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Article Category

Design and Fabrication of Two-Plate Molds for ID Card Holder Products Using Injection Molding

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A B T R A C T

This study discusses the design of a two-plate type mold for ID Card Holder products made of polypropylene (PP) using the injection molding process. The focus of the research includes the design of cavity and core inserts, the selection of standard base molds, and the evaluation of mold assembly results. The research method is carried out systematically through the stages of 3D model design, CAM program creation, machining process, mold assembly, and printing trials. S50C carbon steel material is used as the main material of molds because it has mechanical strength and thermal properties suitable for tooling applications. The design results show that the two-plate mold with the 2030 MFI standard mold base is able to meet the dimensional and structural stability needs. The calculation of the projection area of 12,902 mm² resulted in a clamping force requirement of 64.51 tons, so that the mold was declared safe to use in an injection molding machine with a capacity of 80 tons. The resulting ID Card Holder product demonstrates a geometric and functional fit with the initial design without significant visual defects.

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INTRODUCTION

The development of the plastic production sector encourages the use of the Injection as the main way of mass-producing polymer products with a high degree of accuracy and good dimensional consistency (Safril et al., 2023; Safril et al., 2024). Polypropylene (PP) was chosen as the material for the ID card holder because of its excellent combination of mechanical, thermal, and chemical properties, such as low density, good impact resistance, high dimensional stability, and strong chemical resistance. (Shalihah & Kiswanto, 2023) Injection molding widely applied to everyday functional items, including ID Card Holder, which requires dimensional precision, surface standards, and sufficient mechanical strength. Product ID (Nurhadi & Arista , 2025)A Letter to It usually has a sleek shape and some specific details so that the way it is formed is greatly influenced by the process parameters Injection Molding and the mold design used. Some local studies show that errors in the setting of injection parameters can lead to product defects such as (Huda & Hendaryanto, 2024)short shot, Warpage, and Zinc Mark which resulted in a decrease in the quality of plastic products. (Wicaksono, Zuliansyah, Dhewanto Santo Ajie, & Fauzan , 2024)

One of the main problems in creating an ID Card Holder through the Injection Molding is the stability of filling the liquid material into the mold Cavity. Unconstant flow can result in variations in thickness and defects in the structure of the product. In addition, ineffective cavity design can lead to increased injection pressure and prolong the production cycle time, which impacts the efficiency of the manufacturing process. Research conducted by shows that the design (Ismoyo, Hartono, & Murdani, 2024)(Hakim, Putra, Maskarai, & Priyanto, 2020)(Widyasmoro, Widiastuti, Estriyanto, & Budiyanto, 2024)Cavity that accurately plays an important role in regulating material flow, temperature distribution, as well as cooling processes for plastic products that have minimal thicknesses, such as ID Card Holder.

Based on the problems that have been identified, a more in-depth analysis is needed regarding the application of the injection molding process, especially at the design and mold manufacturing stages for ID card holder products. The purpose of this study is to evaluate the design of ID card holder injection molding, focusing on cavity design and material filling characteristics so that the resulting product has maximum dimensional quality, surface, and mechanical strength. Previous research has generally emphasized the optimization of parameters in injection molding in general or in large plastic products and simple geometries, so it has not specifically addressed the challenges in mold design for thin products such as ID card holders (Hakim, Putra, Maskarai, & Priyanto, 2020; Widyasmoro, Widiastuti, Estriyanto, & Budiyanto, 2024). Therefore, the contribution of this study is to provide a more in-depth technical analysis of the manufacture of injection molding molds for ID card holders, especially regarding cavity design and material filling mechanisms, so that it is expected to be a guide in the development of mold design and improvement of the quality of similar plastic products in the manufacturing industry in Indonesia (Huda & Hendaryanto, 2024; Arif, Windyatri, & Suhendra, 2024).

METHOD

The flow chart in Figure 1 shows the stages of the cavity insert manufacturing methodology used in this study. The sequence of the process begins with the selection of materials, then continues with the preparation of tools and the creation of the CAM program, until it reaches the machining, assembly, and trial stages. The systematic preparation of work stages aims to ensure that each stage of production is carried out in a structured, controlled manner, and in accordance with the design specifications that have been set, so as to support the achievement of optimal print quality.

