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The effect of temperature and injection time on the injection moulding process on the final weight of the mini tray product

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Abstract

Injection molding is an important process in plastic manufacturing, especially for mini tray production that requires stability and severe accuracy. Temperature and injection time affect product quality, including material distribution and possible defects. This study aims to analyze the effect of these two parameters on the final weight of the product and determine optimal arrangements to achieve consistent quality. This study uses an experimental method with independent variables in the form of temperature and injection time, as well as the dependent variable in the form of product weight. Data is collected through testing with KT-105 injection molding machine and analyzed using Minitab 19 software to test the relationship between variables statistically. The results showed that the temperature and time of injection had a significant effect on the weight of the mini tray. Anova analysis proves a strong relationship between these two parameters, with a p-value value <0.05.

Keywords: Injection molding, mini tray, injection temperature, injection time, product weight, anova, manufacturing quality.

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INTRODUCTION

Injection molding is a very important process in the plastic manufacturing industry, especially for the production of small components such as mini tray, where the stability and weight accuracy of the product is very calculated. Temperature and injection time are two main parameters that affect the final outcome of the injection molding product, including quality and final weight. The right injection temperature ensures that the plastic material melts perfectly so that it can fill all the molds evenly, while the optimal injection time allows the distribution of stable material and reduce defects such as cavities or imperfections in the product. The combination of these two variables can create conditions that affect the density and weight of the final product, which in the context of mini tray products, is very influential on the quality, performance, and durability of the product.

Therefore, the analysis of the effect of temperature and injection time becomes very important in determining the optimal parameter of the injection molding process to produce a mini tray with a consistent weight and quality, thus meeting manufacturing standards and the needs of the product application. This study aims to explore how the variations of the two parameters affect the final weight of the mini tray product, in order to provide recommendations for effective parameter settings for optimal product quality.

Injection molding is one of the techniques in the manufacturing industry to print material from thermoplastic. Injection molding is a production process method that tends to be used in producing or processing small and complicated components, where the cost is cheaper when compared to using other methods commonly used [1]. Plastic injection mold is the manufacturing process to make plastic parts of various sizes, complexities, and applications. This process requires a vertical or horizontal injection printing machine, mold, and raw plastic resin. Plastic resin material is merged in an injection printing machine and then injected into a mold, where it cools and hardens into the end or end. This process consists of four stages which include narrowing, injection, cooling, and ejection [2]. Injection mold is a major part of the plastic industry and is a large business worldwide, consuming around 32% WT% of all plastic. This is in second place after the extrusion, which consumes around 36% WT% (1, 3, 7). 11: The United States alone there are around 80,000 IMM and around 18,000 extruders operating to process all different types of plastic. In the IMM industry is not considered an extruder; However, basically this is a non -ontinu extruder and in some operations even operated continuously (Chapter 15). IMM has a screw plasticator, also called an extruder screw, which prepares melt [3]. All of these machines perform certain important functions: (1) plasticization: heating and fusion of plastic in the plasticator, (2) injection: injecting from the plasticator under the pressure of the molume volume of the volume controlled into a closed mold, with compaction of plastic begins on the wall of the cavity mold, (3) afterfilling: maintaining the injection material under pressure for a certain time to prevent melt back flow and to compensate for a melting volume decrease during compaction, (4) Cooling: Cooling the thermoplastic molds (TP) in molds until it is stiff enough to be removed or heating: Heat the thermoset mold (TS) in the mold until it is rigid enough to be removed, and (5) the

release of the mold: opening the mold, removing the part, and closing the mold so that it is ready to start the next cycle with a melted shot [4].

The process of making plastic has a variety of systems or systems, this follows the suitability of the product, the amount required but the most important is the amount of price that can be paid for the process. The process of injection molding, blow molding, extrusion molding, rotor molding and compression molding are several types of plastic manufacturing processes that are commonly used [5]. Several factors in production need to be considered in addition to product design factors, conditions in the injection machine need to be taken into consideration in determining the parameters such as filling time, surface pressure, product shrinkage, plastic materials used, as well as some possible product defects after the production process [6]. Plastic has several types including PE, PET, HDPE, LDPE, PVC, PS, PP, and PS. These types of plastic can be used in different goals [7]. The mixture of polycarbonate (PC) with Acrylonitrile Butadiene Styrene (ABS) is an important thermoplastic engine engineering and is often used by the automotive industry. PC/ABS has a very good combination of properties, because PC material has high impact strength properties, resistance to the effects of weather, high use temperatures, easily processed, and high melting viscosity, while ABS has a clay, hard, rigid and resistant properties of corrosion [8]. Plastic products are found in many daily life such as electronic objects, mobile phones, household appliances, electrical equipment such as cables and sockets, and others. The process of plastic fabrication can be done through several methods depending on the type and character as well as the geometry and size of the desired final product. The plastic fabrication methods include compression molding, vacuum molding, blow molding, injection molding, and extrusion. One of the plastic fabrication processes used is injection molding [9]. The injection molding machine was recorded for the first time in 1872 in the United States to process Celluloid. Next in the 1920s in Germany the injection molding machine began to be developed but was still operated manually where mold grip still uses levers. In the 1930s when various resins were available, a hydraulic injection molding machine was developed [10].

