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DESIGN AND CONSTRUCTION OF SMALL SCALE PLASTIC INJECTION MOLDING MACHINE USING HIGH-DENSITY POLYETHYLENE (HDPE) MATERIAL

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Abstrak.

Pencetakan injeksi telah menjadi teknik manufaktur utama dalam produksi komponen polimer yang rumit. Efisiensi pencetakannya bergantung pada berbagai parameter proses dan mesin, yang menentukan kualitas produk akhir dalam hal berbagai respons keluaran. Sangat penting untuk menyatakan bahwa pengoptimalan yang tepat dari berbagai parameter masukan sangat penting untuk mencapai indeks kualitas yang diinginkan. Dalam artikel ini, tinjauan berbagai teknik yang digunakan hingga saat ini untuk mengoptimalkan berbagai parameter pencetakan injeksi disajikan beserta kelebihan dan keterbatasannya. Ditemukan dalam tinjauan bahwa teknik cerdas lengkap yang dapat dioperasikan tanpa campur tangan manusia belum dikembangkan. Rencang bangun mesin injeksi menggunakan skala kecil antara 75gr sampai dengan 150gr dengan variasi pemanasan berkisar antara 200 ^{0}C sampai dengan 250 ^{0}C. pada saat melakukan pengujian alat menunjukkan bahwa untuk mencapai hasil akhir yang optimal dari sebuah produk memerlukan waktu 228 detik di suhu panas 200 ^{0}C, bila suhu dinaikan menjadi 225 ^{0}C maka membutuhkan waktu 217 detik dan jika dinaikan menjadi 250 ^{0}C memerlukan waktu yang lebih singkat yaitu 208 detik.

Kata kunci: rancang bangun, injeksi plastik, HDPE.

Abstract.

Injection molding has become a significant manufacturing technique in producing complex polymer components. Its molding efficiency depends on various process and machine parameters, which determine the quality of the final product in terms of various output responses. It is important to state that proper optimization of different input parameters is essential to achieve the desired quality index. This article presents a review of various techniques used so far to optimize various injection molding parameters, along with their advantages and limitations. It is found in the review that a brilliant technique that can be operated without human intervention has not been developed. The design of the injection machine uses a small scale between 75 gr to 150 gr with a heating variation ranging from 200 ^{0}C to 250 ^{0}C. When testing the tool, it showed that to achieve the optimal final result of a product, it takes 228 seconds at a hot temperature of 200 ^{0}C; if the temperature is increased to 225 ^{0}C, it takes 217 seconds, and if it is increased to 250 ^{0}C, it takes a shorter time of 208 seconds.

Keywords: *design, plastic injection, HDPE.*

Introduction.

Nowadays, plastic injection machines can help reduce plastic waste in Indonesia, which is the leading cause of the large amount of waste, especially plastic materials that are not easily decomposed. The plastic injection machine is a tool that can utilize plastic waste to make valuable items according to human needs. This paper aims to design a tool that can use waste to be recycled and made into items such as glass bowls and key chains. The benefits of this study are that it will reduce the amount of plastic waste in Indonesia and become a good solution without polluting energy sources or the surrounding environment. The method used in collecting data in this report is by collecting all data obtained when going to the field. Then, to strengthen the data, the author also looks for references from other sources, such as the internet or books. From testing for three months based on the results of the design and process, this plastic injection machine uses an automatic system, more precisely hydraulics, and achieves a time in one design according to the desired target [1][2]. Plastic waste refers to waste materials made of plastic, which people commonly use for their daily needs. The presence of this waste harms the ecosystem. To overcome this problem, the Government is promoting the 3R Movement (Reduce, Reuse, and Recycle). A practical solution to this problem is building equipment or implementing plastic forming. Several manufacturing methods are involved in its production, including extrusion, blow molding, thermoforming, and injection molding. However, recycling has proven to be ineffective due to the lack of proper technology to recycle plastic waste. It has overcome this problem, and a plastic forming machine or tool was created, with one option being an injection molding method that uses a compact linear actuator that offers the advantage of reducing production costs. One of the essential advantages of this machine is its compact size, energy efficiency, and portability. In addition, it is cost-effective and suitable for manufacturing small plastic items [3][4].

