Indicate the Functions and Effects of Autodegating Mold Door Modifications on the Injection Molding Process on Productivity

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Abstract. Gate is an important part of the injection molding process which has the main objective of transferring liquid plastic into the mold chamber. There are various types of gates, one of which is the edge gate. The most simple and flexible gate of other gate types. However, in the production process, the mold uses the edge gate type, the part that comes out of the injection molding machine is still attached to the runner. Thus, rework is required by the operator to separate the plastic parts and runners which can extend the cycle time and can cause product defects in the form of overcuts. This research was conducted to determine the function of mold modification which can make runners and plastic parts separate automatically after leaving the injection molding machine and its effect on the cycle time in achieving the target output. This research was conducted through a process of observation and interviews before making designs and autodegating modifications to mold doors. The results of this study indicate that the autodegating modification of the mold door can cut the plastic part and the runner apart automatically. In the production process, the rework process by the operator is no longer there, the part after leaving the injection molding machine is immediately packed by the operator. The production process cycle time was reduced from 34 seconds to 30 seconds so that the output target was quickly achieved. It can be concluded that the production process has become more efficient and productive with the level of effectiveness of the production process increasing by 6.8%.

Keywords: Gate, Edge Gate, Autodegating, Injection Molding

1 Introduction

The use of plastic is much needed in human life. Many components use plastic materials, both from industry to household needs. This is because plastic material has many advantages such as being easy to shape, lightweight, non-rusting, durable, recyclable, and cost effective. Therefore, the use of plastic can save substantial costs and energy when compared to the use of other materials. One of the processes of forming plastic is using injection molding. The injection molding process is the process of forming a work piece from a granular thermoplastic material that is placed into a hopper/toron. The material then enters the injection cylinder barrel which is driven by a screw mechanism through the engine nozzle and sprue bushing through a channel called the runner system. This process

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culminates in the gate until the process of filling the material in the cavity occurs when the mold is closed [1]. As can be seen in the following figure number 1.

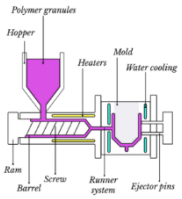


Fig.1 Injection molding process

Gate is an important part of the injection molding process. Where the gate has the main purpose of transferring liquid plastic into the mold space. The gate has control over the flow of the melt from both the filling and packing stages [2] . In general, there are 2 types of gate types in molds, namely [3] :

- *manually trimmed gate,* namely the gate on the product is cut using a tool such as a knife or scissors.
- *Automatically trimmed gate, namely* the gate on the product will be cut automatically when the product is pushed by the ejector pin and lifter.

On the mold door apply a manually trimmed gate. This type of gate has various types of gates, one of the gates used is the type of edge gate. Edge gate is the simplest and most flexible gate compared to other types of gates [4]. This gate is easy to produce and modify as needed [5]. As illustrated in figure 2.

Fig.2 Edge Gates

In the production process the results of the plastic door parts which then come out of the injection molding machine are still integrated with the runner. Can be seen in picture number 3.

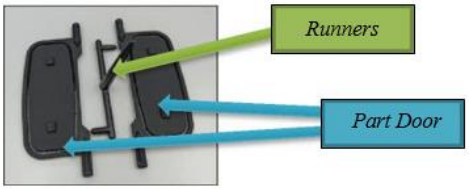


Fig.3 *Part Door* And *Runners*

This resulted in the need for rework by the operator to separate the plastic part and the runner. In the process of rework that is done manually by humans, of course there are no errors that can cause product defects in the form of overcuts. In addition, there will be time needed by operators in the rework process which can extend the cycle time or production time. Therefore, this research was conducted to find out the function of mold modification which can make runners and plastic parts separate automatically after leaving the injection molding machine and the effect on the cycle time in achieving the target output. The results of this study are expected to have an impact on a more productive and efficient production process.