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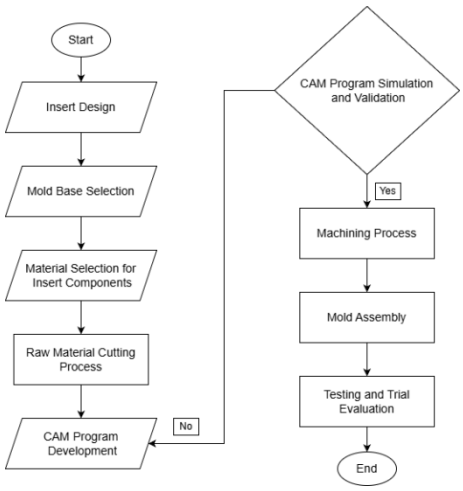


Fig. 1. Flowchart

RESULT AND DISCUSSION

Two-plate Mold Design

The design of two-plate type mold is applied in the manufacture of ID Card Holder products. The discussion focused on the results of product design evaluation as the basis for cavity and core formation, insert mold design that affects the accuracy of the dimensions and quality of the product surface, and the analysis of the mold assembly stage in ensuring the suitability of position and function between components. In addition, a Bill of Materials (BOM) is also presented as a form of technical verification of the completeness of mold components and overall design efficiency.

Product Design Result

The 3D model is designed based on standard card size and ideal wall thickness to avoid surface defects such as sink marks and curves in the final product, as well as the integration of additional features in the form of hanger holes. The application of these design parameters aims to ensure the structural strength of the product while maintaining the efficiency of material use and the ease of the printing process. The resulting product design visualization is presented in Figure 2 as a basis for evaluating the product's readiness for the next stage of mold design. The material chosen in the design of the ID Card Holder product design is PP which is often used in daily life. The characteristics of PP material are that it has a liquid temperature of 170°C - 230°C, a semi-transparent natural color, a specific gravity lighter than water, and a density ratio of 0.95 g/cm3 (Alfian, Rina, Azri, Riki, & Randa, 2021).



Fig. 2. 3D ID Card Holder Design

Contruction Sprue, Runner, and Gate

The construction on the sprue adjusts to the specifications of the hole diameter on the sprue bushing component, the construction on the gate uses the edge gate type, and the construction on the runner uses the half-round runner type.

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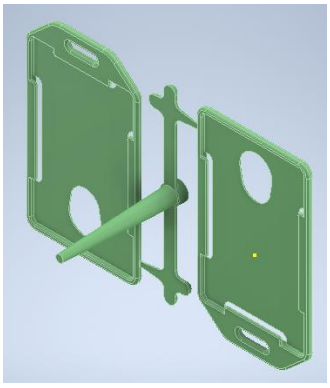
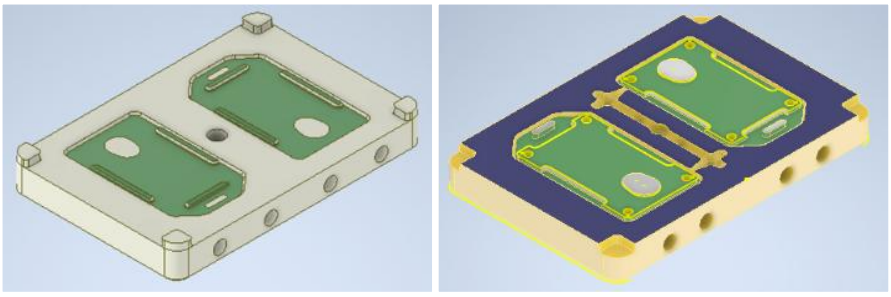


Fig. 3. Contruction runner and gate

Insert Design

Based on the final design of the product, the division of the area Cavity and Core done by paying attention to the geometric shape of the ID section Card Holder to simplify the demolding process, as well as take into account the durability aspect Mold. Core and Cavity are the two main components in the mold that directly determine the outer and inner shape of the final product. Design Insert cavity and Core The resulting mold is designed to minimize the complexity of mold manufacturing while improving the efficiency of the injection process. This approach is in line with scientific principles in Core and cavity generation which emphasizes that a quality mold structure must not only be able to produce components that meet specifications but must also pay attention to the material flow, cooling process, and strength of the mold to injection pressure (Tang, Kong, Sapuan, Samin, & Sulaiman, 2006).