Plastic injection machines on the market are generally large, so they are less effective in making small-sized products. In this study, a small, energy-efficient, portable, and economical plastic injection machine was designed to produce small-sized plastic products. The design process was carried out using the Pahl and Beitz method. For the feeder and injection system, a screw mechanism was chosen because it does not require a power pack, so it is more space and energy efficient, as well as its clamping system. The resulting plastic injection machine design has dimensions of 645x150x347 mm, with a total weight of around 35 kg, and requires 533 watts of electricity, which can produce products with a mass of up to 3 grams with a production capacity of 240 products per hour [5]. Plan the injection process on the injection molding machine, Determine the clamping pressure according to the machine and mold, and Determine the injection time and mold cooling. Therefore, the parameter setting data is calculated, including the mold closing force, mold opening force, clamping force, injection time, injection pressure, and mold cooling. The injection pressure is 800 bar, and the barrel temperature is 2800C. Planning the production process with an injection molding machine needs to be done to get the expected final result, namely a perfect and flawless product, and to increase production by accelerating the cycle time. After calculating the parameters for the Flip-top Cap, there was a decrease in pressure of 508.46 bar with an initial injection pressure of 800 bar, mold cooling of 19 seconds, material amount 50.11 cm^3, material flow rate 18.5 cm^3 / second, injection time 3.08 seconds [6].

This study used two types of polypropylene (PP) materials, namely recycled PP and PP homopolymer. Both materials have different characteristics. The difference in material properties causes the optimal value of the melting temperature of the two materials to be different. The optimization process is carried out by changing the material melting temperature variable. The value limit of the material melting temperature analyzed is 180-280ºC. From the processing of optimization data, the optimal value for the melting temperature of PP Homopolymer material is 225^0C and recycled PP 200^0C. A trial was carried out on software simulation based on the optimal value obtained. The trial results showed that short mold defects did not occur, and the time required to fill the mold was faster than it [7]. The high use of plastic products is because plastic has several advantages, such as being lightweight, corrosion resistant, easy to shape, and inexpensive. The tendency of consumers to prefer using plastic products causes manufacturers to compete fiercely to

meet consumer demand. Manufacturers, as the leading producers of plastic products, are trying to increase the quantity and quality of production. This study aimed to determine the effect of injection time and pressure parameters on the weight of the funnel product using polypropylene plastic. The method for data collection is experimental. This study uses independent variables of injection time and pressure with injection time variations of 5 seconds, 6 seconds, and 7 seconds. In comparison, the injection pressure variations are 36 bars, 37 bars, 38 bars, 39 bars, and 40 bars. This study uses an experimental method and uses correlation analysis. The study results can be concluded that the independent variables of injection time of 7 seconds and injection pressure of 40 bars have a significant effect on the dependent variable of the weight of the funnel product [8].

Plastic has an essential role in human life. Plastic is often used as packaging because it is light, strong, transparent, and affordable. Given the nature of plastic, plastic is often used as a laminate material combined with other packaging materials. The advantages of plastic are that it can be used as a primary material to meet material needs in the automotive sector. Plastic needs to be combined with other renewable materials. New materials combined with plastic and natural fibers can be utilized in the automotive industry because the materials used are environmentally friendly. In this study, we will design a plastic injection machine with a small capacity of 75 grams to 150 grams. The heating system of this injection machine is set between 200 C and 250 C. With this small-scale design, we can analyze the optimum for the injection process with High-Density Polyethylene (HDPE) material.

Research Methods

The method used in this study is to design and build a plastic injection molding machine to replace the function of small-scale tools projected from the capacity in the industry. Sequentially, the design of this machine begins with a concept design using sketch drawings, preparation of tools and materials, material measurement, cutting, inspection, welding, assembly, and finishing [9]–[12]. The sequence of processes can be shown in Figure 1. After all components are designed, the next step is to make the machine according to the design results, conduct testing and analysis, and improve the desired machine performance.

