A Study of Mold Flow Analysis Of Three Phase Meter Box Using Plastic Advisor- Part -1

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***Abstract*—Injection molding is the most widely used method for the production of intricate shape plastic parts with good dimensional accuracy. The current plastic industry is under great pressure due to the globalization of the market, the short life cycle of the product, increasing diversity and also the high demand of product quality. To meet such requirements it is very important to adopt various advanced technologies like CAD/CAE/CAM, concurrent engineering and so on for the development of the injection molded part. While doing this manufacturing process we have to face some problems in filling process, clamping, cooling, and amount of material to inject into the cavity area. Due to the above problems there is wastage of material, time, poor component quality. In this study we are conducting mould flow analysis by varying processing conditions for different materials. Processing conditions used in this project are Material melting temperature, mould temperature, Maximum machine Injection pressure, velocity/pressure switch-over by volume, injection time, Machine clamp open time. Materials used are P.P, and ABS**

Keywords—Injection molding,mold flow analysis,optimum time,Injection time.

INTRODUCTION

Injection molding is a process that forces molten plastic through a nozzle into a mold cavity. The mold cavity can initially be empty or contain an object to be encased by the plastic. Figure 1 shows a simplified drawing of an injection molding machine. The plastic is fed into the machine as granules. A screw-type plunger transports the granules through a heated barrel towards the nozzle. Along the barrel there are typically three heating zones called rear, center, and front. The front zone, next to the nozzle, is the hottest. On the way to the nozzle the plastic granules soften and become a homogenous mass, which is forced under high pressure into the mold cavity, where it quickly cools and hardens. The mold is then opened to remove the molded object and to prepare the mold for the next cycle. The processing conditions specification in the data sheet for the plastic material lists the appropriate temperatures of the zones and the mold.

Name	Full Name	Mold Tem-perature (°C)	Melt Tem-perature (°C)
ABS	Acrylonitrile-Butadiene-Styrene	49 to 85	105
PA	Nylon	66 to 107	220
PP	Polypropylene	32 to 66	130–171
GPPS	Polystyrene	38 to 66	
PC	Polycarbonate	66 to 121	

Table 1.1 Typical Plastics for Injection Molding

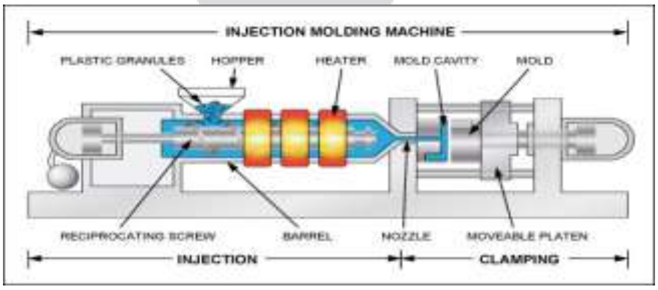

Fig. 1 Injection molding machine

GENERAL RAW MATERIALS IN INJECTION MOLDING

There are roughly 30,000 different materials available for injection molding,[4] finding the right plastic may appear like a serious challenge. The task becomes easier with some insight into the characteristics of various plastic materials.
There are thermosetting plastics, which can be heated and run through an injection molding machine just once. Epoxy, a plastic commonly used for IC packages, falls into this category. Once processed, the thermosetting plastic remains solid, regardless of the temperature. There are thermoplastics, which soften whenever they are heated. Thermoplastics can have an amorphous or semi-crystalline structure, which affects mechanical stability, chemical/wear resistance[5, 6] and suitability to sterilization methods.

Table 1.1 shows a selection of plastic materials for injection molding.

a. Acrylonitrile butadiene styrene (ABS): It is a common thermoplastic. Its glass transition temperature is approximately 105 °C (221 °F).[1] ABS is amorphous and therefore has no true melting point.
b. Nylon (PA): Nylon is a thermoplastic. Nylon fibers are used in many applications, including clothes fabrics, bridal veils, package paper, carpets, musical strings, pipes, and rope etc.The melting point of nylon is 220 °C.
c. Polypropylene (PP): It is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles. The melting point of polypropylene occurs at a range, so a melting point is determined by finding the highest temperature of a differential scanning calorimetry chart. Perfectly isotactic PP has a melting point of 171 °C (340 °F). Commercial isotactic PP has a melting point that ranges from 160 to 166 °C (320 to 331 °F)
d. Polystyrene (GPPS): Polystyrene Bead insulation should not be used above 80c and the product starts to soften at greater than 70c with decomposition happening at 220 ^{o}C.The melting point is around 240 ^{0}C.
e. Polycarbonate (PC): Polycarbonate possesses extraordinarily good dimensional stability with a high impact strength which is maintained over a wide temperature range. This makes PC ideal for the manufacture of laboratory safety shields, vacuum desiccators and tubes. The melting point is 155 °C.

