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INTERNATIONAL JOURNAL FOR ENGINEERING APPLICATIONS AND TECHNOLOGY

A Review on Study of Injection Moulding Process & Advancements in the field of Plastic Injection Moulding

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Abstract **-The aim of this review paper is to represent a study of injection Moulding process & advancements in the field of plastic injection Moulding. Plastic injection Moulding is a complex, continuous & sensitive process which is widely used for manufacturing plastic parts using both thermoplastic and thermosetting plastic materials. Presently, plastic industries are under great pressure due to the globalization of the market, The short life cycle of the product & increasing diversity. The high demand of product quality can be fulfilled by adapting various advanced technologies like CAD/CAM/CAE, concurrent engineering and so on for the development of the injection moulded part. This paper covers study of all these aspects related with injection Moulding & new trends for the same**

Keywords**—Plastic injection Moulding, thermoplastic material, thermosetting plastic material, CAD/CAM/CAE, concurrent engineering.**

I. INTRODUCTION

Plastic industry has been growing rapidly in recent years. The growth will be accelerated by the tendency of substituting plastics for metal, which is appearing throughout the world. Injection Moulding is the most common and versatile process for mass production of complex plastic parts with good dimensional tolerance. It is a process by which plastic pellets are melted and injected into a cavity to form a complex three-dimensional part in a single operation. The process includes the injection or forcing of heated molten plastic into a mould which is in the form of the part to be made. Upon cooling and solidification, the part is ejected and the process continues. The injection Moulding process is capable of producing an infinite variety of part designs containing an equally infinite variety of details such as threads, springs, and hinges, and all in a single Moulding operation.

The Moulding may cause defects and its processing offers a challenge during its development phase. The cost of the mould is high and any process that is not optimized renders heavy overheads during its development cycle and production. So designing the mould which ensures best suitability for the features on the component with smooth flow of molten plastic is very important part of development process. There are a lot of limitations in the traditional process of mould design and manufacturing. With the development of the science and technology, CAE technology is applied widely in the process of modern mould design and manufacturing. The results of CAE simulation analysis of injection Moulding can provide reliable and optimized reference data for mould design and manufacturing. Applying CAE simulation analysis technology of injection Moulding can not only increase the probability of success in mould test but also improve greatly the quality of mould design and manufacturing.

A. HISTORICAL BACKGROUND

As a result of extensive research, Development of the process of injection Moulding began in the late 19th century with a modified form of existing die-casting machines. A single-action hydraulic injection machine was designed in the U.S.A. in 1870 by Hyatt. This process was adapted for covering metal and wood parts. The material was cellulose nitrate and was extruded in its plastic state round a core contained in a cavity and allowed to cool in the cavity. [1]

The process of injection Moulding known today began in the early 1920″s. At that time, cellulose acetate was first used to make a solid part. Arthur Eichengrün developed the first injection Moulding press in 1919.Heating cylinder design was first recognized in a patent issued to Adam Gastron in 1932.The industry expanded rapidly in the 1940s because World War II created a huge demand for inexpensive, mass-produced products. In 1946, American inventor James Watson Hendry built the first screw injection machine, which allowed much more precise control over the speed of injection and the quality of articles produced. This machine also allowed material to be mixed before injection, so that colored or recycled plastic could be added to virgin material and mixed thoroughly before being injected. [1]

In the 1970s, Hendry developed the first gas-assisted injection Moulding process, which permitted the production of complex, hollow articles that cooled quickly. This greatly improved design flexibility as well as the strength and finish of manufactured parts while reducing production time, cost, weight and waste. [1]

II.LITERATURE REVIEW

Plastic is one of the most versatile materials in the modern age which is widely used in many products in different shapes which are moulded through the application of heat and pressure. Injection Moulding has become the most important process for manufacturing plastic parts due to its ability to produce complex shapes with good dimensional accuracy. The injection Moulding process involves feeding raw material, plasticize the raw material, fill the mould, packthe mould, hold pressure, cooling of mould and lastly opening of mould and Part ejection. [2]

The main factor in the injection Moulding are the temperature and pressure history during the process, the orientation of flowing material and the shrinkage of the material. The raw material is generally fed through an angular type sprue channel which feeds the resin pellets forward inside the heated barrel. [4] To start-up a new mould design, the designer should know some important points to avoid some mistakes before going further. i.e., Product outlook design, material usage, correction shrinkage of the material, number of cavities and selection of mould base. In injection Moulding, there is an optimum gate size and it should large enough for suitable fill rate and small enough seal off and prevent back flow or over packing [3].