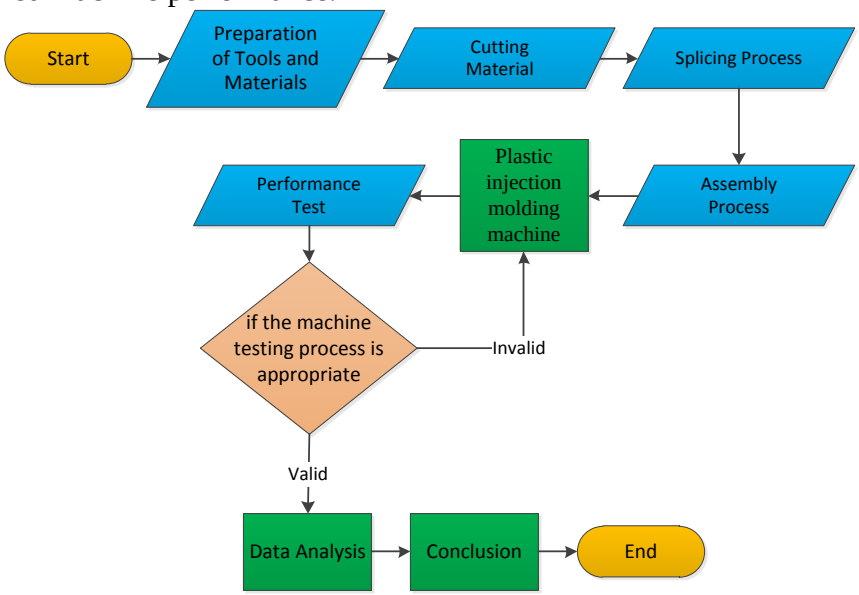

Figure 1. Plastic injection molding machine design diagram.

Results and Discussion.

The way this machine works is very simple, just put the plastic pellets in the hopper, then it will enter the barrel where there is a heater which has a temperature of 200 ^{0}C to 250 ^{0}C and it will melt so it will be pushed by a screw into the mattress which will then become a mold. ready to use.

Table 1 shows the results of plastic injection machine testing with HDPE material. The table shows the variation of HDPE material capacity and temperature levels.

Tabel 1. Machine performance test with 75 gr material capacity.

HDPE Material Capacity		Input Time	Temperature	Results	Output Time
Start	End	(second)	(^{0}C)		(second)
75 gr	69,5 gr	141	200	1	228
75 gr	64,5 gr	130,5	225	1	217
75 gr	59,5 gr	120	250	1	208

in table 2 shows that the capacity of the material he added will affect the time and temperature produced. the table shows an increase in the number of products produced compared to the previous variation.

Tabel 2. Machine performance test with 150 gr material capacity.

HDPE Material Capacity		Input Time	Temperature	Results	Output Time
Start	End	(second)	(^{0}C)		(second)
150 gr	139,5 gr	250	200	2	228
150 gr	129 gr	231	225	2	217
150 gr	118,5 gr	210	250	2	208

From Table 2, it can be seen from the assessment that the concept variant with the highest value is the concept variant that will be selected to be used as the design for the machine to be made.

Figure 2. Plastic injection molding machine design.

Conclusion.

The design of the plastic injection mold is made with dimensions of 80cm x 30cm x 80cm which consists of several components that support the performance of the tool and is designed with a 12V DC dynamo drive as a screw drive where the screw itself functions to push the plastic beads into the mat or a mold that produces one product that can be used that has been melted by the barrel with the help of a heater that has a hot temperature of 200-250 ° C. For the materials used, there are HDPE plastic beads which will then be inserted into the hopper as much as 75 grams and melted with a barrel containing a heater/heater, which the screw of the mattress will then push. After data collection during the tool testing, it can be concluded that to achieve the final result of becoming a

product, it takes 228 seconds at a hot temperature of only 200°C. If the temperature is increased to 225°C, it takes 217 seconds; if it is increased to 250°C, it takes a shorter time, with only 208 seconds for a product in the form of a glass lid.

References.

[1] W. Wijaya and A. Deharisdi, "Proses Pembuatan Produk Pisin Gelas Pada Mesin Injeksi Molding Plastik dengan Berbasis Sistem Otomatis," *Rekayasa Ind. dan Mesin*, vol. 5, no. 1, pp. 33–38, Jul. 2023, doi: 10.32897/RETIMS.2023.5.1.2429.

[2] M. S. Mahaputra, "Analisis Pengendalian Kualitas Produk Plastik Injeksi dengan Menggunakan Metode Statistical Process Control (SPC) dan Kaizen di CV. Gradient Kota Bandung," *Media Nusant.*, vol. 18, no. 1, pp. 1–16, Jun. 2021, doi: 10.30999/MEDINUS.V18I1.1226.

