduced by 30% at 2025, and a specific 70% target for plastic waste in the same year [2].

One way to recycle plastic waste in the household is to make ecobricks. Ecobricks are materials made from used plastic bottles filled with materials such as soil, foam, plastic food wrappers, plastic bags, and other plastic materials [3]. The main purpose of loading ecobricks is to reduce plastic waste which is very difficult to decompose. Another goal is to recycle plastic waste by putting it in the used plastic bottles to add value to other products [4]. The function of ecobricks is to make these plastics last longer and their processing is beneficial for

the benefit of humans in general [5][6]. Ecobricks can be used as a building material to replace bricks, chairs, tables, flower pots and so on. The advantages of ecobricks are that they are strong, durable, and last a long time because of the original nature of the plastic which is water-resistant and not easily decomposed.

The process of compacting the ecobrick plastic begins with inserting pieces of plastic into an empty bottle little by little and then compacting it using a wooden stick, the process is repeated until the bottle is fully filled and has a hard texture. Based on observations on the real system, the average time to compact the plastic pieces into 1 bottle with a volume of 600 ml until it is full, which is 28.97 minutes. The factor that affects the length of time for compaction is because the location of the cardboard where the empty bottles and filled bottles are located is outside the working range.

The work of inserting plastic materials into bottles is done by sitting on the floor without adequate support. The worker's body bends slightly when doing activities that are out of reach and are repeated. This condition causes complaints in the waist. Bending posture is carried out monotonously in a repetitive way with muscle stretches exceeding the limits of maximum movement [7][8] can have the effect of musculoskeletal complaints on workers [9]. Unnatural work attitudes can be caused by equipment that is not in accordance with the size of the user and this results in non-ergonomic work attitudes causing fatigue, feeling uncomfortable, and decreasing work efficiency [10]. An ergonomic concern that frequently encountered at the place of work, especially pertaining to human power and stamina to carry out the work, is a musculoskeletal disorder (MSD) [11][12].

The place in the form of a basin to accommodate plastic pieces is only able to accommodate as much as 300 grams so that you have to repeatedly fill the plastic pieces into the basin. Besides that, tools such as sticks, scissors and other materials are placed irregularly, so it takes time to find them. This kind of work is considered not ergonomic, it is shown that the work attitude is bent, the location of the equipment is not well organized, the distance between the workers and the workers who will use it is far apart [13]. Based on the results of interviews, ecobrick plastic compaction workers complain of feeling uncomfortable when doing their work, workers often feel pain in the neck, shoulders, back, waist, and hands.

2. METHODS

This research was conducted on the design of ecobrick plastic compaction work facilities using the Rapid Entire Body Assessment method and the Nordic Body Map-VAS Modification Questionnaire. The study used an experimental design with the same subject (tby subject design treatment). The sample treatment was carried out in two ways, namely ecobrick plastic compaction workers working in initial conditions and compacting ecobrick plastic with work facilities after design with an ergonomic approach. The decrease in muscle complaints is seen by comparing when working before and after repairing work facilities.

