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THE EFFECT OF HOLDING PRESSURE AND INJECTING PRESSURE TO SHORT SHOT DEFECT IN INJECTION MOLDING COVER POT

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Abstract. Inappropriate injection molding parameters often result in product defects, one of which is the short shot, which is a condition where the plastic to be injected into the cavity does not reach the ideal capacity. The purpose of this research is to understand and be able to explain the parameters of holding pressure, inject pressure, and the interaction of these two parameters on short-shot defects in cover pot products with the injection molding process. This research uses independent variables, namely holding pressure with variations of 20 bar, 30 bar, and 40 bar, and injecting pressure with variations of 15 bar, 30 bar, and 45 bar, and dependent variables in the form of short-shot defects. The method used in this research is a factorial experiment with replication of 10 (ten) times and data processing analysis using ANOVA with the help of statistical software. The result of this research is that there is a significant influence of holding pressure, inject pressure and the combination of these two parameters on short shot defects in cover pot products with injection molding process. The average weight of the product produced at the combination of the parameters holding pressure 40 bar and injecting pressure 45 bar is 8.8 grams (normal) so as to minimize product defects to improve the quality and quantity of cosmetic packaging production cover pot.

Keywords : Holding Pressure, Inject Pressure, Injection Molding, Polystyrene, Short Shot.

1. INTRODUCTION

The need for plastic consumption in Indonesia is quite large, based on data from the Ministry of Environment and Forestry in 2022 the amount of plastic packaging consumption in Indonesia reaches 18 million tons [1]. With high public interest and purchasing power, companies in the field of plastic packaging make various innovations to their products. The most commonly used plastic processing method is injection molding [2]. Injection molding is the process of processing a part or product made from plastic that is heated and injected into a tool in the form of a mold. Common product defects in injection molding methods include voids, surface blemishes, short shots, flashing, flow marks, weld lines, burning, and warpage [4].

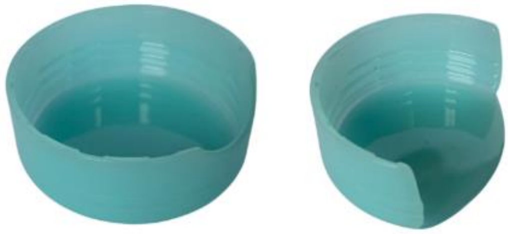

Figure 1. Short shot defect in injection molding cover pot

Based on these various defects, short shots are types of product defects that are not intact, so that the plastic hardens first before filling the cavity.

Plastic is a material that is in great demand by consumers as a substitute for other materials, because plastic materials are easy to find and easy to process. The formation of this thermoplastic material through a heating process then melts in the cylinder, which then the melt is injected into the mold [3].

This research was conducted because there were problems at PT Albea Rigid Packaging Surabaya with the 2019 mold cover pot production by polystyrene materials with a stable number of orders but declining performance. In 2019-2022, the average order reached 5,254,124 but mold performance is declining every year. The root of the problem of defects in plastic products is divided into 4 categories, namely material, injection machine, parameters, and mold [4]. The purpose of this research is to understand and be able to explain the effect of the independent variable holding pessure and inject pressure on the dependent variable, namely short shot.

2. RESEARCH METHODS

2.1 Types of Research

The type of research used is quantitative with experimental methods. This method is used to find out what factors can affect the results of the research. Data analysis was carried out with the aim of testing the research hypothesis with the ANOVA method.

2.2 Time and Place of Research

This research was conducted from February 2023 to April 2023, located at PT Albea Rigid Packaging Surabaya with the address Jl. Rungkut Industri IV No.23, Rungkut Tengah, Gunung Anyar District, Surabaya City, East Java 60293.

2.3 Research Tools and Materials

The tools and materials used in this research include:

1. Injection Molding Machine

Injection molding machines are used to melt plastic pellets and then inject molten plastic into mold, as in this Figure 2.