2 Research methodology

This research begins with observing and interviewing related parties and then identifying the causes of the length of the production process and the possibility of defective products due to overcuts. Then make a design for the application of autodegating to the mold door and make modifications to the mold parts. After that, the mold is tested and collects data before and after modification to prove the level of success and the effect of applying autodegating to the mold door. This process can be described in the flow chart in figure 4.

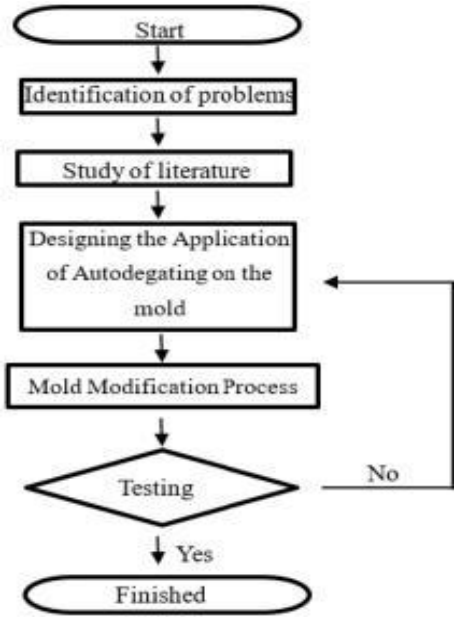


Fig.4 Flow Chart Research Methodology

2.1 Problem Identification

Identification is done by observation and interviews. Observations were made to see directly the production process, in this process the operator still separates runners and parts manually by cutting them with a cutter which affects the cycle time. Interviews were conducted with related parties, namely the production leader regarding daily monitoring on the mold door, it can be seen that there was an overcut found on the part that was recorded on the daily

monitoring. In addition, data collection was also carried out with clerck production to see daily output monitoring during mold running in March. Data can be presented in the form of tables and figures. To improve the production process, it is necessary to modify the mold door.

2.2 Literature Study

The design method refers to a standard plastic mold design, namely the concept of autodegating by creating a delay on the pin runner. The concept that will be applied to this type of mold door is to provide a gap between the ejector plate and the runner pin and add a plate and stopper pin to create a delay.

2.3 Making Design Modifications

In the mold door design, an autodegating system will be implemented, so it is necessary to modify the design before modifying the mold. The following is the mold door design before being modified. Can be seen in picture number 5.

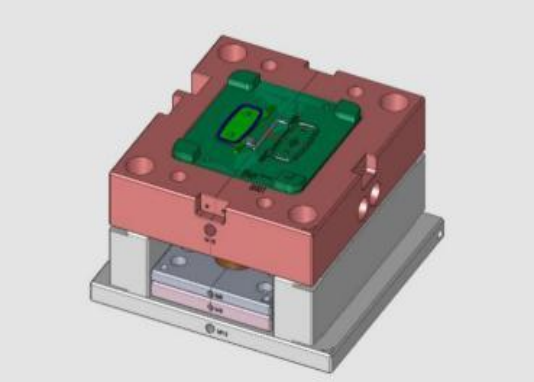


Fig.5 Mold Door core design

The mold door design will be applied to an autodegating system, along with pictures and descriptions of the parts of the mold that will be modified. Can be seen in picture number 6.

