Improving the Efficiency of Injection Moulding Processes

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Abstract— Now Days most of the Plastic materials are proceed by process called Injection Moulding, from smallest components to entire body panels of cars. During this process plastic are resins pellets are heated until they melt. The melted plastic is introduced under pressure into mold. There are three processes for increasing energy efficiency in injection moulding – Melting the polymer, forcing in to mold and then cooling down the polymer. Unlike earlier plastic manufacturing processes advanced technology have led to improved in plastic manufacturing now plastic can be recycled and eco-friendly plastics are being created. Important parts of the plastic Injection Moulding process are process parameter settings such as hold time and screw plasticizing time. Its give the direct control over part quality and cycle time.

Keywords: Injection Moulding Processes, Conventional and Conformal Cooling Channels, Hydraulic machines

I. INTRODUCTION

Plastic industry is one of the world leading and fastest growing industries. Almost every product that used in daily life that include the usage of plastic material and most of the product produced by plastic injection moulding process. Injection Moulding is manufacturing process to producing parts by injecting the material. This manufacturing process to generate products with various shapes, size with low cost. And is cyclic process followed by filling, packing, cooling and ejection. Mainly it can be performed with host of material like thermoplastic, thermosetting polymers including metals (that process called Die- Casting). Material are fed through heated barrel, mixed (helix) and forced to mould. Parts to be injection moulded must be very exactly designed to make the moulding process, the material used for the part depending upon the shape and features of parts.

To design and process of injection mould parts with desirable properties is a valuable process influenced by empiricism and including modification of tooling. To prepare the new mould design, designer must know about some valuable points to bypass mistakes before going further process. i.e. material usage, correction shrinkage of martial, number of cavities.

II. MODE OF PROCESSING

There are different kind manufacturing process and techniques are available to produce varies parts, but there two type of machine are mostly used to produce various parts.

1) Hydraulic machines
2) Electric machines

Hydraulic machines are still used for moulding process because of it's cheaper than electric machines. But traditional hydraulic machine have less efficiency than electric machines because its consume more energy in even idle cases also. But electric injection moulding machine consume energy only whenever its need for action. Electric machine are digitally controlled while hydraulic machine driven by hoses, valves and pipes its leading to much of lost energy. All the electric machines have the benefit of more speed and more efficient during process because of independent motors control for everything from infection to extruder to clamping and ejection.

That process turned to be a difference from hydraulic machine has lot components and fluids that have to come up to temperature. These allow the electric machine less start up and scarp run as well as saves the money. This all leads to reduce the energy consumption around 60 to 70 percentages and one of the most benefits of all the electric machine is there no change leakage that means less down time and martial contamination because of there is no oil or filters.

Although electric machines may be more expansive than hydraulic machine, the savings over time are dramatic, justifying the investment. This maximized performance allows the companies that use all electric injection moulding machines to deliver the best products and solutions for manufacturing units.

III. METHODOLOGY

Basic manufacturing process of injection moulding plastics goes down into barrel or chamber via hopper then plastics are melted in high temperature using heater bands and the frictional action of a reciprocating screw barrel. The moulded plastic injected through nozzle into mould cavity where its cools and hardens to the configuration of the cavity. The mould tool is mounted on movable platen when the plastics has solidified from movable platen plastics (part) is ejected out using ejector

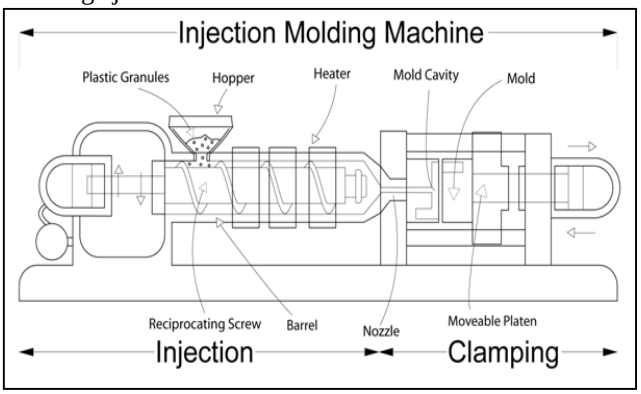


Fig. 1: Injection Moulding Process

Most of manufacturing parts in injection moulding process made by thermoplastic material only, Thermoplastic are polymers that can be frequently or quickly molted or softened by heating and solidified by cooling. Physical change rather than a chemical change takes place during creation of thermoplastic material and most important thing depending upon the application or parts thermoplastic materials used

1) ABS - Acrylonitrile Butadiene Styrene
2) Polyethylene

3) Polycarbonate
4) Polypropylene
5) Polyamide(Nylon)
6) High Impact Polystyrene

Depending upon the application, thermoplastic material will be used. Process is used to produce variety of products, 75% of energy cost goes towards electricity, and there are some processes available to increase the efficiency of moulding process as well as reduce the electricity cost.

A. Actionable Points

The cycle time of the injection moulding process divided into injection time, cooling time and resetting or changeover time. Cycle time is total time is required to completed injection moulding process. The cycle time of a part can be reduced by decreasing cooling time which can be attained by the uniform temperature distribution in molded part which helps in nimble dissipation of heat. Conformal cooling channel design is solution to the problem which basically conforms to the shape of cavity in the molds.