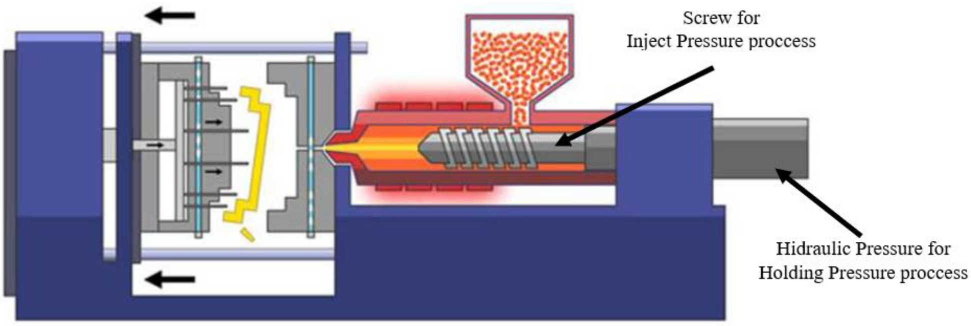

Figure 2. Injection molding machine [5] (waykenrm.com)

2. Mold Cover Pot

Mold is useful as a container for forming products/parts with plastic material that has been injected by an injection molding machine.

Figure 3. Mold cover pot

3. Polystyrene Plastic Material
The material used in making cover pot is polystyrene (PS). Polystyrene material is a rigid and hard material. This material is suitable for use as the basic material for cover/casing products.

4. Digital Scales
Digital scales function to weigh the materials to be used and the results of finished products, as in Figure 5. Next:

2.4 Research Variables
In this research, there are variables that play an important role in taking data during research, as in Table 1. Next:

Table 1. Research variables

	Independent Variable	
1.	Holding Pressure (bar)	: 20, 30, & 40
2.	Inject Pressure (bar)	: 15, 30, & 45
	Dependent Variables	
1.	Weight of cover pot product	: $8{,}8^{\pm 0{,}1}$ grams
	Controlled Variables	
1.	Materials	: Polystyrene (PS)
2.	Nozzle Temperature	: 220°C
3.	Shoot Materials	: 93 grams
4.	Runner Gate	: Submarine Gate
5.	Inject Time	: 3,5 s

2.5 Research Hypothesis
The hypotheses in this research are:

^{Nul} Hypothesis (H_0) : There is no effect of Holding pressure, Inject pressure and combination of both variables on product defects Short shot

^{Alternative} Hypothesis (H_1) : There is an influence of Holding pressure, Inject pressure and the combination of both variables on Short shot product defects.

3. RESULTS AND DISCUSSION
3.1 Result
The results of product identification and weight measurement obtained from the data collection process were 90 cover pot products. Products with short shot defects weigh less than $8.8^{\pm 0.1}$ grams, as shown in Table 2:

Table 2. Product weight data retrieval

NO	**Holding Pressure**	**Inject Pressure**	**Replication** (grams)										**Avarage** (grams)
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	

	(bar)	(bar)											
1	20	15	6,6	6,6	6,6	6,3	6,3	6,9	6,3	6,6	6,6	6,9	6,6
2	20	30	7,6	7,6	7,6	7,7	7,7	8,0	8,0	8,7	8,7	8,0	8,0
3	20	45	8,0	8,8	8,7	8,0	8,7	8,8	8,0	8,9	8,8	8,8	8,6
4	30	15	6,9	6,9	6,9	7,3	7,4	6,9	6,6	6,9	7,3	7,3	7,0
5	30	30	8,0	8,0	8,7	8,7	8,0	8,0	8,0	8,7	8,8	8,0	8,3
6	30	45	8,7	8,7	8,0	8,0	8,8	8,8	8,9	8,9	8,8	8,7	8,6
7	40	15	7,4	7,4	7,4	7,3	7,3	7,6	8,0	7,6	7,6	7,4	7,5
8	40	30	8,0	8,0	8,7	8,7	8,0	8,0	8,0	8,7	8,8	8,8	8,4
9	40	45	8,7	8,7	8,8	8,8	8,7	8,8	8,8	8,9	8,8	8,8	8,8