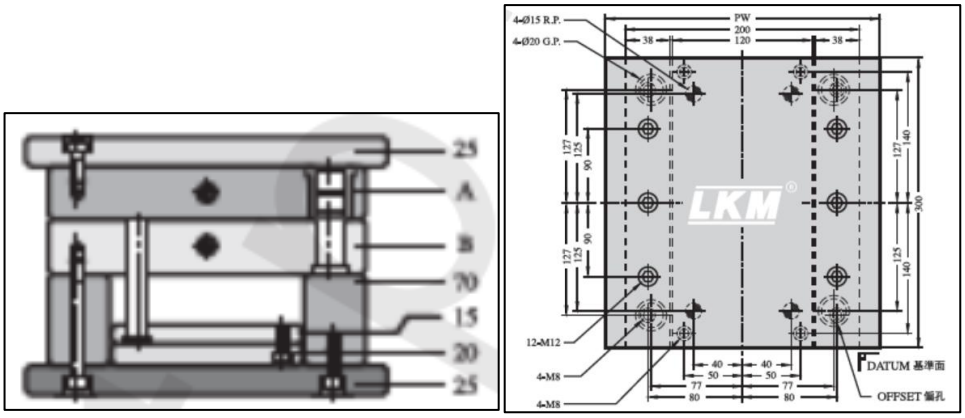


(a) (b)

Fig. 1. (a) Insert cavity and (b) Insert core

Mold Base Selection

Based on the cavity layout that has been designed, the mold base chosen is the MFI standard mold base with the CI type series 2030. The picture below shows some of the plates used including the top clamp plate (25 mm), cavity plate and core plate (35 mm), spacer block (70 mm), ejector retainer plate (15 mm), ejector plate (20 mm), and bottom clamp plate (25 mm)



(a) (b)

Fig. 2. (a) Contruction and (b) layout mold base CI type

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Assembly

The mold assembly process shows that all major components, including cavity plates, core plates, ejector systems, as well as guide components, have been well put together according to the design that has been set. This assembly aims to ensure the suitability of the position between the components and the overall function of the mold.

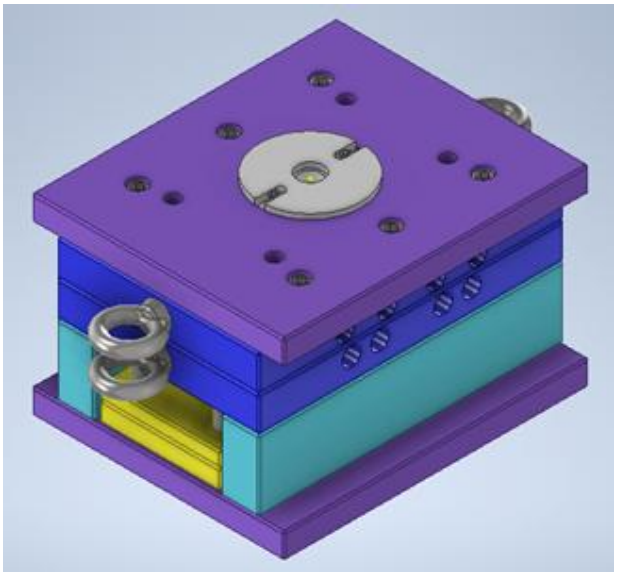


Fig. 3. Design assembly

Bill Of Materials

The BOM is prepared to recognize all the components of the mold along with the amount and type of material used. The process of preparing this BOM is very crucial to support production, assembly, and also estimated mold manufacturing costs.