Traditional trial runs on the factory floor can be replaced by less costly computer simulations. Now a day″s, research on optimizing the plastic injection Moulding process has developed a lot. CAD/CAE tools are used to produce an optimal mould gating design using Catia and Mould flow applications. The mould flow analysis helps in reducing costs and time and also prevents other defects occurring in the process [3].

III.PLASTIC INJECTION MOULDING

"Plastic Injection Moulding is a manufacturing process for producing parts by injecting material into a mould. Injection Moulding can be performed with a host of materials, including metals, glasses, elastomers, confections, and most commonly thermoplastic and thermosetting polymers."

A. INJECTION MOULDING MACHINE:

Injection Moulding machines are manufactured in many designs and configurations based on their functions and applications. There are various types of injection machines available ex. Hand injection Moulding machine, plunger type injection Moulding machine and screw type injection

Moulding machine etc.

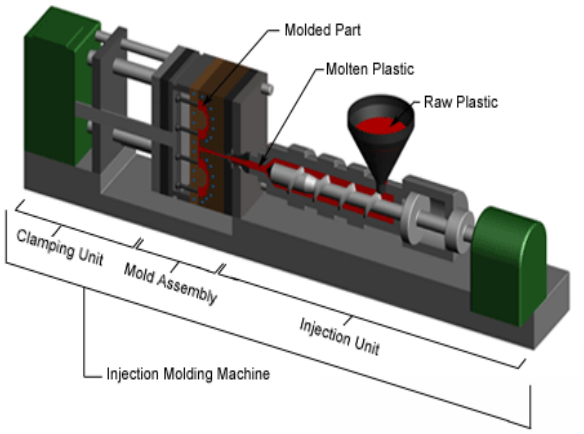

Fig 1 Injection Moulding Machine

The injection Moulding machine consists of three basic units as shown in Fig 1:

- The machine base unit,
- The injection unit, and
- The clamp unit.

B. INJECTION MOULDING CYCLE

Following are the steps involved in the injection Moulding process:

1.Close The Mould – After clamping the mould on injection Moulding machine, close the mould by hydraulic actuators. As the mould closes the screw begins to move forward for injection.

2.Material Injection – The solid plastic material is fed into an injection Moulding machine, heated and then pressed into the mould. In injection Moulding, plastic pellets or granules are fed from a hopper into a heating Chamber. A plunger or screw pushes the plastic through the heating chamber, where the material is softened into a fluid state.

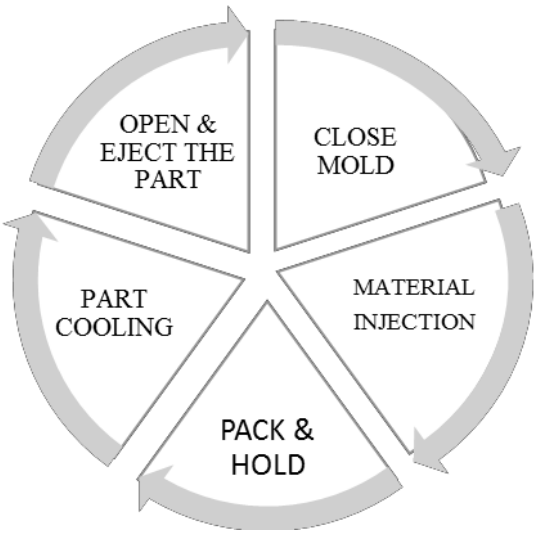

Fig 2 Injection Moulding Cycle

3.Pack and hold – the cavity is packed as the screw continuously moves forward. Then plunger is hold for some time

4.Part cooling – the cavity cools as the gate freezes off & the screw begins to retract to plasticize material for the next injection.