From the data collection of 90 products, product documentation was obtained with short shot (a) and normal (b) conditions as in Figure 4. the following:

(a) (b)

Figure 4. (a) Product weight 6.6 grams (short shot) and (b) Product weight 8.8 grams (normal)

Cover pot product weight under $8{,}8^{\pm 0{,}1}$ grams is defect (short shot) as show arrow in Figure 5:

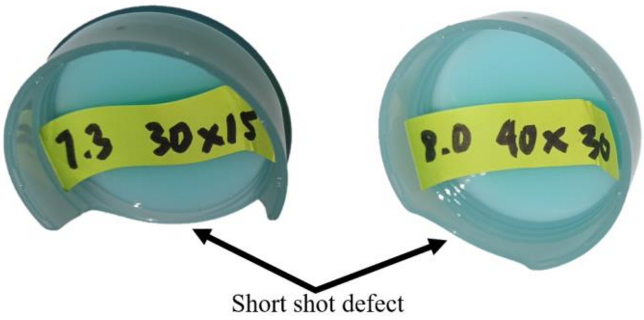

Figure 5. Product weight is 7,3 g and 8,0 g are short shot defect

3.2 Discussion

The normality test is an important part of regression analysis. Normal probability plots are an effective alternative method in determining the model to be analyzed whether the research is normally distributed or not.

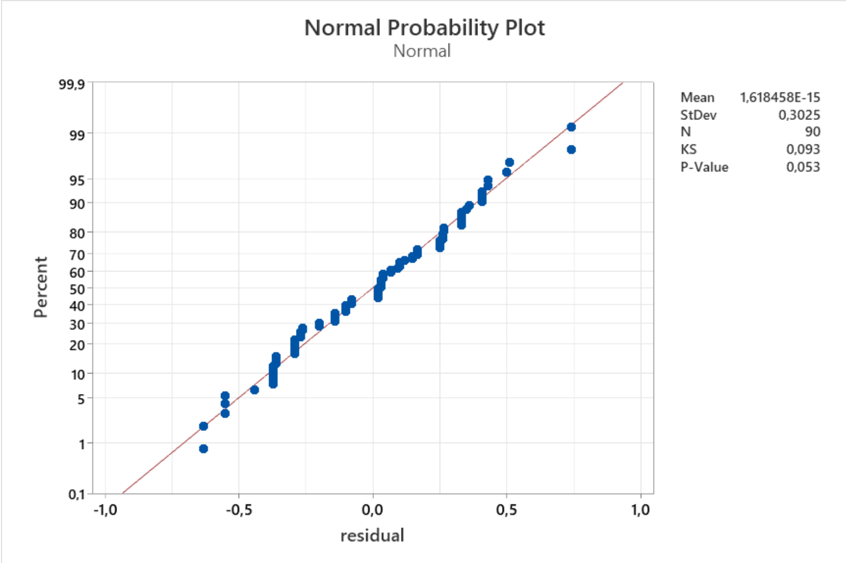

Figure 5. Graphic normal probability plot

The normality method uses the Kolmogorov smirnov method, where the data is said to be normally distributed if the p-value is greater than the alpha value. it can be seen in Figure 6. that the P-value is 0.053 > 0.050 so that it can be concluded that the data of this research are normally distributed and the data points spread around the normal line or not far from the normal line. Thus it can be known that the data in this research meet normal assumptions.

Next is an ANOVA (analysis of variance) table image and a summary model from the analysis results using statistical software.