Increasing the use of plastic products by industry because it has several advantages. Plastic has the nature of being easily formed, lightweight, not corrosive, and can be recycled. Plastic is easily formed because it has a low tire, melting and low melting

temperature [11]. Factors that influence in injection molding are plastic materials used, injection machines and injection molding processes. Quantitatively the injection molding process is strongly influenced by material teter, pressure, material flow velocity in the molding cylinder, molding temperature, resin thickness, cooling rate. But not all of these factors can be measured in the isolated injection molding room [12]. Plastic has taken the role of a very important technology, this is caused by its mild properties, resistant to moisture and corrosion, easy to form and easily processed [13]. While the emergence of product defects results in high production costs and less efficient operating levels because many products need to be recycled and the number of final products produced decreases. [14]. The temperature decrease factor experienced by plastic liquid has a major effect on mold results. The efficiency of the cooling system in the injection molding process affects the cycle time and quality of plastic products. This step must be as short as possible and be able to achieve a homogeneous heat exchange between the plastic and mold [14].

For this reason, it is necessary to do continuous quality control. One of them is by controlling quality in the production line (inprocess) to reduce the occurrence of product defects. The In-Process section must be careful and observant in conducting diagnoses and adjustments so that the final product is expected to be in accordance with customer specifications [15]. But for the application in the field of thermoplastic engineering is still limited to its use because it has a high level of shrinkage and low polypropylene temperature [16]. Plastic is generally classified into 3 (three) types, namely: Thermoplastics, Thermo-setting and elastomer. Thermoplastic (thermo-plastics) is a type of plastic that will soften if heated and harden when cooled. Examples of thermoplastic materials include: polyethilin, polypropilin, and PVC (Polivinyl chloride). Thermosetting plastic will harden when heated and cannot be recycled (recycle) [17].

For the purposes of mass production, making preforms is generally carried out with molds that can produce many products in one cycle. Preform The results of the injection process will determine the quality of the bottle made in the stretch blow molding process. Preform quality indicators can be seen from the sink mark value, product weight and cycle time. Preform quality is influenced by the process parameter settings, among others: liquid temperature, mold temperature and resistant time [18]. Of the various parameters, one of the dominant factors is the setting parameter settings on the injection molding machine.

Where the paramter has a big influence on Shrinkage product defects, namely injection time and backpressure. One of the factors that affect the quality of a product is the temperature of heating plastic raw materials, because inappropriate temperatures can produce defects in the products of their products [19]. Temperature settings that are too hot can also result in silver or the product becomes very shiny. Injection pressure is the pressure given when the inject of the material into the mold. Adjust the pressure at each stage of the injection, the first pressure should not be too large from 30 to 100mpa depending on the engine tonnage used. The second injection pressure is between 40 - 60% of the first pressure. High pressure will result in overpack or flashing, it can even cause damaged mold. Conversely, if it is too low it will make the Shot Short / product not full. Holding Press is the pressure that is held so that the material that has been injected into the mold does not change its shape. In this stage the quality of the product is very influential. Holding press adjustment for the initial stage is recommended by 50% of the Injection Press [20].

Not many studies have explored how the temperature and injection time variations in injection molding affect the final outcome of plastic products on a micro scale. The effect of injection molding parameters, such as temperature and injection time, on aspects of plastic product microstructure such as mini tray is still lacking in depth. The purpose of this study was to analyze how the temperature and injection time variations in the injection molding process affect the final weight of the mini tray product, as well as determining the optimal parameters that can produce products with a consistent weight and quality according to manufacturing standards.