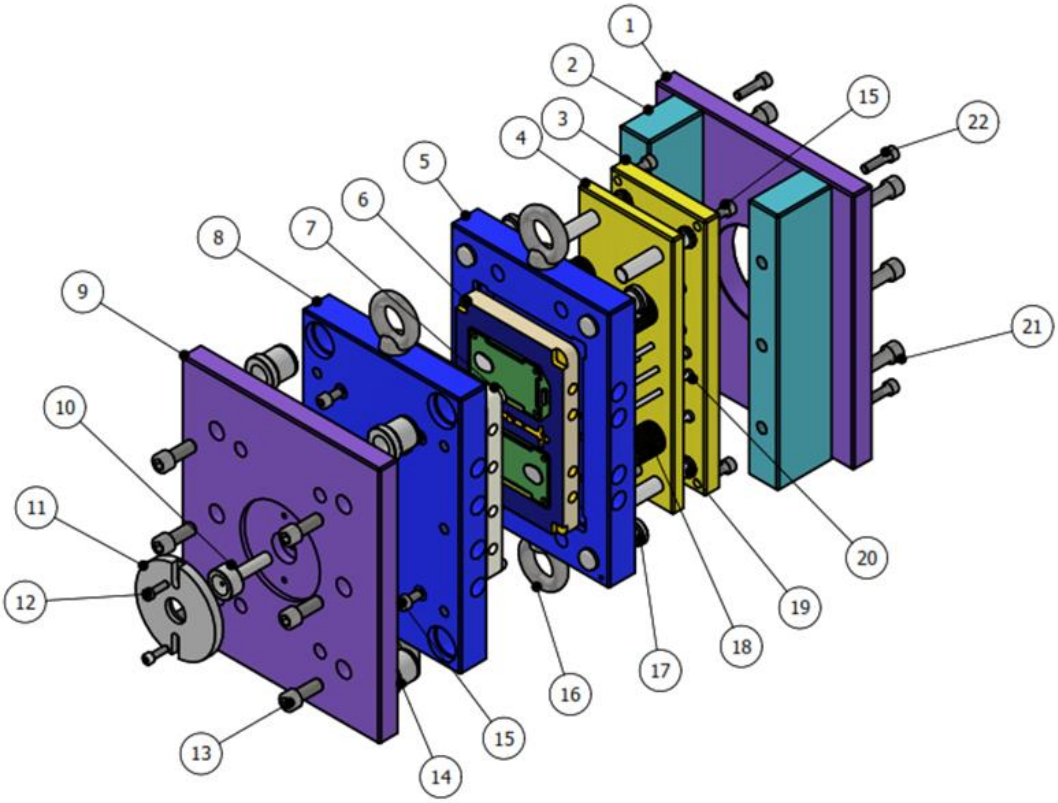


Fig. 4. Bill Of Material (BOM)

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Based on the results of figure 7, the following table will be attached to the 2030 MFI-based mold base specifications along with other supporting components in the injection molding process.

Table 1. Bill Of Material (BOM) mold components

No	Component Name	Dimensions (mm)	Quantity	Ingredients
1	Bottom Clamp Plate	$300 \times 250 \times 25$	1	S50C
2	Spacer Block	$300 \times 38 \times 70$	2	S50C
3	Ejector Plate	$300 \times 120 \times 20$	1	S50C
4	Ejector Retainer Plate	$300 \times 120 \times 15$	1	S50C
5	Core Plate	$300 \times 200 \times 35$	1	S50C
6	Insert Core	$200 \times 135 \times 23.5$	1	S50C
7	Insert Cavity	$200 \times 135 \times 27$	1	S50C
8	Cavity Plate	$300 \times 200 \times 35$	1	S50C
9	Top Clamp Plate	$300 \times 250 \times 25$	1	S50C
10	Sprue Bushing	$\emptyset 20 - L60$	1	SKD61
11	Locating Ring	$\emptyset 100 - L10$	1	SKD61
12	Bolt M6×1	$M6 - L16$	2	SUS304
13	Bolt M12×1.75	$CB12 - 30$	4	SCM435
14	Guide Bushing (Head Type)	$\emptyset 30 - L35$	4	SUJ2 (GCr15)
15	Bolt M8×1.25	$CB12 - 16$	12	SCM435
16	Eye Bolt	$M12$	4	SS304
17	Guide Pin	$\emptyset 20 - L70$	4	SUJ2 (GCr15)
18	Coil Spring	$SWF30 - 35$	4	-
19	Return Pin	$\emptyset 15 - L95$	4	SUJ2 (GCr15)
20	Ejector Pin	$\emptyset 5 - L95$	12	SKD61
21	Bolt M12×1.75	$CB12 - 100$	6	SCM435
22	Bolt M8×1.25	$CB8 - 30$	4	SCM435

Calculation

Calculations are presented to support the technical aspects in designing mold injection molding quantitatively. The purpose of this calculation is to ensure that the design parameters applied have met the needs in the production process as well as in accordance with the specifications of the machines used. The calculations included determining the area of the projection

and clamping force, both of which play an important role in ensuring the stability of the mold during the injection process and preventing product defects.