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	8	47,399	5,9249	58,92	0,000
Linear	4	45,988	11,4970	114,33	0,000
holding pressure	2	4,129	2,0647	20,53	0,000
inject pressure	2	41,858	20,9292	208,12	0,000
2-Way Interactions	4	1,411	0,3528	3,51	0,011
holding pressure*inject pressure	4	1,411	0,3528	3,51	0,011
Error	81	8,146	0,1006		
Total	89	55,545			

Figure 6. Analysys of variance

In this study, the confidence level or alpha value (α) was determined to be 5% or 0.050 in decimal form it can see in Figure 8. The alpha value (α) is the limit value of acceptable hypothesis error. From Figure 4.8 above shows that the P-value of the variable holding pressure (0.000), injecting pressure (0.000), and the interaction of both variables (0.011) are smaller than the alpha value (α). This resulted in the decision that the null hypothesis (H0) which includes no there is no influence of the holding pressure factor on short shot product defects, there is no effect of the inject pressure factor on short shot product defects, and there is no interaction effect of the holding pressure and inject pressure factors on short shot product defects is rejected, which means that there is an influence of the holding pressure factor on short shot product defects. holding pressure on short shot product defects, there is an effect of the factor inject pressure on short shot product defects, and there is an interaction effect of holding pressure and inject pressure on short shot product defects. factors of holding pressure and inject pressure on short shot product defects.

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,317116	85,34%	83,89%	81,90%

Figure 7. Model summary

Like Figure 8. there is a model summary image, which is a collection of observations as a percentage of each category. R-sq is the correlation number of independent variables, as in Figure 4.9 above, the R squared (R-sq) value is indicated value of 85.34% the following figure means that the two independent variables holding pressure and inject pressure have an effect on the dependent variable, namely short shot by 85.34% for the remaining 14.66% explained by other variables outside the independent variables.

Next is a linear regression graph, which is a data analysis technique that is useful for predicting product weight values from unstudied parameters using known and related product weight values. From the results of research on holding pressure analysis of short shot defects based on product weight, a linear regression graph as shown in Figure 9 was obtained.

In the graph above there is a simple regression picture of the analysis results holding pressure on short shot defects, like this $Y = 6{,}909 + 0{,}0457x - 0{,}000326x^2$ holding pressure increases by 1 unit (bar), the weight of the product will increase by 0,0457 units (grams). Then if the holding pressure value is 0, the resulting weight is 6,909 units (grams). Next is a linear regression graph from the results of inject pressure analysis of short shot defects that refer to the weight of the product obtained by the graph as in Figure 11.

