Modelling of Rapid Injection Moulding by Geneva Mechanism in Plastic Manufacturing

[1]Venkatesulu.T, [2]Dinesh Kumar.T,
[3] Sherin Feno.K, [4]Siva Kumar.P, [5]Karthikeyan.R
Department of Mechanical Engineering,
Panimalar Engineering College

***Abstract* - The manufacturing field in the engineering society is more dependent on production time. One of the most common manufacturing technique is the Injection Moulding. Though it is using widely, it has a problem of time consuming to create a product. To reduce the time consuming, we present a new and faster way of Moulding technique called Rapid Injection Moulding. In this way of Moulding objects, the cooling time of the molten plastic in the mould cavity is replaced with magazine of mould cavities. These mould cavities are operated using Geneva Mechanism(Rotary Path). Once the molten plastic is injected into the mould cavity, the mould rotate itself such that the adjacent mould can be injected. Hence the former mould get enough time for cooling. Depending on the cooling time, number of moulds in the magazine and the radius of Geneva wheel can be adjusted. This method saves most of the time and hence increases productivity.**

I. INTRODUCTION

INJECTION MOLDING:

The process of creating a 3D objects of any shapes of plastics by giving a source through injection process is known as injection moulding. This injection moulding process is also called conventional injection moulding.

RAPID INJECTION MOULDING:

The name itself says that rapid injection moulding which belongs to creating a 3D injected mould parts faster than the existing injection moulding methods.Injection moulding is a manufacturing technique for making parts from thermoplastic and thermosetting plastic materials. The process of creating 3D object of any shapes of plastic by giving a source as molten plastic through injection is known as injection moulding. Injection moulding has gained wide popularity as one of the top choice manufacturing method of production complex shapes. The first injection moulding machines can be dated back as far as 1872. The evolution of technology of Injection Moulding is day by day modifying from initially used technique for injecting, it is used as a plunger to push the molten into the mould. Nowadays ranging from hydraulic, hybrid and electrical.

In this paper, more time consuming areas are noted and modified. By making analysis of time consuming, we came to know that the time is consuming more between the filling of the mould and solidification of the mold. To reduce the time, a modification is done in the mould cavity. The replacement of a single mold cavity into no of multiple mould cavities was done. The mould cavities are placed circumferentially called cavity magazine.

The mould cavity magazine is the rotary element which can be operated by Geneva Mechanism. In this arrangement the filling of the mould is directly proportional to the rotation of geneva wheel.

II. DESIGN OF INJECTION MOULDING

(i) PREPARATION OF GATE:

Gate (or) Sprue is the place where the very thin injection of a molten injects into the mould.There are many types of gates such as standard gate, submarine gate, fan gate and tab gate.

The gate is selected in the case to push the maximum materials in the shortest possible time. For the easy flow, sprue type was selected.

TEMPERATURE DISTRIBUTION FROM INJECTION POINT TO END OF MOULD FILING:

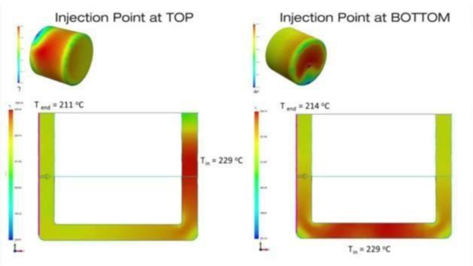


Figure 1-Temperature distribution between the mould cavity

TOP GATE:

In this gate system the mould flows from one top end of the cavity. The difference of temperature at the inlet and the end will be more. The travelling time of the flow of the mould also more.

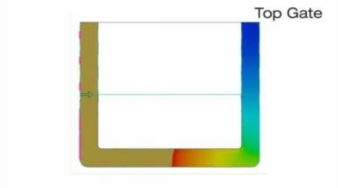


Figure 2-Temperature distribution through Top Gate

BOTTOM GATE:

In this gate system, the mould is injected at the bottom of the cavity in which the mould is evenly supp;ied to the both sides. The travelling time and the length of the mould also less. Here we can reduce the consumption of time.