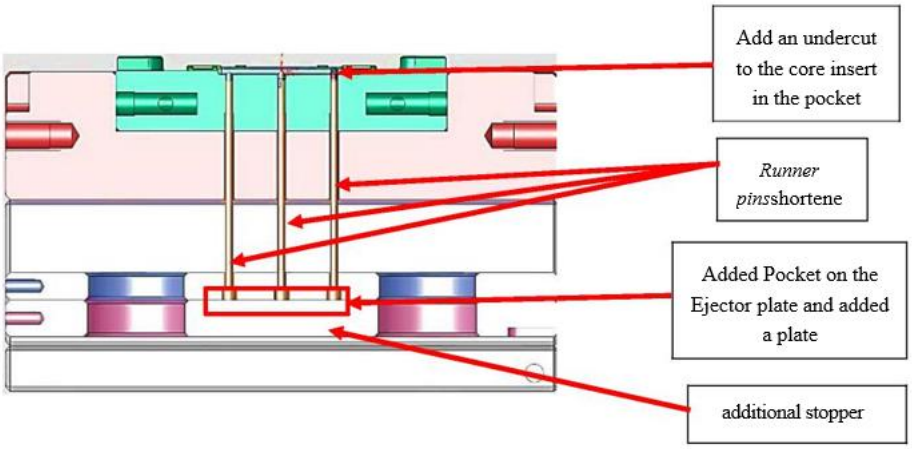


Fig.6 Design Before Mold Door Modification

2.4 Mold Modification Process

The modification process for each part of the mold is as follows:

- *Core inserts*: for the pocket runner, an undercut is added with an angle of 6˚, this process uses a cnc milling machine. Can be seen in picture number 7.

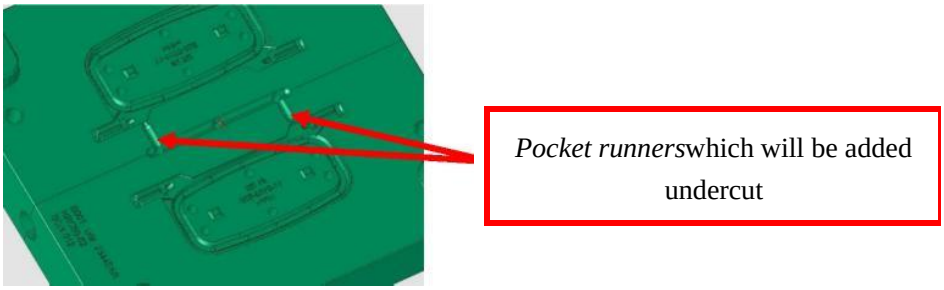


Fig.7 Pocket Runner on the Core Insert

- *Runner pins*: the length of the pin runner is shortened from 155.5 mm to 115.5 mm, this process uses a grinding machine. Can be seen in picture number 8.

Fig.8 Pin Runners

- *ejector plates*: on the plate, a pocket is made with a length of 75 mm, a width of 18 mm and a depth of 6 mm, this process uses a CNC milling machine. Can be seen in picture number 9.

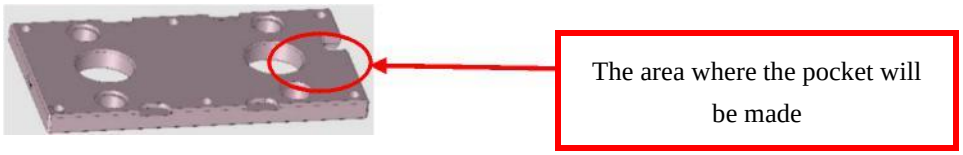


Fig.9 Ejector Plate

- *Ejector retainer plates*: on the plate, a pocket is made with a length of 75 mm, width of 18 mm and a depth of 5 mm, this process uses a milling machine. Can be seen in picture number 10.

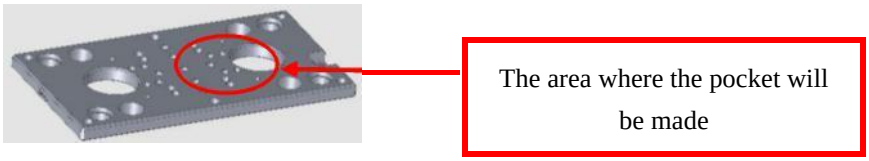


Fig.10 Ejector Retainer Plate

- Additional plates: make plates 74 mm long, 17 mm wide and 8 mm high, this process uses a wire cut machine. Plate can be seen in picture number 11.

Fig. 11 Additional Plate

- Additional stopper pins: stopper pins with a length of 22 mm, pins made 2 pcs using a grinding machine. Pins can be seen in picture number 12.

