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Review: Plastic Injection Molding Process, and its aspects

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Abstract: Plastic injection molding process is a complex process and behavior of the polymer inside the mold is difficult to describe because it depends upon several factors such as material properties, geometry of the product, process parameters selection, mold characteristics, runner shape, gate geometry and machine set-up. Lack of skills and selection of inappropriate factor will lead to defective product. Although use of simulation software has replaced conventional trial and error method for design and analysis but they have limitations. So this review paper deals with the past research work done on plastic injection molding process and presents an overview about the process and issues which are in focus of researchers. For this purpose, plastic injection molding processhas been categorized into four major aspects like material, product, process parameters and mold attributes which require attention before and at the time of production. This paper also deals with role of simulation in plastic injection molding process. The aim of this review work is to provide groundwork information to the researcher about the process. Factors which arein spotlight of researchers and to identify the factor which can be easily controlled and modified to optimize the process in term of quality, cycle time and defects.

Keywords: Cycle Time, Molding, Polymer, Process

Introduction

Due to some of the distinguish characteristics of plastics such as weight, strength and rigidity etc. made them to prefer over metal in many fields such as automobile, pharmaceutical, bearing etc. Processing techniques of plastics is similar to those of the metals[1]. It includes injection molding, blow molding, casting, extrusion etc. Among all these methods, possibly injection molding is the most significant for industry. Almost all the plastic parts are injection molded, whether they are toys, electrical appliances, automobile parts or home-fixtures, watches, computers, etc. [2]

Plastic injection molding process performed in the following manner:

1. Selection of product and resin for production.
2. Preparation of mold having suitable characteristics like heat transfer capacity, provision of cooling channel etc.
3. Selection of appropriate process parameters based on history and experience of operators.
4. Injecting the melt resin into the mold and allowing it to solidify.
5. Taking out the final product from mold [3].

The final product taken out from the mold may be subjected to some issues like cycle time, cost and defects like shrinkage, warpage, weld-lines, air-traps etc. These issues may be due to the procedure followed in the production. Broadly, it includes polymer properties, product shape and size, machine set-up and specification, processing parameter, mold materialproperties, cooling channels design, channel location, runner shape, runner length, gate shape and sizeetc[4]. So, plastic injection molding process is a complex process and for any manufacturer, product quality is the basic issue. Researchers and industries always try to find the suitable environment which will guide them to the production of good quality plastic products.[5]

Simulation of plastic injection molding process: With advancement in the technology, many simulation softwares are available in the market. Simulation software creates a virtual environment for the production and analysis of a product. They are frequently used in the automobile sector, medical sector, manufacturing sector etc[6]. Plastic injection molding process can be

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simulated through two famous softwares which are commercially available. One is Moldflow Advisor and another is Moldflow Insight. They can perform simulation on both 3D and 2D geometry. Both are capable of performing filling, packing, and cooling analysis. They are also capable of performing warpage analysis. These softwares can advise about design, result and cost [7].

Objective of the study: Plastic injection molding process is widely accepted as a rapid manufacturing process but still industries are struggling with problems like defects, cycle time, and cost. For this purpose many researcher and industries have been trying to optimize the process through simulation and various techniques like Taguchi, ANOVA, S/N ratio, ANN and LCA, GRA. This review work is done to

1. Identify major issuesof plastic injection molding process.
2. Provide preliminary information to the researcher about the process and its aspects.
3. To show the role of simulation softwares in the processing of polymer.

Methodology: As discussed in introduction, injection molding process performed in five steps. Out of five, first four steps of the production do requires attention. Polymer properties, product shape and size, machine set-up and specification, processing parameter, mold material properties, cooling channels design, channel location, runner shape, runner length, gate shape and size etc. were issues addressed by the researchers in past research work on injection molding process. Based on this, four major aspects of injection molding process have been considered like Material, Product Attributes, Processing Parameters and Mold Attributes. According to this, past research work have been categorized in those factors. These are discussed as follow.

Literature Review: Based on the categorization, literature review has been discussed in four sections

Material: Material selection plays a key role in appearance and performance of the product. Material properties which satisfy the need of the product selected. It solely depends upon the experience of the operator and past history of the product. Selection of polymer depends upon the area of application of the product. Properties of polymer like density, viscosity, coefficient of thermal expansion and compressibility plays a crucial role in quality of the product. Selection of polymer is done on the basis of history of the product and knowledge of operator. Past research work done on the material properties, material behavior inside the mold, orientation related and mechanical properties of product included in this section.