Characteristic Product

The characteristics of the ID Card Holder product design can include the mass, surface area, and volume of the product which is the result of calculations from iproperties in the Autodesk Inventor software. The material used to determine the characteristics of ID Card Holder products is PP

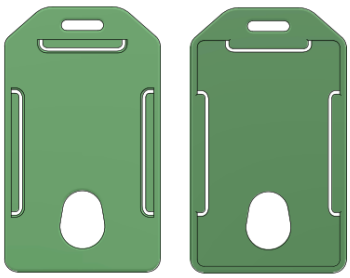


Fig. 5. Physical characteristics of the product

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Mass $= 6.35\ gr$ (1)
Surface Area $= 11831.290\ mm^2$ (2)
Volume $= 7075.700\ mm^3$ (3)

Meanwhile, the construction of the product along with the runner and gate have different physical characteristics. These characteristics are visual physical characteristics to determine the mass, surface area, and volume of the product.

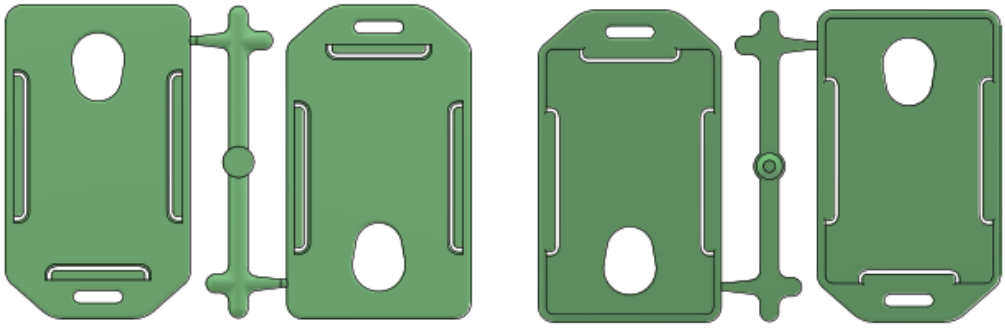


Fig. 6. Physical characteristics of the product

Mass $= 16.329\ gr$ (4)
Surface Area $= 26854.866\ mm^2$ (5)
Volume $= 17965.566\ mm^3$ (6)

Projection Area

The area of the projection is one of the important factors in mold design for the injection process because it directly affects the amount of force received by the mold surface during the injection process. The determination of the area of the projection area is carried out based on the shape and dimensions of the product which is shown perpendicular to the direction of clamping the mold. This value is then used as a reference in the calculation of the force required to keep the mold in a closed state during the material filling process. the mold. This value is then used as a reference in the calculation of the force required to keep the mold in a closed state during the material filling process.

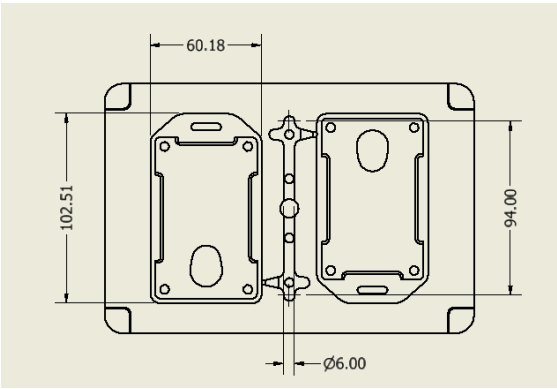


Fig. 7. Projection area dimension

$$\boldsymbol{A_{Projection}} = \boldsymbol{A_{Product}} + \boldsymbol{A_{Runner\ Area}} + \boldsymbol{A_{Gate}} = \mathbf{12338.1036 + 564} = \mathbf{12902\ mm^2} \quad (7)$$

$$A_{Product} = Total\ Cavity\ x\ Length\ Product\ x\ Width\ Product = 2 \times 102.51 \times 60.18 = 12338.1036\ mm^2 \quad (8)$$

$$A_{Runner + Gate} = Runner\ Width\ x\ Effective\ Runner\ Length = 6 \times 94 = 564\ mm^2 \quad (9)$$

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Clamping Force

Clamping force is the force required by the injection molding machine to withstand injection pressure so that the mold does not open during the process of filling liquid material. The clamping force calculation is carried out by paying attention to the area of projection and the maximum injection pressure acting inside the cavity. Determining the right clamping force is essential to prevent flash in the product and ensure that the mold is of consistent quality.