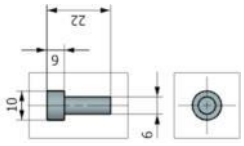


Fig.12 Stopper Pins

After the modification process, the mold is assembled and ready for testing on the injection molding machine.

2.5 Testing

The test was carried out by testing the mold on a 12 ton Haitian injection molding machine. The machine will issue several samples of plastic products for checking. Data in the form of product photos will be presented in a table along with data on daily output results to see changes in cycle time in achieving production targets.

Table 1: Comparison Table Format Before and After Modification

Before modification	After modification
Notes :	Notes :

2.6 Discussion and Report

The mold mechanism in implementing the autodegating system, namely making separate parts and runners, will automatically create a modified design. Next, the mold will be machined and tested on an injection molding machine. The function performance test is said to be successful if the plastic part and the runner removed from the injection molding machine separate automatically when the mold is opened. While the effect on the production process, it is hoped that the cycle time can be reduced due to the autodegating system and there will be no rework process by the operator. Reports in the form of comparisons of daily output data before modification and after modification to see changes in cycle time in achieving target output.

3 Results and Discussion

3.1 Data Collection

At the time of observation, the plastic part of the mold door that came out of the injection molding machine was still attached to the runner. In this process the operator performs a rework process to separate them. All processes are recorded by the leader during hourly monitoring, then the data is reported to the production clerk for key in. The data obtained from clerk production is the daily output of mold doors in January, total running for 6 days for orders of 20,000 pcs, can be seen as follows:

Table 2: Mold Door Daily Output Data for January

date	*Part Name*	*No Machine*	*SHIFT (TIME)*	*Cycle Time*	*Target Quantity*	*Finish Good*	*Reject Over Cut*
January 17, 2023	*door*	M/C 20	1 (22:45-06:45)	34	1694	1511	0
January 17, 2023	*door*	M/C 20	2 (06:45-14:45)	34	1694	1634	6

date	*Part Name*	*No Machine*	*SHIFT (TIME)*	*Cycle Time*	*Target Quantity*	*Finish Good*	*Reject Over Cut*
January 17, 2023	*door*	M/C 20	3 (14:45-22:45)	34	1694	1652	0
January 18, 2023	*door*	M/C 20	1 (22-45-06:45)	34	1694	1682	7
January 18, 2023	*door*	M/C 20	2 (06:45-14:45)	34	1694	1631	5
January 18, 2023	*door*	M/C 20	3 (14:45-22:45)	34	1694	1634	0
January 19, 2023	*door*	M/C 20	1 (22-45-06:45)	34	1694	1678	10
January 19, 2023	*door*	M/C 20	2 (06:45-14:45)	34	1694	1686	8
January 19, 2023	*door*	M/C 20	3 (14:45-22:45)	34	1694	1688	0
January 20, 2023	*door*	M/C 20	1 (22-45-06:45)	34	1694	1685	9
January 20, 2023	*door*	M/C 20	2 (06:45-14:45)	34	1694	930	13
January 21, 2023	*door*	M/C 20	2 (06:45-10:30)	34	1694	580	0
January 21, 2023	*door*	M/C 20	3 (10:30-14:15)	34	1694	791	0
January 21, 2023	*door*	M/C 20	4 (14:45-18:00)	34	1694	578	11
January 23, 2023	*door*	M/C 20	2 (06:45-14:45)	34	1694	1633	5
January 23, 2023	*door*	M/C 20	3 (14:45-22:45)	34	1694	1547	0
January 24, 2023	*door*	M/C 20	1 (22:45-06:45)	34	1694	105	7

It is expected that production results can reach the target quantity faster, so it is necessary to modify the mold to reduce the cycle time when the part comes out of the mold and eliminates the rework process for the efficiency of the production process and avoids parts being rejected over cut.

3.2 Design Making

Implementing an autodegating system in the mold design by adding several components, namely stopper pins and additional plates and changing several mold components such as runner pins, ejector plates and ejector retainer plates. Can be seen in picture number 13.