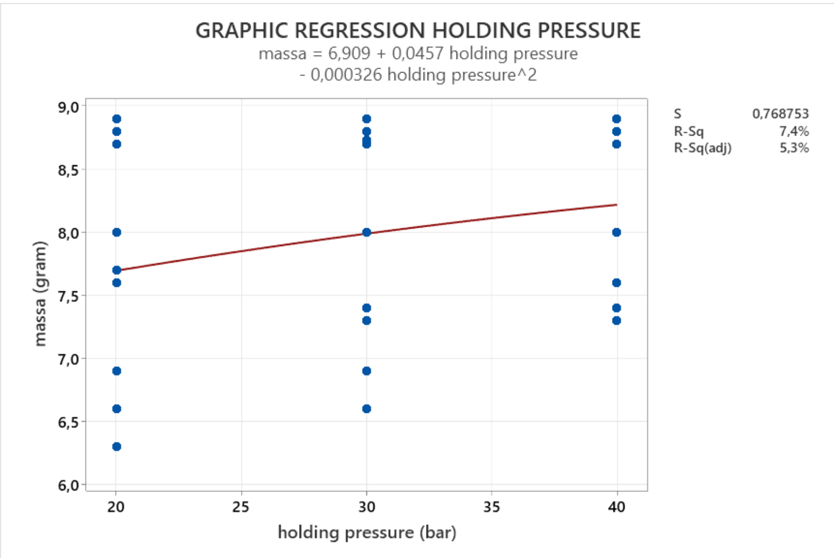

Figure 8. Graphic regression holding pressure

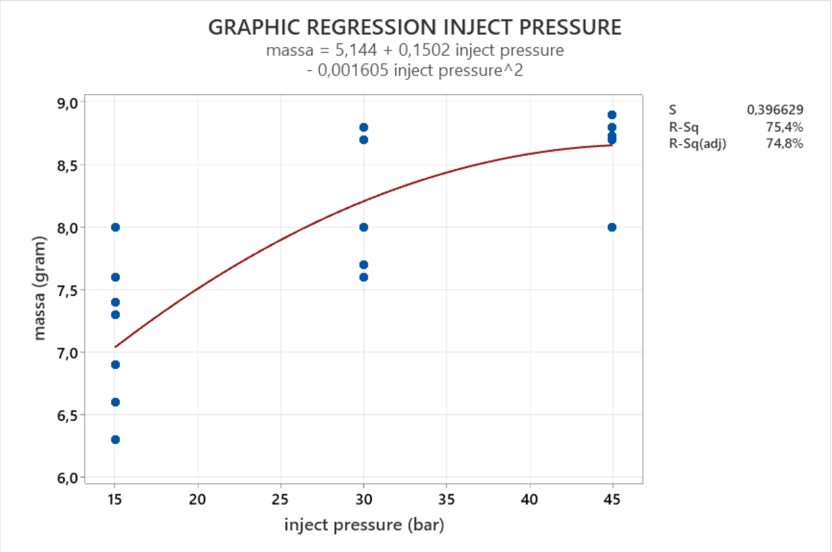

Figure 9. Graphic regression inject pressure

In the graphic image above, linear regression from the results of inject pressure analysis of short shot product defects , namely. This means that if the $Y = 5{,}144 + 0{,}1502x - 0{,}001605x^2$ inject pressure increases by 1 unit (bar) then the weight of the product will increase by 0,1502 units (grams). Then if the inject pressure value is 0 then the resulting weight is 5,144 units (grams).

The left side there is a graph of the effect of holding pressure and the right side is the graph of the effect of inject pressure. At the horizontal axis shows the variation of the independent variables when the the holding pressure and inject pressure, the vertical axis shows the the dependent variable of the study is short shot with reference to product weight. The graph the left side shows that at a holding pressure variation of 20 bar the average weight of the of cover pot products produced is 7.7 grams, at a holding pressure variation of 30 bar the average weight of the cover pot product produced is 8.0 grams, and at a variation of holding pressure 40 bar the average weight of the cover pot product produced is 8.2 gram. Furthermore, the right side graph shows that in the variation of inject pressure 15 bar the average weight of the cover pot product produced is 7.0 grams, in the 30 bar inject pressure variation the average weight of the cover pot product produced is 8.2 grams. 8.2 grams, and in the 45 bar inject pressure variation the average weight of the cover product is 8.7 grams. pot produced is 8.7 grams. From Figure 4.11 it can be concluded that the higher the level of holding pressure and inject pressure, the lower the potential short shot defects with the weight of the cover pot product produced approaching the normal standard of 8.8 grams. normal standard of 8.8 grams.

Next there is an interaction graph or interaction plot, which is a graph to display a level of one factor at the level of another factor (interaction level of two factors).

