# Comparison of Polypropylene Flow Index to Increase Injection Efficiency In Plastic Injection Mold, 2 Cavities of Different Shapes Plastic (Case Study : Pencil Box)

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**Abstract**
This research used a computer program to simulate the flow, experimental design and statistical analysis to find the right parameters and properties of polypropylene to fix the problem of the injection of molded plastic with two cavities, when the shape is different and the time to fill a minimum of two different indicators to the cavities. The results of the experiment; plastic polymer polypropylene grade RJ6420 is more suitable for forming injection molded plastic pencil boxes than grade RP348S due to the flow characteristics when observing and recording the time to fill the two cavities. And has filled different than 0.0097 seconds to molding. The real piece of work is complete.

**Keywords**: Melt flow index, Plastic injection molding, Taguchi

## 1. Introduction

The Injection molding process is a process of molding plastic into the desired shape. It is a very common process that produces complex plastic parts well so that the surface of the workpiece is smooth. It can produce large quantities of workpieces at a time and quickly [1-7], but the design of the mold must be suitable for the workpiece because it affects the quality of the completed work piece [8]. Various parameters used in the injection process include the temperature of the plastic melt before injection, the crimping pressure, and the cooling time. and appropriate injection speed, considered together with the properties of plastics used for injection molding, such as flow index and Young's modulus [9-10]. Such factors affect waste in the process as a wasted expense, so it must be calculated and tested to find the value and optimal parameters of each type of plastic but trial and error take time and the cost of conducting many experiments to obtain appropriate parameter values [11-12]

Currently, computer aided design and computer aided engineering technologies are used to help design and produce injection molding parts [13-15], where manufacturers can simulate the flow of molten plastic in the injection molding process in a virtual computer graphics format to analyze the flow patterns that affect waste in the injection molding process Watchara S. [16-20]

uses recycled plastics such as recycled polypropylene and polyoxymethylene, which are industrial plastics and engineering plastics commonly used today. The flow pattern was studied using the flow index and modulus and also the plastic property value to determine the parameters for forming plastic cup products and injecting the complete specimen with real specimens. Yunus M. et al. [21] used an experimental design tool (DOE) to analyze the flow of polypropylene molten plastics to form the fan blade back cover with two cavities to optimize the parameters for injection molding to be complete, but the simulation of flow by retesting in the experimental design (DOE). If the same parameter value is used in repeated testing, the result of the original simulation is obtained. This reduces testing time. Noppharit W. [22-25] analyzed the flow pattern combined with the Taguchi simulation design to find the optimal parameters for injection molding of pencil boxes with two cavities of different shapes to increase the inlet size factor of the appropriate molten plastic. In this study, a single grade RP348S injection molding plastic was used. There is no comparison of other grades of injectable polypropylene plastics, which may affect the flow balance and different filling times of better two cavities mold Watchara S. [26] studied the flow properties of four recycled polypropylene plastics that affect the filling of a single cavity plastic injection mold.

The objective of this study was to study the flow of polypropylene injection molds to compare the flow characteristics, different filling times of two cavities molds and optimal parameters of RP348S grade and RJ6420 grade polypropylene plastics with different flow index values and modulus values using flow simulation and statistical finished programs to choose the right polypropylene plastic grade for pencil case molds with two cavities with different shapes.

## 2. Research operations

Flow simulation and comparison parameters to increase injection efficiency in two cavities injection molds of different shapes. The properties of polypropylene plastics of that grade must be referenced using the flow index and modulus values obtained from the plastic manufacturer's data sheet, SPT brand injection molding machine model TR80EH2 is used to the workpiece, use Minitab software to make Taguchi, and use Solidwork for simulation.