A Brief Outline of the Mold Flow Study:

Thermoplastic injection molding is a well known process for manufacturing effortless and complex shaped products in short time and at low cost. Nowadays there is a need for optimizing the processing parameters to increase productivity. In the cycle time the cooling time can represent more than 70% of the injection cycle. Cutting down the cycle time for each part is a major concern in injection molding machine. In order to set the processing parameters, they commonly follow on experience and trial-and–error method. This process becomes inadequate and unpractical for complex products. As a consequence the designers need a more powerful tool to analyze and to optimize the process. This project is to design an experiment to optimize an injection molding machine by manipulating parameters to reduce cycle time. However the development of CAE technology especially the Mold flow software, the number of testing mold can be reduce and the efficient can be improved by using CAE software to analyze, evaluate and optimize the related process data .Plastic is one of the most versatile materials in the modern age which is widely used in many products in different shapes which are molded through the application of heat and pressure . Injection molding has become the most important process for manufacturing plastic parts due to its ability to produce complex shapes with good dimensional accuracy . However, the current plastics industry is under great pressure, due to the globalization of the market, and high demand of product. In injection molding, the design of mould isof critical importance for the product quality and efficient processing, which is also responsible for the economics of the entire process. Mold designers are required to possess thorough and broad experience, because the detail decisions require the knowledge of the interaction of various parameters. Due to the lack of experienced designers, intelligent CAD tools that can assist in the various tasks of the mold design process can be used for the good productivity of mold making industry . The mold surface temperature has great influence for plastic injection molding. With high mold surface temperature, the surface quality of part will be better, but the cooling time will increase and accordingly the cycle time will rise as well. The decreasing of the mold surface temperature will reduce the cooling time, but there is no benefit for the surface quality of part. Therefore, how to shorten cooling time and maintain mold surface temperature meanwhile is a crucial issue for current studies. For the cooling process, two cooling systems, namely, traditional cooling and pulsed cooling are used for the mold temperature control without changing cooling system design. With the traditional cooling method, const coolant flow is employed in the overall molding process. Generally, the coolant temperature is almost the same as the mold temperature by this approach. For the pulsed cooling method, applying variable coolant flow time to interrupt cooling processing shows the cooling time decrease, but the mold surface temperature keeps high. By means of less cooling time, lowering the usage of power contributes to saving more. One of the main goals in injection molding is the improvement of quality of molded parts besides the reduction of cycle time, and lower production cost. Solving problems related to quality has a direct effect on the expected profit for injection molding companies. As in many manufacturing processes, meeting required specifications means keeping quality characteristics under control. Quality characteristics in injection molding are classified as mechanical properties, dimensions or measurable characteristics, and attributes. In general, some of the main causes of quality problems are material related defects i.e., black specks and splay, process related problems such as filling related defects i.e., flash and short shots, packing and cooling related defects i.e., sink marks and voids, and post mold related defects i.e., warpage, dimensional changes, and weight. Factors that affect the quality of a molded part can be classified into four categories: part design, mold design, machine performance and processing conditions. The part and mold design are assumed as established and fixed. During production, quality characteristics may deviate due to drifting or shifting of processing conditions caused by machine wear, environmental change or operator fatigue. Determining optimal process parameter settings critically influences productivity, quality, and cost of production in the plastic injection molding (PIM) industry. Design of the mould filling testing specimen to be used in plastic injection mould. It is clear that mold filling is the main problem that exists in product with thin shell feature. The actual part is first being measured and the data is recorded; the part model then created in PROE by using the Sketcher Workbench, the original part and the solid model of the part that has been developed by using PROE software and import to mould flow software for analysis and simulation. The mould filling testing specimen, the material used for producing the mould filling testing specimen was acrylonitrile butadiene styrene (ABS) and polypropylene(PP). Placing a gate appropriately is the most critical factor in determining the quality of the part. The analysis result, the gate location on the part may be preset or appeared with two or three choices; then the optimum gate locations may need to be examining by running the filling analysis on best gate locations. Show the result of gate location analysis Blue area represents the best gate locations for the part. Material property determina-tion is an important aspect of stress analysis. When compared to the conventional materials like steel,wood, etc., polymers exhibit lower strength and modulus. Their viscoelastic behavior reflects