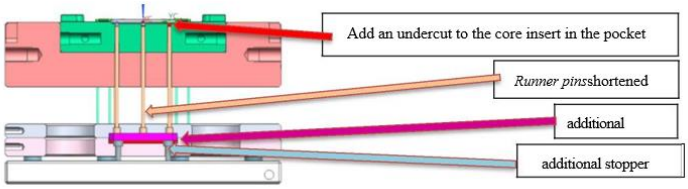


Fig.13 Design after Modification

Design after modification. Can be seen in the following pictures numbers 14 and 15.

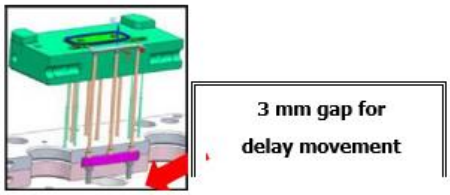


Fig.14 First Position before Ejection

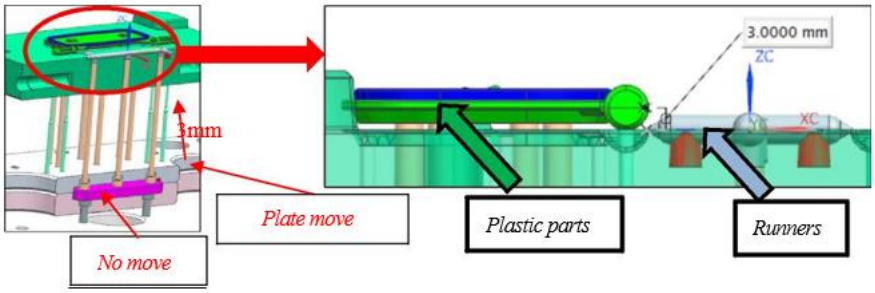


Fig.15 Ejection position up to 3 mm

Figure 15 shows the ejection position of up to 3 mm, the plastic part has been pushed while the runner is still stuck in the mold, this is due to the 3 mm gap in the runner pin plate. This keeps the part and runner separate automatically.

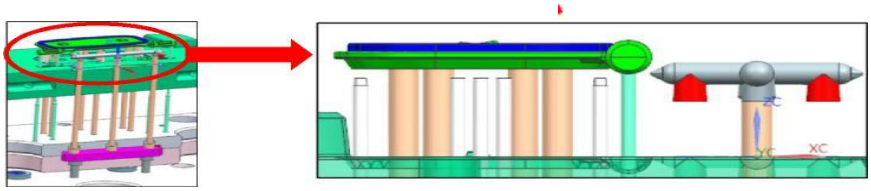
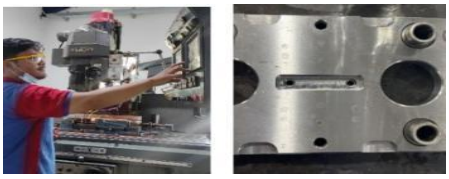


Fig.16 Ejection position after 3 mm

In Figure 16, after 3 mm movement, the part and runner are pushed together with separate conditions. The results of making the mold door design after being modified can be seen in pictures number 17 to number 20.

(a) (b)

Fig.17: (a) Pocket Runner CNC Process and (b) Results after CNC



(a) (b)

Fig.18: (a) Pocket ejector plate CNC process and (b) Results after CNC

(a) (b)

Fig.19: (a) Wirecut Plate Process and (b) Results after Wirecut

(a) (b)

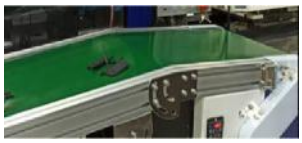
Fig.20: (a) Pin Stopper Grinding Process and (b) Results after Grinding

After the mold part is modified, the mold is assembled and will be tested on an injection molding machine.

3.3 Show the Result Function After Modification

Mold doors modified through the machining process following the design. The design applies an autodegating system to the mold to cut the runner from the plastic part automatically due to a 3 mm delay on the runner pin. After modifying the mold, testing was carried out using a Haitian 12 ton injection molding machine and using PP type material. The following is a comparison of the results of the plastic door parts before and after the mold door modification.