[3] S. Perancangan Pembuatan Mesin Injeksi Plastik Otomatis untuk Pemanfaatan Limbah Plastik yang Berbahan Polypropylene, W. Wijaya, and E. Noval Hidayat, "Sistem Perancangan Pembuatan Mesin Injeksi Plastik Otomatis (Linear Actuator) untuk Pemanfaatan Limbah Plastik yang Berbahan Polypropylene," *Rekayasa Ind. dan Mesin*, vol. 5, no. 2, pp. 59–64, Jan. 2024, doi: 10.32897/RETIMS.2024.5.2.2932.

[4] M. Matahelumual, D. Muslimin Program Studi Magister Terapan Rekayasa Teknologi Manufaktur, J. Pascasarjana, and P. G. Negeri Jakarta Jl A Siwabessy, "Pengujian Prototype Mesin Injkesi Plastic Molding Manual Double Barrel Kapasitas 5 TF," *J. Rekayasa Mesin*, vol. 19, no. 2, pp. 233–242, Sep. 2024, doi: 10.32497/JRM.V19I2.5317.

[5] N. Noor and B. Triyono, "Perancangan Mesin Injeksi Plastik Portabel," *Pros. Ind. Res. Work. Natl. Semin.*, vol. 11, no. 1, pp. 222–227, Sep. 2020, doi: 10.35313/IRWNS.V11I1.1998.

[6] H. Permana;, T. Topan;, and S. Anwar., "Produksi Proses Komponen Plastik Flip Flop Dengan Mesin Injeksi Molding Type Hidrolik," *J. Baut dan Manufaktur J. Keilmuan Tek. Mesin dan Tek. Ind.*, vol. 3, no. 2, pp. 8–17, 2021.

[7] P. T. Devalia and T. M. Arief, "Analisis dan Optimasi Parameter Proses Injeksi Plastik Multi Cavity untuk Meminimalkan Cacat Short Mold," *Pros. Ind. Res. Work. Natl. Semin.*, vol. 10, no. 1, pp. 553–560, Aug. 2019, doi: 10.35313/IRWNS.V10I1.1465.

[8] S. Sulistyono and A. Dani, "Variasi Waktu dan Tekanan Injeksi terhadap Perubahan Berat Produk Corong pada Cetak Plastik Sistem Injeksi," *J-Proteksion J. Kaji. Ilm. dan Teknol. Tek. Mesin*, vol. 7, no. 2, pp. 64–68, Feb. 2023, doi: 10.32528/JP.V7I2.9235.

[9] G. Setyono, S. Riyadi, Muharom, O. A. W. Riyanto, and S. Pratama, "Effect of Cutting Parameter Toward The Surface Roughness Applied In Turning Tool Steel Material," *Infotekmesin*, vol. 13, no. 2, pp. 233–238, Jul. 2022, doi: 10.35970/INFOTEKMESIN.V13I2.1533.

[10] H. Siswanto, S. Riyadi, S. Siswadi, G. Setyono, D. Khusna, and W. Nugroho, "Design And Build The Appropriate Technology Machinery For Shredded Fish Processing," *J. Syst. Eng. Technol. Innov.*, vol. 2, no. 01, pp. 106–110, Apr. 2023, doi: 10.38156/JISTI.V2I01.38.

[11] A. R. Dewananta, R. A. Rahmadhani, D. M. Fantoja, M. Muharom, and G. Setyono, "Rancang Bangun Rombong Listrik Dengan Menggunakan Pembangkit Listrik Tenaga Surya (PLTS) Kapasitas 200 Watt," *J. Syst. Eng. Technol. Innov.*, vol. 1, no. 01, pp. 1–6, Apr. 2022, doi: 10.38156/JISTI.V1I01.9.

[12] D. Khusna, G. Setyono, S. Siswadi, S. Riyadi, N. Kholili, and A. Nugroho, "Investigasi Efek Debit Fluida Dan Karakteristik Pembebanan Disk Valve Terhadap Performa Water Hammer," *J. Syst. Eng. Technol. Innov.*, vol. 1, no. 02, pp. 38–43, Oct. 2022, doi: 10.38156/JISTI.V1I02.25.