Research Methods

The type of research conducted is a type of quantitative research with the experimental method because it wants to know the factors that affect the results and analysis of data used can be measured with the aim of testing the predetermined hypothesis. In this research there are 3 variables, namely the independent variable, the dependent variable and the control variable, the following variables used in this study:

The independent variable in the study is injection temperature, and injection time, while the dependent variable is the weight of the product.

RESULT AND DISCUSSION

Data collection was carried out at UD Bina Jaya Polehan Malang City. The machine used is the KT-105 injection molding machine with specifications as shown in Table 1.

Table 1. Injection Molding Machine Specifications

a. Machine	KT-105 G
b. Clamping Force	95 ton
c. Injection Rate	81 cm^3/detik
d. Injection Pressure	1816 kg/cm^2
e. Shoot Volume	136 cm^3

Table 2. Test results

No.	Injection time (*second*)	Injection temperature (°C)				
		220	230	240	250	260
1	7,5	88.64	88.73	88.54	88.48	88.66
		88.55	88.92	88.22	88.33	88.4
		88.55	88.38	88.11	88.17	88.09
	Average	88.58	88.68	88.29	88.32	88.38
2	8	88.65	88.15	88.43	88.96	89.06
		88.02	88.66	88.43	88.71	89.11
		88.16	88.46	88.64	88.53	88.76
	Average	88.28	88.42	88.5	88.73	88.97
3	8,5	88.74	88.27	88.93	88.67	88.76
		88.77	88.83	88.78	88.82	89.25
		88.52	88.16	88.88	88.66	89.95
	Average	88.68	88.42	88.88	88.72	89.32

Figure 1 KT-105 g injection molding machine

After carrying out the production process of mini tray products with injection molding machines, data is taken by weighing the product weight. Weighing is done carefully and done to determine the weight of the product in units of grams with accuracy of one per thousand. From the weighing results, the results are obtained as in Table 2.

From the data collection then the data will be processed into information using Minitab 19. Following Software Below is the analysis of data processing as shown in Figure 2.