5.Open & Eject – Once the plastic cools to a solid state, the mould opens and the finished part is ejected.

C.MATERIAL SELECTION FOR INJECTION MOULDING:

It is very important to ensure that the correct materials are specified in all new injection MOULD designs. Use of incorrect or inappropriate materials can lead to poor MOULD performance in production and to early failure of the tool.

Material selection depends to a large extent on functional constraints of the parts. Ideally, while selecting the material for mould design, following properties are considered:

- Good machining properties
- Ease of heat treatment where hardening is required
- Good toughness and strength
- Good resistance to heat and wear
- Good fatigue resistance, corrosion resistance
- High thermal conductivity for effective water cooling

Unfortunately, in practice no single material will exhibit all these characteristics and therefore a compromise has to be reached depending on the type of tool design being employed. Generally, materials like Acetal, Nylon, Polypropylene(PP), polyethylene, ABS are used for injection Moulding. [1]

D. Types of Thermoplastic Injection Moulds:

The Moulds are the most important component of the injection Moulding process. It will determine the finish size of the parts that is produced, the surface finish of the final Product and dictate just how well the injection Moulding process will run.

Basically the injection Moulds are classified as:

1.Two plate Mould:

The two plate mould is most widely used. It has a conventional runner system at the mould parting line, with a single drop from the sprue to the runner. It is used for simple parts requiring limited cam actions. The parts are usually ejected while attached to the runner and is gate design dependent and limited to edge gating. This is less costly than three plate and hot runner Moulds and has fewer restrictions for cooling channel layouts. It is also easy to maintain. [6]

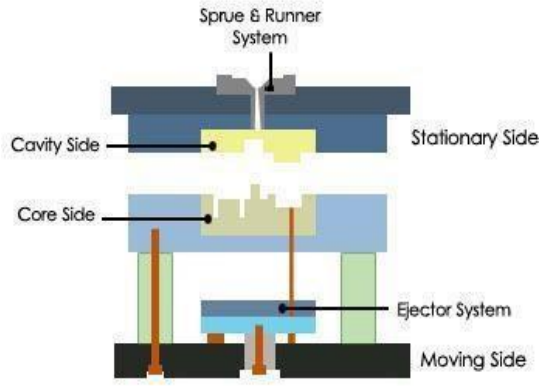

Fig 3 Two Plate Mould

The advantages of the two-plate Moulds are:

- Low fabrication cost.
- Simple mould design.
- Easy to set injection Moulding machine parameter during Moulding.

The limitation of two-plate Moulds is:

- The gate area can be seen clearly after cut.

2. Three-Plate Mould:

The three - plate mould is becoming more widely used, with gate placement not restricted to the edge of parts. It uses separate plates for the runner system and cavity/core. The runner systems can be down-sized, thereby obtaining shorter flow paths. It uses conventional ejection techniques, with minor limitations on cooling channel placement. Although more expensive than two plate Moulds, it can run automatically, with no operator required for part/runner separation. [8]

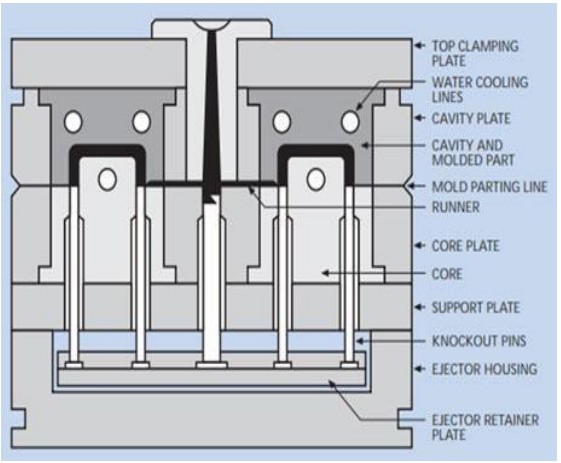

Fig 4 Three Plate Mould

The advantages of three plate Moulds are:

- The runner is automatically separated from the part during mould opening.
- The part cycle time can be reduced. (No need to cut the gate).
- Reduce production cost.