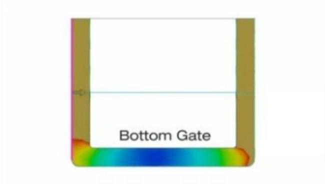


Figure 3-Temperature Distribution through Bottom Gate

(ii) MOULD FILLING TIME CALCULATION:

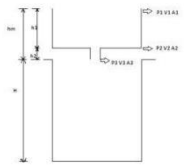


Figure 4-Schematic diagram for mould fill

By Bernoulli's Equation,

We Get,

$$T_f = \frac{A*H}{A_3*V_3}$$

Where,

T_f = Mould filling time (sec)

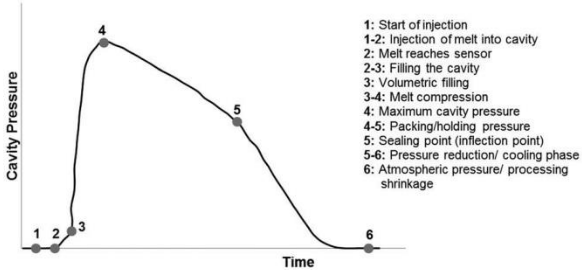
A = Area of the mould cavity (cm^2)

H = Height of the mould (cm)

A_3 = Area of injection (cm^2)

V_3 = Volume of the mould in the cavity (cm^3)

(iii) CHARACTERISTICS OF CAVITY PRESSURE AND TIME CONSUMING:



(Source : Characteristics of energy consumption injection moulding)

Figure 5- Characteristics of Energy consumption

One of the benefits of the proposed model is that the split of the overall injection molding process into energetic steps (melting, Em, filling, Ef , cooling, Ec, and reset, Er, i.e., clamping, ejection) serves to facilitate the understanding and applicability of complex fluid dynamics concepts.

In order to design the cavity magazine and geneva mechanism according to the mould flow initially from injection cylinder, injection point and finally to the mould cavity through the selected sprue gate. We studied the ranges of pressure and corresponding time consuming for the respective regions. In the study we came to know that, at the initial field of the mould, the flow pressure of the molten plastic will be higher at certain period of time i.e., till to the partial fill of the mould and pressure becomes gradually decreases at the end and remains constant. This achieves a even supply of molten to the mould cavity. This characteristics of the studied experiment is shown in the figure 6.

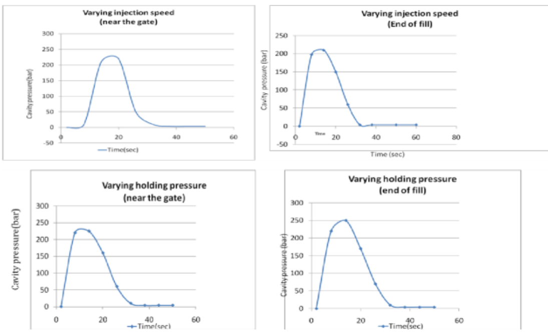


Figure 6- Characteristics

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iv)ORTHOGRAPHIC VIEW OF INJECTION MOULDING UNIT:

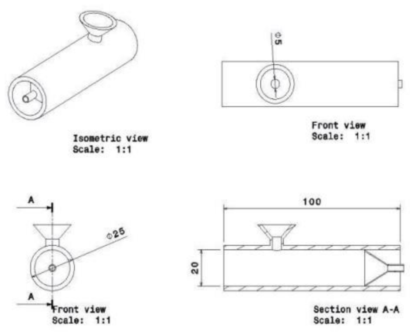

Figure 7-Orthographic view of injection moulding unit

ISOMETRIC VIEW OF INJECTION MOULDING UNIT:

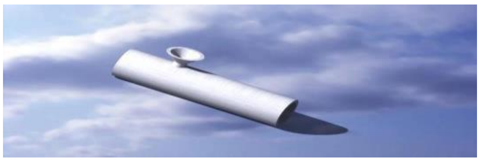

Figure 8-Isometric view of Injection moulding unit

(v) ORTHOGRAPHIC VIEW OF CAVITY MAGAZINE:

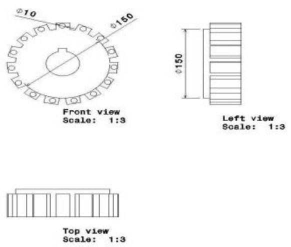

Figure 8-Orthographic view of cavity magazine

ISOMETRIC VIEW OF CAVITY MAGAZINE:

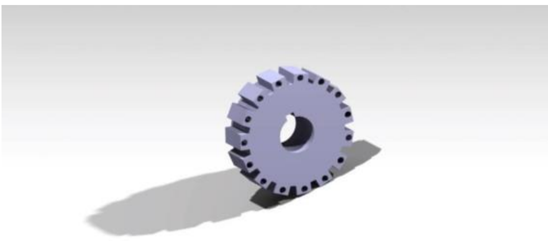

Figure 9-Isometric view of cavity magazine

(vi) CALCULATION OF GENEVA MECHANISM:

For the analysis we have taken assumption as,

Moud cavity = Cylinder

Let,

Diameter of cylinder, d = 8cm

Height of cylinder, h = 5cm

Area of mould, A = 16π

Volume of mould, V = 80π

Discharge, Q = 20π cm^3/sec

Now,

Mould filling time, T_f = Volume/Discharge

$= \frac{80\pi}{20\pi}$ = <u>4sec</u>

Dwell Period = 4 to 5

sec t= 5 sec

<u>Outer Circumference of geneva</u> <u>wheel:</u> D = 120cm + 21 = 141 cm

No of moulds = $\frac{120}{8}$

= <u>15 Moulds</u>

Solidification Time,

$T_{cooling}$ = 15 * One mould time of dwell. = 15* 5

= <u>75 sec</u>

<u>Angle of mould cavity:</u>

By Design Data Book,

We have taken,

α = 12°, r/e = 0.2079

<u>r = 29.97 cm</u>

β = 75°, R/e = 0.97815

<u>e = 144.15°</u>

$\frac{Z+2}{2Z} = \frac{tr}{t}$

Where,

Z = No of mould cavities = 15

t_r= Resting time

t = Total time

Now,

$\frac{15+2}{30} = \frac{17}{30}$

= <u>0.567</u> <u>t = 8.823 sec</u> <u>Crank Speed:</u>

Crank Speed, n = $\frac{60}{t}$ rpm

$= \frac{60}{8.823}$

<u>n = 6.8 rpm</u>

III.RESULTS AND DISCUSSION

Thus, studying the previous methods of injection moulding and their industrial requirements in plastic manufacturing. We can understand the parameters which involving in the plastic injection moulding and came to know that the factors can consume the time in the solidification process. Through the Rapid injection moulding by geneva mechanism, it can be know that we can improve the overall productivity rate by 60% by reducing the lead time of previously used methods and cost efficient. Thus it is shown that overall time consuming is reduced by comparing Rapid injection moulding and Conventional injection moulding in the following chart.

TIME CONSUMING AREA IN RAPID INJECTION MOULDING:

In this paper, thus we came to know that the time which can be saved in the solidiication area by developing n no of mould cavities according to the need and the mould filling time can be achieved. The comparison of time between the existance injection mouldding and the rapid injection moulding is shown in the following figure.

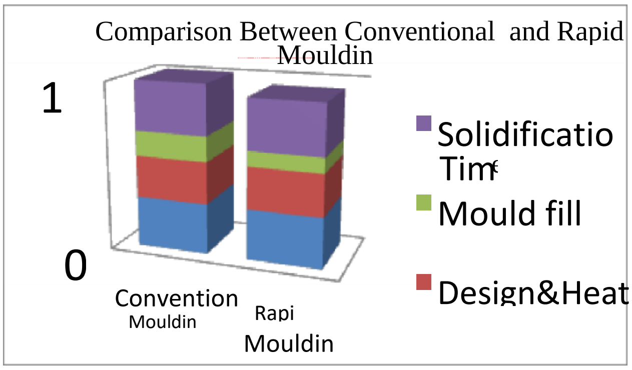

Figure 10-Comparison between Rapid Vs Conventional Injection Molding

IV. CONCLUSION

The research presentation hence was able to showcase the effectiveness of the proposed energy model with a study representatuve of small/medium manufacturing environment. The calculations in this paper is assumed for the prototype model. This technique can be used further according to respective injection moulding sizes and the requirement.

In overall, an analysis of the observed advantages and disadvantages for the use of multiple cavity by geneva mechanism is summarized below.

- Enables time consumption of real time moulding than the older injection moulding equipment (Significant Upgrade).
- Productivity will be increases, since it is the most requirement in present manufacturing sector.
- Easy and simple way of mechanism is used.

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