3. RESULTS AND DISCUSSION

3.l. Antropometric Data and Facility layout design

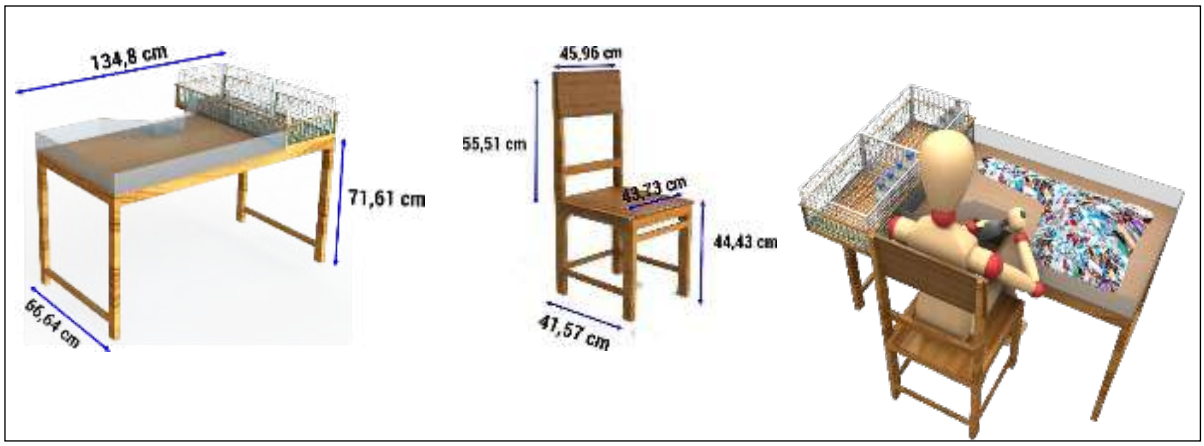
Anthropometric data collection of worker dimensions is used as the basis for the redesign of the ecobrick plastic extinguisher work facility. Anthropometry is a science of certain body dimensions which is very suitable to be applied in the design process [14]. The application of anthropometric data in the redesign of ecobric plastic compaction work facilities is taken from suitable body parts. The design of the facility is expected to provide comfort and safety in carrying out ecobrock compaction activities. The results of the measurement of the subject's anthropometric data are presented in Table 1.

Based on the anthropometric data of workers presented in Table 1, it is then used as a basis for determining the dimensions of the ecobric plastic compaction work facility design. The height of the table is determined by the elbow height in the sitting position (Tsdkd+Tp) which is 71.63 cm using the 50th percentile. The length to 134.44 cm is determined on the basis of the length of the arm span (Prt) using the 5th percentile. The width of 66.39 cm is determined by the basis of arm reach (M) using the 5th percentile. The seat base height of 44.51 cm was determined on the basis of popliteal height (Tp) using the 5th percentile. The seat length of 41.41 cm was determined based on the dimensions of the popliteal length (Pp) with the 50th percentile. The width of the seat base of 43.97 cm is determined on the basis of the dimensions of the hip width (Lp) using the 95th percentile. The seatback height of 55.5 cm is determined based on the dimensions of the sitting shoulder height (Tbd) with the 50th percentile. The seatback width of 45.88 cm is determined based on the dimensions of the shoulder width (Lb) with the 95th percentile. The design of work facilities in the compaction process of ecobric plastic materials in full is shown in Figure 1.

The relationship between the dimensions of the worker's body and the work facilities used have an effect on work attitudes which then have an impact on work comfort. The design of the ecobric plastic compaction work facility is designed to improve the working position more naturally on the basis of the worker's body dimensions using the appropriate percentile [9]. Accuracy in percentile application is the main key in designing work facilities.

Tabel 1 Subject anthropometric data

No.	Dimention	Symbol	Average (cm)	Percentile 5	Percentile 95
1.	Shoulder Height In Sitting Condition	Tbdkd	55,5	55,08	55,92
2.	Elbow Height In Sitting Condition	Tsdkd	27,12	22,83	31,4
3.	Popliteal Length	Pp	42,98	41,41	44,55
4.	Popliteal Height	Tp	44,51	41,51	47,35
5.	Shoulder Width	Lsb	41,25	36,62	45,88
6.	Hip Width	Lp	40,64	37,30	43,97
7.	Hand Reach	Jt	69,44	66,39	72,50
8.	Hand Span Length	Prt	146,43	134,44	158,43



Gambar 1. Development of Ergonomic Ecobrick Plastic Compactor Work

3.2. Work Posture before and after Design Improvement

In the initial conditions, the ecobric plastic compaction workers worked with non-ernomic work postures. The worker sits with his legs folded inward (bursila) and his right hand raised up to form a 45ºC angle while pushing a stick of plastic material into the bottle. Kriri's hand holds the bottom of the bottle and attaches it to the left thigh. This condition is carried out repeatedly for a long time as shown in Figure 2. Before the design of the plastic compactor is done geometrically, the body posture while working looks unnaturally awkward. This work is done repeatedly, with a lot of strength and in quite a long time.