Table 1 Factors for Taguchi Design.

| | Grade | Melt flow index (g/10min) | Young's modulus (Mpa) |
|---|---|---|---|
| PP-H | RP348S | 35 | 1030 |
| PP-L | RJ6420 | 28 | 1177 |

### *2.1 Creating a molding model*

Modeling of the two grades of polypropylene plastic uses the same shape model for comparison. By choosing a pencil box model with two cavities, the shape is different in the simulation because polypropylene plastic is a common plastic that is popular in industries, consumer products, and electronic products as well as automotive products. The pencil box model with two cavities can therefore be used in many products, such as the pencil box side being used for volumetric work, car wheel eyebrows or plastic drinking glasses. The side of the pencil case lid is used for flat items such as employee ID cards, coasters, etc. show in Figure 1

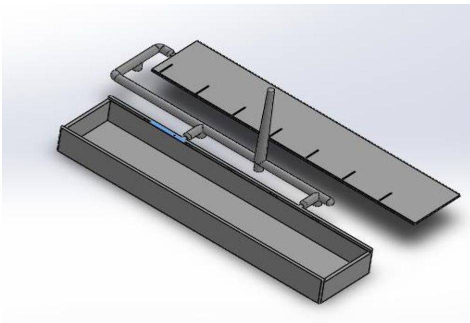

Figure 1 Pencil box model.

### *2.2. Creating Elements Simulate Forming*

The flow simulation with the finished program requires the workpiece to be divided into several sub-elements for the program's analytical resolution, with both grades of polypropylene plastic using the number of elements in the simulation at 261446 elements for comparison. shown in Figure 2

Figure 2 Mesh model to element.

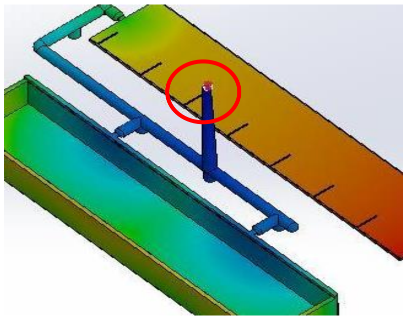

Figure 3 Temperature analysis of injection parts.

*2.3. Configure parameters in the simulation*

Determining the parameters in the injection process used in the simulation including melt/ temperature, meltflow, Young's modulus, holding time, cooling time, injection pressure and adding the inlet size factor of the molten plastic because it affects the flow balance of two molds of different shapes [22-25], and determine the type of material used to make the mold for the accuracy of the simulated results. The type of mold used to simulate polypropylene plastic in both grades is 20P steel.

*2.4. Results of flow analysis of plastic injection molds with basic ready-made programs*

Using the Taguchi Design table in the statistical program to determine the smallest difference in filling time of the two cavities, the injection parameters were determined: the melting temperature is 160 – 240 degrees Celsius; The mold temperature is 30 – 70 degrees Celsius, the injection speed is 1.2 – 1.6 seconds, the entrance size of the workpiece is 2 – 6 millimeters, and the entrance size of the pencil case is 0.5 – 4.5 millimeters. [27-31,34-36,39-45]

*2.5. Results of actual injection work from parameters obtained from preliminary plastic injection simulation analysis.*

Determining the starting point of the inflow of molten plastic into the injection mold is determined in the middle of the starting point to balance the flow of molten plastic to the gravity of both cavities and run flow simulator to find the appropriate parameters and defects of the process for further analysis. [32-33,37] show in Figure 3

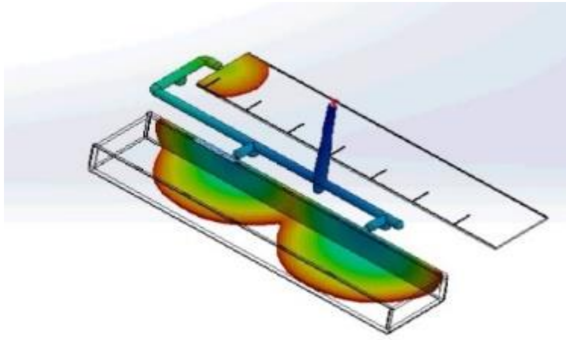

Figure 4 Run Program.