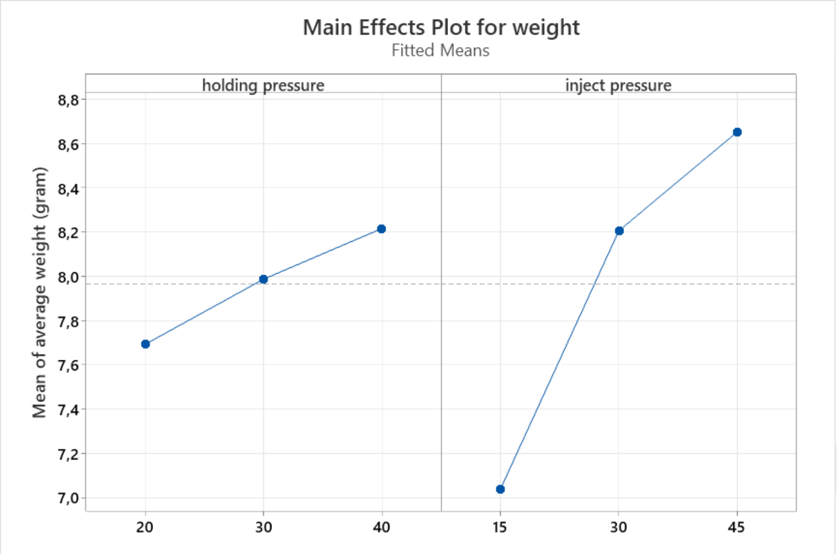

Figure 10. Main effect plot

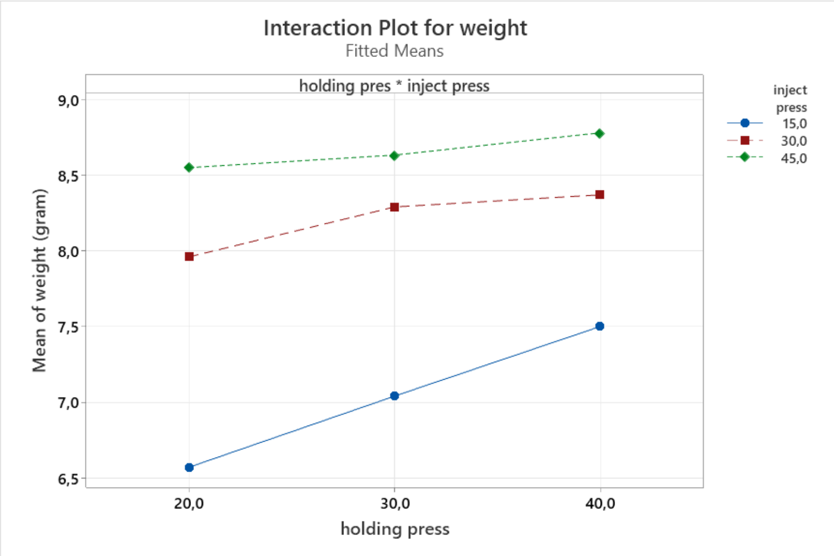

Figure 11. Graphic interaction plot

There are three types of lines with different colors, the three lines represent 15 bar inject pressure (blue line), 30 bar inject pressure (red line), and 45 bar inject pressure (green line). The horizontal axis shows the levels of 20 bar, 30 bar, and 40 bar of holding pressure, the vertical axis shows the bound variable, namely short shot with reference to the weight of the cover pot product.

From the plot, it is known that the smallest possibility of short shot product defects is found in the holding pressure of 40 bar interacting with the inject pressure of 45 bar (green line) with an average weight of 8.8 grams of cover pot product. Then the greatest possibility of short shot product defects is found in the holding pressure of 20 bar interacting with the inject pressure of 15 bar (blue line) with an average weight of 6.6 grams of cover pot product. It can be concluded that the higher the holding pressure and inject pressure levels, the less likely the short shot product defect.

4. CONCLUSION

From the results of the holding pressure and inject pressure research on the weight of the cover pot product (short shot product defects), the conclusions that can be drawn are:

1. Independent variable holding pressure has a significant influence on short shot product defects based on the weight of the cover pot product. This is because the holding pressure serves to hold the product after the filling process so that the cavity remains fully filled and the material does not return to the barrel. From the results of the main effects plot graph, it can be concluded that the higher the level of holding pressure, the heavier the resulting cover pot product, which is 8.2 grams

2. Independent variable inject pressure has a significant influence on short shot product defects based on the weight of the cover pot product. This is because the inject pressure is in charge of transferring material into the cavity cavity. From the results of the main effects plot graph, it can be concluded that the higher the level of inject pressure, the heavier the resulting cover pot product, which is 8.6 grams

3. The interaction of the two variables independent holding pressure and inject pressure has a significant influence on the defects of short shot products based on the weight of the cover pot product. On average, the weight of the product interaction holding pressure 40 bar and inject pressure 45 bar is in accordance with the normal cover pot product weight guidelines, which is $8.8^{\pm 0.1}$ grams. From this it can be concluded that the higher the level of interaction of holding pressure and inject pressure, the heavier the resulting cover pot product, this affects the reduction of short shot product defects.

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