Gambar 2. Initial Condition Worker Posture

Gambar 3. Worker Posture Design conditions

Physical conditions of work using awkward postures, high repetition, excessive force, static, cold nature of work and strong correlates of vibration cause musculoskeletal disorders [15]. The work activity of compacting ecobricks after applying an ergonomic work facility design, the worker's posture is no longer sitting with folded legs and the position of the hands is at an angle of 90º. The bottom of the bottle is fully supported by the concave and is more natural and comfortable as shown in Figure 3.

3.3. Musculoskeletal complaints

Based on the Nordic Body Map questionnaire, workers in the initial conditions showed complaints of pain in the upper neck, lower neck, upper right arm, left wrist and right hand. The complete pain complaints are shown in Figure 4. In this condition, the workers looked awkward and used their facilities moderately. The incompatibility of work facilities with the size of the worker's body that causes awkward or non-physiological postures [10], such as the conditions of workers in compacting ecobric plastics, may cause injury if not managed ergonomically [16] pain in right hand back pain in left hand.

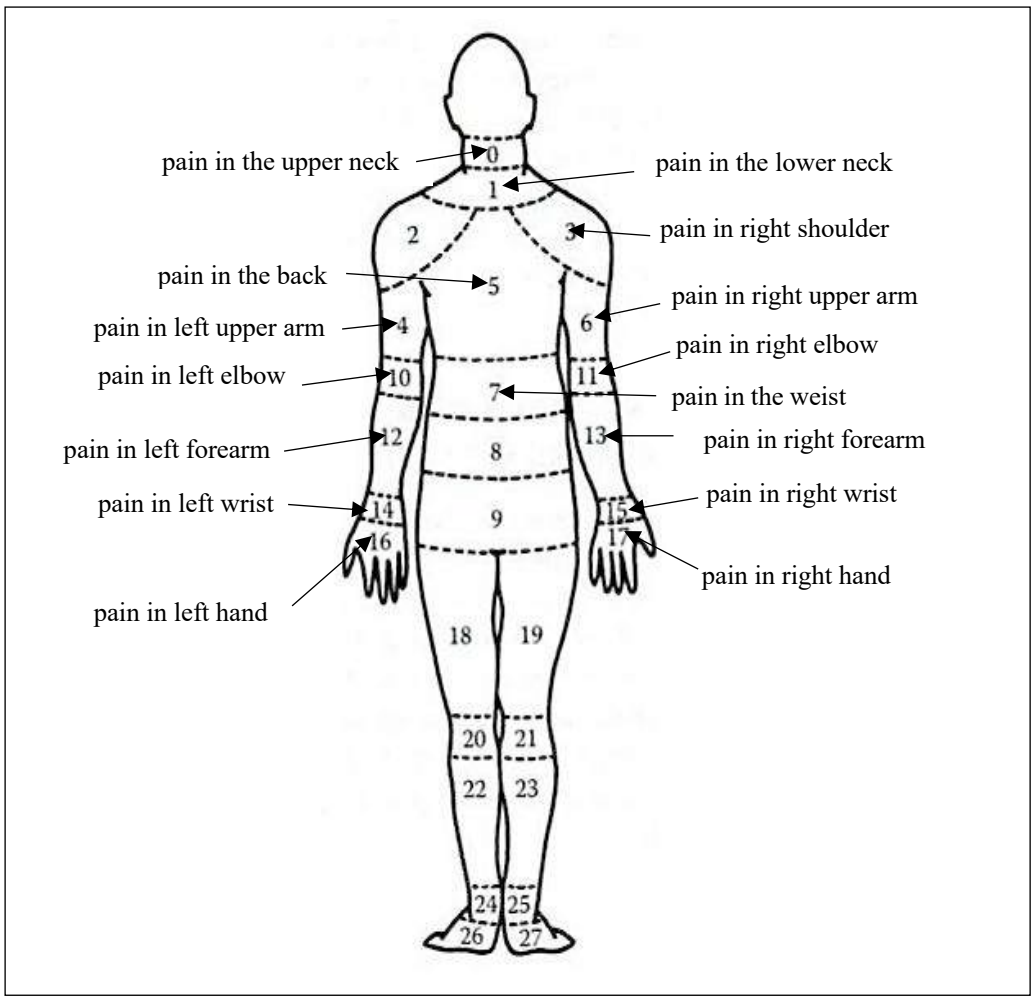


Figure 4. Painful body parts

Complaints on certain body parts can be quantified with a scale model, namely the Visual Analog Scala (VAS). Visual Analog Scale (VAS) which is intended to measure certain pain qualities such as intensity or discomfort [17]. The Visual Analog Scala has recommended categories of no pain on a 0-4 mm scale, mild pain on a 5-44mm scale, moderate pain on a 45-74 mm scale, and severe pain on a 75-100mm scale [18][19]. Some complaints, such as in the Nodic Body Map questionnaire (Figure 4), in the initial conditions indicated the moderate pain category. The complete range of scala analog visual images can be seen in Table 2.

After designing work facilities in the form of work desks and chairs with anthropometric data as the basis for determining the size of the work facility design, there was a change in the work position for the better. The neck and back become more upright, the hands position is better and the legs are not folded anymore. The condition of the worker's post looks more natural, it can be seen in Table 3.