*2.6. Flow characteristics and injection time to fill 2 grade 2 polypropylene plastic*

Based on the results of the simulation of the flow of polypropylene plastics of both grades, it is observed from blue to red, indicating ascending filling time. It was found that the filling characteristics of PP-H plastic had a different filling time between the pencil case and the pencil case lid at 0.1332 seconds. Notice the orange-red color at the tip of the pencil case lid and a pencil case section with a volumetric shape appearance. It is characterized by non-simultaneous replenishment. The bottom pencil case floor area (blue area) is full before the top (green area), but around the corners and outer edges. The upper (greenish-yellow area) is full before the bottom (orange-yellow area), where the lower corners and outer edges (circled in red as Figure 4) are the areas that fill closest to the lid of the pencil case, but only a small part of the workpiece. This may cause the workpiece to be not fully injected. There is a difference in filling time between the pencil case and the lid of the pencil case at 0.1235 seconds. By observing the same color of the workpiece on both the top and bottom. The center area of the pencil case goes almost to the corner area and the outer edge. It has a yellowish-green color that corresponds to the upper part of the pencil case lid. The corners and outer edges of the pencil case are orange-yellow, matching the central part to the bottom of the lid of the pencil case (circled in red as shown in Figure 6). The flow characteristics of PP-L plastics are balanced and have a similar filling chance of two cavities to PP-H plastics, reducing the risk of not filling at the same time, which is the cause of problems in injection molding of pencil boxes with two cavities with different shapes.

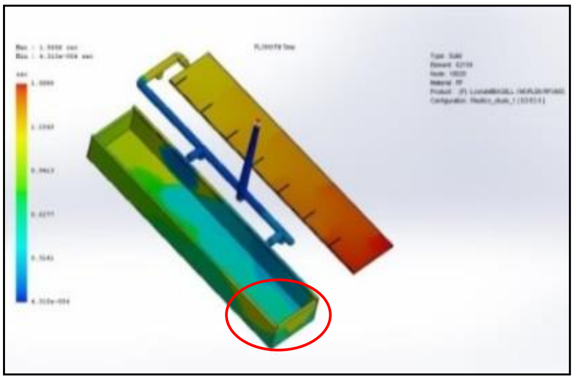

Figure 5 Flow characteristics and injection time value of PP-H plastic filling.

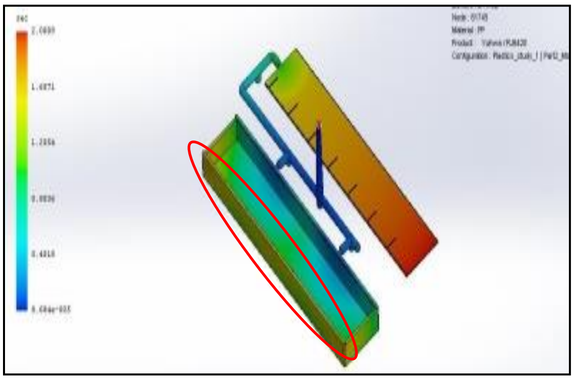

Figure 6 Flow characteristics and injection time value of PP-L plastic filling.

**3. Experimental results**

From the simulation results of the flow of molten plastic in the injection process. In addition to the results of the flow characteristics and obtaining basic parameters for adjusting the injection machine for that type of plastic to solve the problem of incomplete injection in the plastic injection mold process of two cavities with different shapes. Using the least difference in filling time of the two cavity molds as a measurement index. and using statistical analysis programs to find appropriate parameters., Uses a right-angle array (Taguchi design) L25

*3.1 The results of the analysis of the factors that affect the least different replenishment times of the two grades of polypropylene plastic.*

The results were based on the Takushi experimental design and statistical analysis programs. It was found that the effect of the parameters that resulted in the least difference in filling time of the two cavities of PP-H plastic plastics, namely injection speed and the entrance size of the pencil case, had the same impact. When the injection speed is adjusted, it decreases, and the inlet size of the pencil case is larger. Different filling times are reduced, with other fixed parameters which cannot be increased or lowered because it will result in an increase in the different filling times of two cavities molds. Shown as the red square frame in Figure 7 (PP-H), where the level of the parameter that has the greatest impact on the least different filling time of two cavities molds, namely an injection speed of 1.2 seconds and a pencil case inlet size of 4.5 mm, is shown as Figure 8 (PP-H). When adjusting the melting temperature, the plastic decreases. Different filling times are reduced, with other fixed parameters which cannot be increased or lowered because it will result in an increase in the different filling times of the two cavities molds. This is shown in the red square frame in Figure 7 (PP-L). The level of parameters that affect the least different filling time of the two molds is the melting temperature of 220 degrees Celsius, but the level of the corresponding parameters of the two grades of polypropylene plastic is the entrance size of the pencil box souvenir at 4 millimeters. But if the size of the pencil case lid is adjusted more, it will cause the molten plastic to fill up faster, and as a result, the pencil case will not be full. This is shown as circled in red in Figure 7 (PP-H and PP-L).