Table 3: Comparison Before and After Modification of Mold Door

Before modification	After modification
 	 
*Note: Plastic part*s comes out of the injection molding machine still together with the runner and the cycle time part comes out of the injection molding machine for 34 seconds	*Note: Plastic parts* coming out of the injection molding machine is separated from the runner and the cycle time part comes out of the injection molding machine for 30 seconds.

3.4 Effect of Mold Door Modification on Productivity

The application of the autodegating system to the mold door makes the plastic part and runner products separate automatically, this has an impact on operator work, cycle time and product quality. The following is a comparison of the mold door before and after modification to see its effect on productivity.

Table 4: Comparison of Influence on Productivity

Before modification	After modification
	
Production process : 1. *Plastic parts* out of the injection molding machine, then taken by the robot and placed on the conveyor. 2. The operator takes the plastic part, then separates the runner and the door part using a cutter. 3. The operator packs the product into the box. Note: when separating parts and runners using a cutter, it is possible that the part will be rejected due to over-cutting.	Production process: 1. *Plastic parts* out of the injection molding machine, then taken by the robot and placed on the conveyor. 2. The operator packs the product into the box. Note: there is no rework process because the runners and parts are separated, the operator can maintain 2 or more machines only for product packing. For quality parts there are no rejects due to overcuts.

Modifications to the mold door also affect the cycle time and the part door output results, which can be seen in the following table:

Table 5: March Door Mold Daily Output Data

date	*Part Name*	*No Machine*	*SHIFT (TIME)*	*Cycle Time*	*Target Quantity*	*Finish Good*	*Reject Over Cut*
March 27, 2023	*door*	M/C 20	3 (14:45-22:45)	30	1920	1760	0
March 28, 2023	*door*	M/C 20	1 (22-45-06:45)	30	1920	1874	0
March 28, 2023	*door*	M/C 20	2 (06:45-14:45)	30	1920	1907	0
March 28, 2023	*door*	M/C 20	3 (14:45-22:45)	30	1920	1911	0
March 29, 2023	*door*	M/C 20	1 (22-45-06:45)	30	1920	1897	0
March 29, 2023	*door*	M/C 20	2 (06:45-14:45)	30	1920	1915	0
March 29, 2023	*door*	M/C 20	3 (14:45-22:45)	30	1920	1897	0
March 30, 2023	*door*	M/C 20	1 (22-45-06:45)	30	1920	1914	0
March 30, 2023	*door*	M/C 20	2 (06:45-14:45)	30	1920	1889	0
March 30, 2023	*door*	M/C 20	3 (14:45-22:45)	30	1920	1910	0
March 31, 2023	*door*	M/C 20	1 (22-45-06:45)	30	1920	1900	0
March 31, 2023	*door*	M/C 20	2 (06:45-14:45)	30	1920	1906	0
March 31, 2023	*door*	M/C 20	3 (14:45-22:45)	30	1920	1874	0

From the data above it can be seen the changes. To achieve production orders of 20,000 pcs before the modification it took 6 days with a total of 17 work shifts, whereas after the modification it took 5 days with a total of 13 work shifts. The level of effectiveness of the production process increased by 6.8%.

4 Conclusion

Based on the performance of the function on the mold door test, with a delay of 3 mm that occurs in the mold door, the part and runner can be disconnected. The results of the tests also had an impact on production productivity, namely the cycle time for removing plastic parts from injection molding machines was reduced from 34 seconds to 30 seconds. In the work process the operator also experienced changes, namely the rework process carried out by the operator did not exist, the parts that came out of the injection molding machine could be packed directly into the box. In achieving the output target, it became shorter from 6 days with a total of 17 work shifts to 5 days with a total of 13 work shifts. The production process has become more efficient and productive with the level of effectiveness of the production process increasing by 6.8%.

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