Tabel 2. VAS questionnaire based on Nordic Body Map data Initial Condition

Types of Complaints	Complaint Rate	
	No Pain	Very Pain
Pain in the upper neck	0	6,5 cm 10
Pain in the lower neck	0	7,2 cm 10
Pain in right shoulder	0	4,0 cm 10
Pain in left upper arm	0	5,4 cm 10
Pain in the back	0	4,1 cm 10
Pain in right upper arm	0	5,8 cm 10
Pain in the waist	0	4,5 cm 10
Pain in left elbow	0	3,9 cm 10
Pain in right elbow	0	5,2 cm 10
Pain in left forearm	0	3,2 cm 10
Pain in right forearm	0	4,1 cm 10
Pain in left wrist	0	6,2 cm 10
Pain in right wrist	0	4,2 cm 10
Pain in left hand	0	6,1 cm 10
Pain in right hand	0	3,9 cm 10

Tabel 3. VAS questionnaire based on Nordic Body Map data after intervention

Types of Complaints	Complaint Rate		
	No Pain		Very Pain
Pain in the upper neck	0	4,2 cm	10
Pain in the lower neck	0	4,3 cm	10
Pain in right shoulder	0	3,5 cm	10
Pain in left upper arm	0	4,5 cm	10
Pain in the back	0	3,5 cm	10
Pain in right upper arm	0	4,7 cm	10
Pain in the waist	0	4,2 cm	10
Pain in left elbow	0	3 cm	10
Pain in right elbow	0	3,9 cm	10
Pain in left forearm	0	2,6 cm	10
Pain in right forearm	0	3,4 cm	10
Pain in left wrist	0	3,1 cm	10
Pain in right wrist	0	4 cm	10
Pain in left hand	0	3 cm	10
Pain in right hand	0	3,6 cm	10

After using work facilities with ergonomic designs by paying attention to worker anthropometry, almost all of the pain complaints decreased. This can be seen in table 3, which was moderate pain to a little pain and no pain. The ergonomic design of the facility is able to reduce musculoskeletal complaints of pain in the growing area so that it hurts a little or doesn't hurt at all. The application of ergonomic-based dough kneading work facilities can reduce the musculoskeletal complaints of workers who initially felt very sick in 6 parts of the body and pain in 9 other body parts to become slightly sick and not sick [9].

5. CONCLUSION

Ergonomically based ecobric plastic compaction work facility design application is able to reduce workers' musculoskeletal complaints. The initial condition of pain or pain in the upper neck and lower neck with a moderate pain value indicated on a scale of 6.5 cm and 7.3 cm became mild pain on a scale of 4.2 cm and 4.3 cm. Moderate pain in the left wrist and left hand with a massive scale of 6.1 cm to no pain with a scale of 3.1 cm and 3 cm.

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