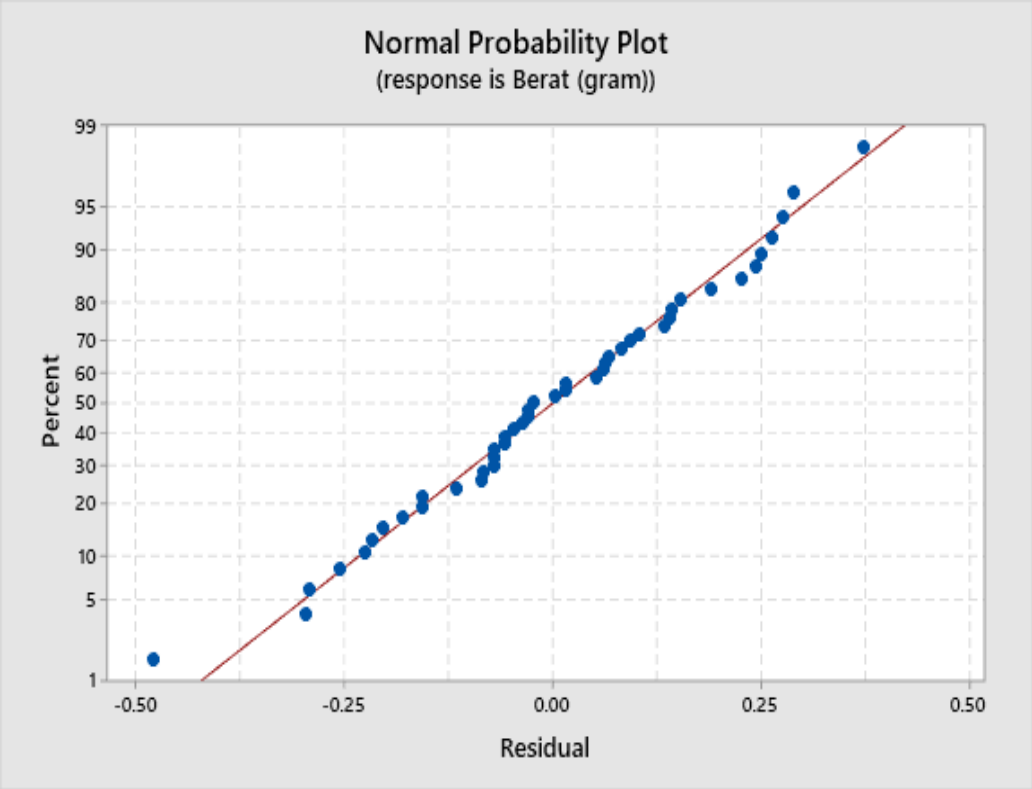

Figure 2 Normal Proability Plot Product Weight Area

One of the requirements in regression analysis is the normality test. Probability plot normality test is an effective normality test to find out whether the data obtained is normally distributed or not. This can be known from the form or model of probability plot graphics. In this graph, if the data tit is getting closer to the diagoognnya line shows that the data approaches normally. In the graph above, almost all data approaches the diagonal line and has a model that follows the normal diagonal line, although there are some data that slightly overshadow the normal lines as a whole the data is close to the normal distribution. Thus the data meets the main requirements for quantitative statistical analysis has been met.

Table 3 shows the results of anova analysis and summary and table 4 product weight summary models from the research results.

Table 3 Analysis of Variance (ANOVA)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	14	2.2313	0.15938	3.30	0.003
Linear	6	1.1846	0.19743	4.09	0.004
Temperatur	4	0.3890	0.09725	2.01	0.018
Waktu Injeksi	2	0.7956	0.39780	8.24	0.001
2-Way Interactions	8	1.0467	0.13083	2.71	0.023
Temperatur*Waktu Injeksi	8	1.0467	0.13083	2.71	0.023
Error	30	1.4483	0.04828		
Total	44	3.6796			

Table 4. Analysis of Variance Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.219722	60.64%	42.27%	11.44%

In this study the value (α) used was 5% or 0.05. The value (α) in this study is the maximum limit of errors or errors of the alternative hypothesis received. By looking at the anova table and the summary model above the injection temperature and the injection time has a significant referral to the weight of the mini tray product, from the results of data processing in this study the value From P-value injection temperature and injection time less than (α) that has been determined (p-value <α), so that the hypothesis (H0) is rejected and the hypothesis (H1) is received because the temperature and injection time have a significant effect on the weight of the mini tray product.

The coefficient of determination (R square) or caused by R^2 in the form of percent aimed at predicting and seeing how much contribution the effect of injection temperature

and injection time on product weight. Based on the results of the analysis carried out the amount of the coefficient of determination (R Square) is 60.64 %, the lift means that injection temperature and injection time have a significant effect on the weight variable of mini tray products of 60.64 %. While the remaining (100% - 60.64% = 42.27%) is influenced by other variables outside of this equation or variables that are not examined.

Based on data that has been obtained from the research on the effect of injection temperature and injection time on the weight of the mini tray product, it is obtained that the results of the influence of the influence between the independent variables and the dependent variable. This is indicated by the weight of the weight of the mini tray product in each combination of injection temperature variables and injection time. The effect of this meaning is shown in the anova table with the injection and injection terrain p-value value of less than the α value determined by the name (p-value <α = 0.05). Based on the results of the analisys carried out by the results of the coevity R^2 60.64% and the rest is affected by external or error factors that are not involved during the data collection process.

In this research the condition of polyprophylene material is not round like polyprophylene seeds in general but rather shaped flakes. This affects the stability of the amount of material that is sauce into the material barrel requires additional pressure outside of the engine capacity in order to be able to fill the barrel constantly. In addition to materials that are not rounded, the engine is also not functioning optimally so the material input is entered manually with the addition of external treatment in the material so that the material enters the barrel constantly. This condition is very influential on the flow capacity of the injection machine, I predest if there is a delay in the supply of material into the barrel then the flow capacity is not met and the filling volume will be reduced while in this condition the injection time continues according to the settings, if the filling volume is not optimal Standard weight is also not achieved optimally and also the opposite of this can be seen in the actual weight of some products have a slices of less than theoretical weight of the design and some more than theoretical weight.

CONCLUSION

1. Injection temperature has a significant effect on the weight of the mini tray. The higher the temperature, the weight of the mini tray decreases because the stability of the

melted temperature of the material increases, allows the material to fill the mold before hardening.

2. Injection time also affects the weight of the mini tray. The longer the injection time, the more material enters, so that the weight of the product increases.
3. Interaction between temperature and injection time has a significant effect, with R^2 of 60.64%. The lowest weight (88.2–88.4 g) occurs at 220 ° C (7.75-8.25 seconds) and 235-260 ° C (7.5–7.75 seconds), while the highest weight (89– 89.2 g) at 260 ° C (8-8.5 seconds).

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