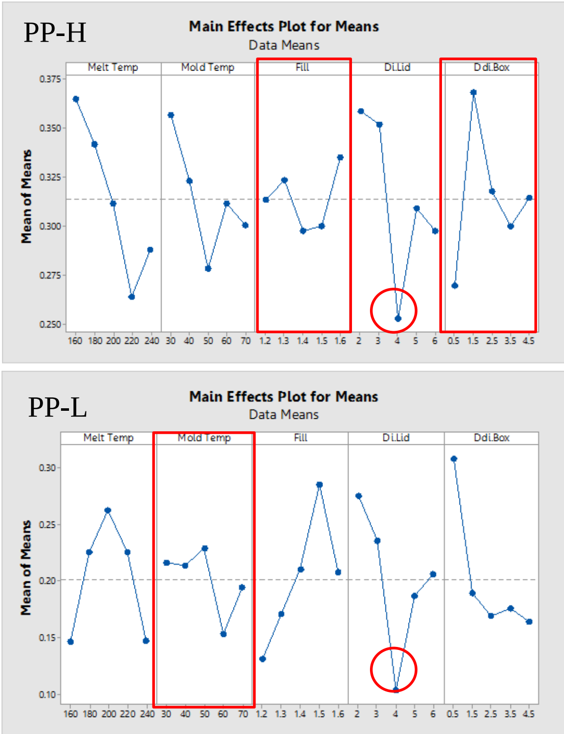


Figure 7 Main Effects Plot for Means.

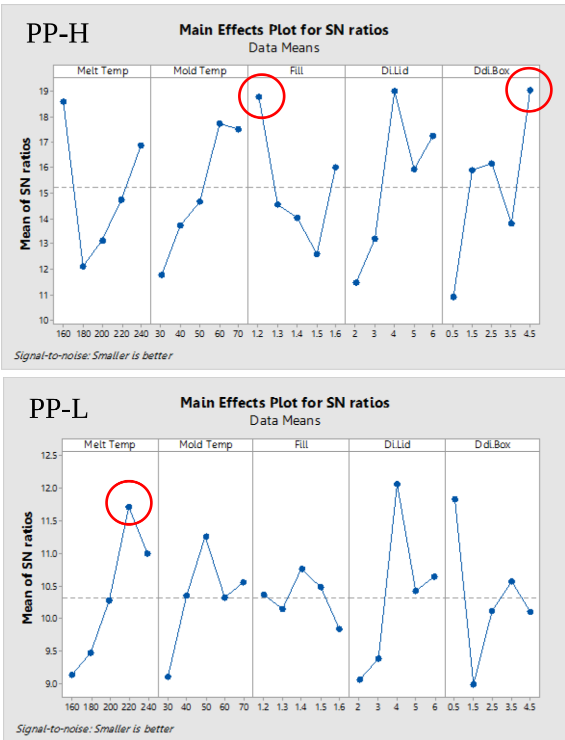


Figure 8 Main Effects Plot for SN ratios.

*3.2 Actual workpiece molding results from parameters obtained from the experimental design Taguchi and Statistical Analysis Program of PP-L Plastic.*

From section 2.6, it was found that the flow characteristics and injection time values of PP-L plastics had a flow time balance and a similar chance of filling molten plastics of two cavities to PP-H plastics at 0.1235 seconds as shown in Figure 6. Mold temperature 50 degrees Celsius Injection speed 1.6 seconds, entrance size of pencil case lid It was found that the flow of molten plastic filled both workpieces as shown in Figure 9, and the actual workpiece was complete. This is shown in Figure 10., Which is obtained from the most suitable parameter values.