Information: PP material injection pressure $= 30 - 50\ Mpa$
Projection Area (A) $= 12902\ mm^2$
Gravitational force (g) $= 10\ m/s^2$

$$F_c = A_{Projection} \times P \quad (10)$$
$$= 12902\ mm^2\ x\ 50\ Mpa$$
$$= 645100\ N$$

$$F_c = mg \quad (11)$$
$$645100 = 10m$$
$$m = 64510\ Kg$$

$$Conversion\ to\ tons = 64510\ Kg \quad (12)$$
$$= 64.51\ tons$$

Fc is the clamping force (N), Pi is the injection pressure (MPa), and A is the cross-sectional area (mm^2) (Noor & Triyono, 2020). If the conversion result is 64.51 tons, then the safe limit of the injection machine used with a capacity of 80 tons.

Product Result

The product results displayed show the achievement of the design specifications that have been determined, both in terms of geometry, dimensions, and function, so that the resulting products are expected to meet the needs of users ergonomically and efficiently. The results of the product have also been tested using injection molding machines with optimal clamping force and optimal cooling time

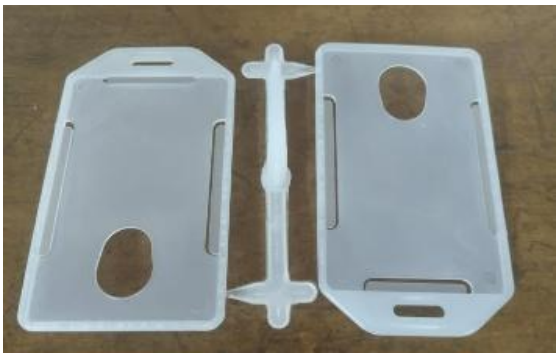


Fig. 8. Product result

In the trial process using an injection molding machine, there are several defective product results with the following types of product defects:

1. Short Shot, Product defects that occur when molten plastic does not completely fill the mold cavity, resulting in incomplete or missing parts. These defects are often caused by insufficient injection pressure or obstruction inside the mold. In this period, the injection pressure was still low at 500 kN.

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Fig. 9. Short shot

2. Flash, Product defects caused by an excess layer of plastic material material to the exit of the mold cavity along the mold separator line or around the ejector pin. Flash can be caused by excessive injection pressure or wear molded components that allow the material to escape. The excess injection pressure used is 600 kN, along with a less than optimal cooling time.



Fig. 10. Flash

3. Flow Line, Product defects caused by visible lines or patterns on the surface of the printed part, caused by cooling and compaction of the material as it flows through the mold. These defects are often associated with inconsistent injection speeds, material temperatures, or poor mold design. The main cause of flow lines in ID Card Holder products is the lack of smoothing process on the surface of the mold.



Fig. 11. Flow line

CONCLUSION

This study aims to evaluate the design of injection molding ID Card Holder products with a focus on cavity design and material filling characteristics to produce optimal dimensional quality, surface, and mechanical strength. The results of the evaluation showed that the design of the cavity and core inserts adjusted to the product geometry was able to support the

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stability of material flow during the filling process, so that the resulting product had good dimensional suitability and surface quality and minimal defects such as warpage and sink marks.

In addition, the filling characteristics of polypropylene (PP) material supported by the two-plate mold configuration as well as the selection of S50C carbon steel mold material provide structural stability during the injection process. The results of the calculation of the projection area of 12,902 mm² resulted in a clamping force requirement of 64.51 tons, which is still within the safe limit of an injection molding machine with a capacity of 80 tons. Thus, the mold design developed is declared suitable for use and is able to meet the research objectives in producing ID Card Holder products with optimal quality.

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