The limitations of three-plate Moulds are:

- High cost of tooling fabrication.
- High maintenance cost of mould.

F. ADVANTAGES OF INJECTION MOULDING PROCESS

Injection Moulding process has following advantages:

- Parts can be produced at high production rates.
- Very small parts which are almost impossible to fabricate by other methods can be easily manufactured.
- Parts requires little or no finishing.
- Close dimensional tolerances can be achieved easily.
- Choice of desired surface finish and colors.
- Economical process.

IV.RECENT TRENDS IN THE FIELD OF PLASTIC INJECTION MOULDING

A.CAD/CAM for Mould Design

In the plastic industry, CAD/CAM has emerged to the point where it now shows the promise of being one of the most significant technological advances of the century. CAD/CAM is enabling the creative energies of plastic part and mould designers to be spent in producing better designs in a shorter time period rather than in doing repetitive mould design tasks. CAD/CAM technologies are normally used for the numerically controlled machining technology to fabrication for the Moulds and also its ability to create three-dimensional product models in the data base and to generate automatically. Also, CAD/CAM can help designers to speed up design for the plastic part and mould design process and reduce the long lead-time. Easy for users to redefine for part geometry which can enhance quality in the mould design by reducing in the number of errors. [1]

B. Computer Aided Engineering (CAE) Simulation

Computer simulation is emerging as an approach to improve productivity and quality of thermoplastic moulded parts. CAE is proved to be useful to obtain geometrically sound Moulding. [4] CAE analysis involves the numerical simulation of a variety of actions on the part. It provides the response of the parts to load, heat or cold soaking and also gives the functional relationship between parts. CAE programs divides the part into smaller entities, called mesh elements. Although not being a part of development of the part drawing, CAE often uses CAD drawing for generating the mesh. Actual execution of the simulation program depends on the number of nodes in the mesh, particular functions that are being modeled and the power of the computer. Motions between parts can be checked for assemblies using CAE Simulation. Thermal expansion and contraction due to hot or cold soaking can also be checked. [8]

C. Computerizing Injection Mould

One of the most important improvements to the Injection Moulding Industry is the advent of the computerized injection mould. This allows the mould process to be fully automated. The injection machine has sensors that allow the computer to control its actions, so that the adjustments can be made on the go. The result is reproducible quality and steady output. Since the process can be fully automated, there is no longer a need for an operator, allowing for reduced costs of manufactured parts. This translates to cost savings further down the manufacturing stream, and ensures that injection mould technology remains competitive with 3Dprinting, which is in many cases still prohibitively expensive.

D. Use of Energy-Efficient Drives

Another trend ensuring that the Injection Moulding Industry remains competitive is the introduction of energy-efficient drives. It results in massive energy savings for manufacturers. The more energy efficient the machines are, the more likely manufacturers are to continue using them, as both the reduced cost of operation and increased output produce favorable economics for the manufacturing plant. An added benefit of reduced energy consumption is, of course, the increase of sustainability within the industry. Many manufacturers would like to market their product as green, and lowered energy can assist in that regard.

V.CONCLUSION

In this review paper, the process of plastic injection Moulding is explained in detail along with advancements in the field of plastic injection Moulding. There are a lot of limitations in the traditional process of mould design and manufacturing. With the development of the science and technology, CAD/CAM/CAE technology is applied widely in the process of modern mould design and manufacturing. The results of this technology provides reliable and optimized reference data for mould design and manufacturing. Along with this, Use of Energy-Efficient Drives and Computerizing Injection Mould reduces cost of operation and increases output produced.

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