Fig: Product Design (Multi Cavity System)

S.No	Aspects of PIM	Area of past research work based on
1.	Material	Polymer properties like fluidity, strength, effect of temperature on properties, flowlines, temperature distribution, rheology etc.
2.	Product Attributes	Product weight, thickness, shape, profile, application etc.
3.	Mold attributes	Mold shape, size, material, application of cooling channels, cooling channel shape, size, position, type

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		runner shape, size, length, gate type etc.
.	Processing parameters	Process parameters like injection pressure, melt temperature, packing pressure, machine type and specification

Year	Issue	Material	Application of simulation	Ref. No
2005	Performance of Bakelite and nylon-6 on injection and compression molding process	Bakelite and Nylon-6	No	8
2014	Effect of additive on the performance of ABS, PP and PVC for minimum warpage	PP, ABS and PVC	Yes	9
2013	Determination of flow length for different materials	ABS, PC and PA 6.6	No	10

Product Attributes: Product geometry and its attributes: Some of defects like shrinkage, short-shot, warpage caused due to geometry and profile of the product. Geometry of product is decided by the market demand and existing product characteristics. This section includes research work which was carried out on product thickness, design based work etc.

Mold attributesMold design and its attributes: Mold is prepared according to product but material selected for mold plays a crucial role in quality of the product. Beside this location of runner, gate and cooling channel is also very important Mold design and material directly control the heat transfer capacity of the mold, cooling time, cycle time and application of cooling channel. Research on runner, gate and cooling channel design, dimension included in this section.

Year	Issue	Product Attributes	Application of simulation	Ref. No
2014	Production of micro optical devices	Thickness	No	11
2013	Shrinkage and warpage problem in product	Thickness	Yes	12

Year	Issue	Mold attributes	Application of simulation	Ref. No
2015	Analysis of gate vestige	Gate	No	3
2014	Determination of gate location for material selection	Gate	Yes	4
2014	Determination of optimal gate location for mold filling	Gate	Yes	5
2013	Determination of gate location	Feeding system	Yes	6
2013	Comparison of cooling channels	Cooling Channel	Yes	7

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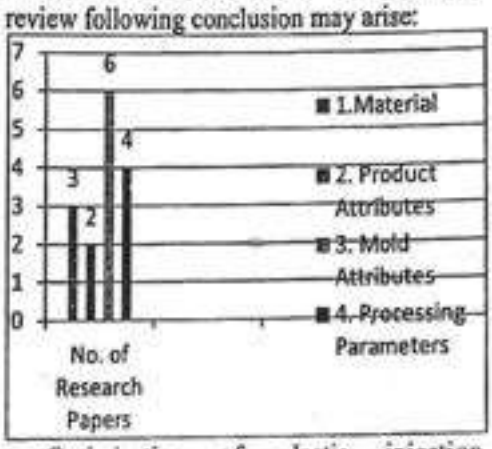
2013	Comparison of mold design on basis of environmental impact	Mold	No	8

Processing parameters: Processing parameters: This section includes research work done on process parameters except runner, gate and cooling channel. Parameters control the internal environment of the mold. Levels of parameters depend upon the machine type and specification. It includes melt temperature, mold temperature, injection pressure, and packing pressure etc. Selection of optimum level of process parameters relies upon the operator and available history of the product.

Year	Issue	No. of parameters	Significant parameters	Application of simulation	Ref. No
2015	Shrinkage control	5	Melt temperature	Yes	9
2013	Shrinkage in the product	3	Injection pressure	Yes	0
2013	Use of hybrid ANN-ABC approach	5	Not Mentioned	Yes	1
2010	Optimum level of process parameters	9	Injection pressure, Packing Pressure	Yes	2

Conclusion: Due to limitation, only few references are given which shows the area of interest of the researchers. Through this review following conclusion may arise:



- Optimization of plastic injection molding process can be done through simulation but they need to be validated. This can be used to identify the effectiveness of the simulation software.
- Optimization of this process in terms of material part is limited due to dependency of material on the application of the product and also due to increased no. of experiments
- It is easy to optimize the process through selection appropriate process parameters and modifying them. It is cost effective and less time consuming.
- Optimization of product can be achieved through proper application of runner, gate and cooling channel.

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