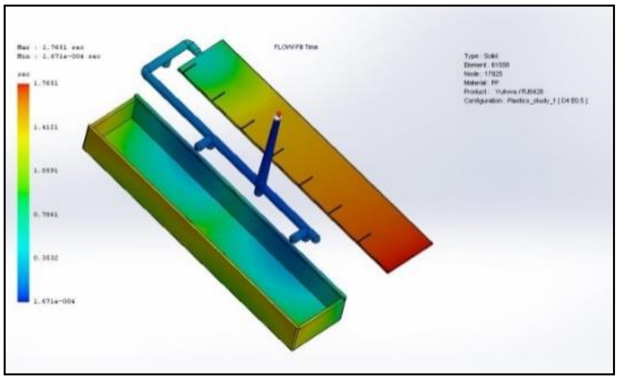

Figure 9 Flow characteristics and injection time value of PP-L plastic injection molded from parameters obtained from the experimental Taguchi design.

Figure 10 The actual specimen is injection molded from parameters obtained from the experimental design; Taguchi and Statistical Analysis Program of PP-L Plastic.

## 4. Discussion

When considering flow simulation in parameterization, it reduces trial and error time, and adjusting the inlet size will be a way of minimizing the cost of plastic injection mold improvement. In addition, the use of experimental design tools is combined with statistical programs to find the appropriate parameter value. The selection of grades based on the properties of suitable polypropylene plastics will reduce the chance that the workpiece is not fully injected, which affects the quality of the workpiece and production efficiency. Results from such experiments, unlike Yunus M. et al. [21], an experimental design tool (DOE) was used to analyze the flow of polypropylene molten plastics forming the fan blade back cover. If the same parameter value is used in repeated testing, the result of the original simulation is obtained. This reduces testing time. The Takushi method has a smaller number of trials, reducing the trial time. Noppharit W. [22-25] analyzed the flow pattern combined with the Taguchi simulation design to find the optimal parameters for injection molding of pencil boxes with two cavities of different shapes. Increase the inlet size factor of the appropriate molten plastic. But grades are not selected based on the properties of suitable polypropylene plastics. and Watchara S. [26] studied the flow properties of recycled polypropylene plastics. It was found that the flow index affects the filling time in the injection molding process, but using a 1 cavity simulation piece, it is recycled plastic that is more difficult to control than new plastic resins with flow index control from the manufacturer. Flow simulation results show discrepancies in finding the best flow balance, because the flow simulation must observe the flow characteristics of the workpiece. The filling characteristics of PP-H plastic with a high flow index fill the pencil case almost completely, which is most of the space left in the lower corner of the pencil case, which is a small part of the space that fills with the movement of the liquid plastic moving to the entrance of the pencil case lid, unlike PP-L plastic with a low flow index. The molten plastic reaches the center area, which is half the area of the pencil case, so the plastic begins to move into the lid of the pencil case and fill in the final area of the pencil case lid and the edge of the pencil case. Due to the low flow index of PP-L plastics, there is a greater slowdown in the flow of molten plastics than in PP-H plastics with a high flow index, resulting in a faster full-capacity time near the main entrance than distant cavities. This causes problems in the infill injection of the injection molding of pencil box workpieces with two cavities with different shapes.

## 5. Conclusions

A comparison of PP-H plastic and PP-L plastic with the flow simulation method, combining the Taguchi weaving design and analyzing the results with statistical programming. It was found that the comparison of the flow simulation results of PP-L plastics had a more balanced flow characteristic due to the color of the filling time of the two cavities that were similar and the difference in filling time was less than 0.0097 seconds, and the two plastics had different flow indexes, with PP-H plastic having a flow index of 35 g/10 min and PP-L plastic having a flow index of 28 g/10 min; parameters that affect them differently. The properties of polypropylene plastic in each grade are suitable for forming workpieces in different plastic mold injection processes. Therefore, before molding with the plastic mold injection process, the flow should be simulated to select the grade of plastic and use statistical programs to analyze the results to find the appropriate parameters to adjust the injection machine for that workpiece.

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