Cycle time is splitted into 1) Fill Time (2% to 5%), 2) Packing Time (12 to 15%), 3) Cooling Time (65 % to 70 %), 4) Mold Open Time (8% to 10%)

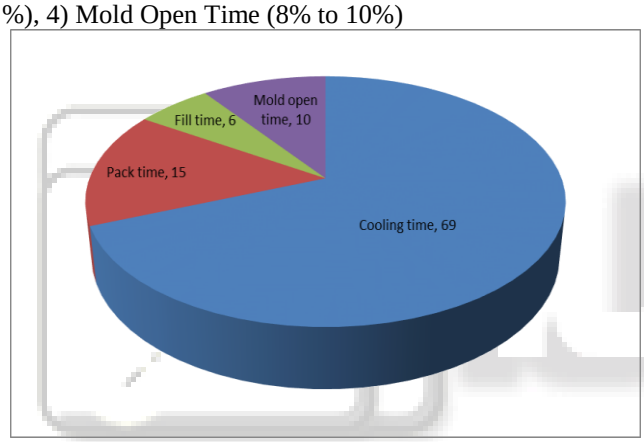


Fig. 2: Division of Cycle time

Total CYCLE TIME T for injection moulding T = Td + Ti + Tc

Td - Intermediate Time

The Sum of the time required to open and close the mold, to remove the molded product from the mold, to place inserts in the mold and to apply agent

Ti - Injection Time

The Sum of the time required to fill the mold cavity with mold polymer and to refill the mold with material to avoid voids and sink marks

Tc - Cooling Time

The time required to coagulate the molten polymer in cavity and cool to a temperature and solidify within the mold so that the ejector will not cause deformation or strain in the molded product during part release.

Formula used to calculate the Tc –

$Tc = -0.2435 * L^2/\alpha * \log \{\pi/4 * (\theta - \theta s) / (\theta o - \theta s)\}$

L – the Maximum thickness(m) of the molded product

α – Temperature conductivity rate of the polymer

θ – Temperature of the polymer in its center at Tc

θs – Mold temperature

θo – Initial Temperature of the polymer

– From this cooling time most important stage in cycle time it's consume more power than other stages. If change or reduce the cooling time of injection moulding machine depending upon the part which we have to injected to save or reduce the power.
– While cooling process, location near the cooling section more was cooling than location away from the cooling section. Why because different temperature causing material thermal stresses. Significant thermal stress can cause the warpage problem
– Cooling channel diameter should be more thicker than wall thickness
– And packing time or hold time it's a when the pressure is applied to the material melt to compress the material and to force the material to mould. The time taken to melt the polymer to compress it huge impact in power consumption for high end parts.
– Then melt is injected into the mould at flow rate and varied pressure. The energy consumed during injection is proportional to Pressure and flow rate
– The power is need for the various movements in the machine

- Mould open/close and clamp
- Injection unit movement
- Screw rotation

The analysis of experiments showed that more option available to reduce energy consumption. Without put any additional process or change, while most injection molders try to optimizing process settings to achieve two to three percent cycle time reduction

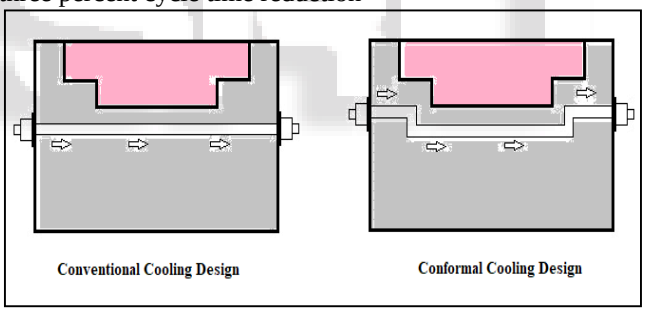
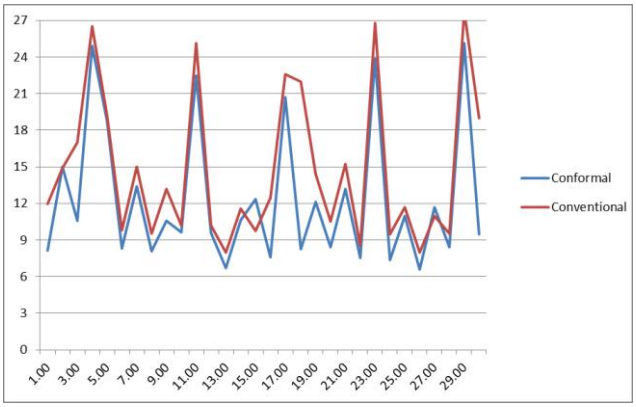


Fig. 3: Conventional and Conformal Cooling Channels

B. Analysis

As per analysis report conventional cooling design consuming more energy than conformal cooling model, graph and table shown in below



C. Energy Consumption Comparison Table

S.No	Time	Conventional Method	Conformal Method
1	1.00 pm to 3.00 pm	6.7	5.9
2	3.00 pm to 5.00 pm	3.5	2.7
3	9.00 am to 11.00 am	6.1	5.2
4	11.00 am to 1.00 pm	3.4	2.4
5	1.00 pm to 3.00 pm	4.2	3.3

IV. CONCLUSIONS

Thereby increase the bottom line process to select the best cooling channel design based upon minimum time to reach ejection temperature, uniform temperature distribution and minimum warpage of part. From this paper it is being concluded that still the conformal cooling line produce better cooling as compared to conventional cooling lines as yet using the additive cooling line with conformal cooling channels provides even more uniform cooling and takes less cooling time.