the combined effect of the viscous and elastic responses and determines the overall mechanical properties of the finished part. The deformation behavior of polymers is thus quite different from that of the elastic materials. Independent studies to validate some of the above claims have been carried out using experimental techniques. These studies have all concluded that there are benefits to employing pulsed cooling method. For instance, pulsed cooling method advantages 20% reductions of cycle time when compared with conventional cooling method. This conclusion was based on results obtained for particular tool geometry, using various different coolant temperature and four different mold temperature: 20, 25, 35 and 50°C . In a further study, pulsed cooling method was applied for injection-compression molded Blu-ray Disc. The result shows that by using pulsed cooling, warpage was reduced and the accuracy in microgroove replication was higher. Besides, coolant temperature was decreased by 8°C, and the cycle time was shorten by 10% as compared to the conventional cooling process . The near study is comparing the results simulating by Moldex3D with experiment. This study demonstrates that pulsed cooling was applied in the injection and packing process for about 0.3 seconds, and mold temperature can be higher than that in conventional injection molding by about 5°C. As known the conventional process with stable mold temperature and constant coolant flow, the required cooling time will stable as well. However, if coolant flow stops during cooling phase, the cooling time must increase to reach the ejection temperature. And pulsed cooling is adopted for changing cooling time and pulsed cooling time to find out the mold open and close temperatures close to those required for conventional cooling. In this paper, the tensile specimen model was injected with PC polymer as model for simulation. Mold open and close temperature will be measured by sensor.The injection molding process involves feeding raw material, plasticize the raw material, fill the mould, pack the mould, hold pressure, Cooling of mould and lastly opening of mould and Part ejection .The main factors in the injection molding 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 augur type sprue channel which feeds the resin pellets forward inside the heated barrel . The resin fed in the barrel through the feed throat is plasticized by screw extruder. The heater bands surrounded on barrel maintains the melt temperature of the resin. This plasticized resin is then injected into the mould after mould closing. Injection of melt is generally done into the cooled mold by hydraulic mechanism. This filling phase generally takes few seconds depending on plastic grades, wall thickness and the shape of the part. After filling the mould cavity with resin the pressure is reduced to the pack value and maintain for a specified time to assure the mold is full. Thereafter a hold pressure is maintained for a set period of time on the solidifying material within the mold. This holding pressure is only effective as long as gate remains open. Critical dimension, surface finish, cycle time etc are all affected by mold cooling . Hence mold cooling is a decisive factor for producing components with good quality and at competitive cost. And as the cooling phase is completed the mold is opened and the component is ejected with ejector pins of the tool. Once the molding is clear from the molding tool, the complete molding cycle is repeated. Factors that affect the quality of a molded part can be classified into four categories: part design, mold design, machine performance and processing conditions. The part and mold design are assumed as established and fixed. During production, quality characteristics may deviate due to drifting or shifting of processing conditions caused by machine wear, environmental change or operator fatigue. Injection molding has been a challenging process for many manufacturers and researchers to produce products meeting requirements at the lowest cost. Its complexity and the enormous amount of process parameter manipulation during real time production create a very intense effort to maintain the process under control. What is more, complexity and parameter manipulation may cause serious quality problems and high manufacturing costs . Plastic industry is one of the world's best ever growing industries, ranked as one of the few billion-dollar industries. Almost all components that is used in everyday life involves the usage of plastic and most of these products can be produced by plastic injection molding method . Plastic injection molding process is renowned as the manufacturing process to create products with different shapes and complex geometry at low cost.Injection molding is considered the most prominent process for mass producing plastic parts. Today, around30% of manufactured plastic goods rely on injection molding, which is based on the injection of a fluid plastic material into a closed mold. The use of plastics has become increasingly important as weight; cost and quality are standard points to stay competitive in the industry. Besides that, plastics can be molded into extremely complex shapes, good dimensional accuracy , making them suited to be used in high technology products. Injection molding operations can also sometimes be quite a challenge to the mold designer as to design a mold that produce products with less defects as plastics material are easily tend to have fill time, shrinkage, weld lines and air traps. Currently, the process of trial and errors required at the tryout stage can be reduce through the CAE by simulation resin flow pattern and predicting possible defects that can be avoided by improving flow balance with the proper selection on gate location. Designing an optimal plastic injection mold require several tasks to be performed. Preliminary part design and part modeling is the first to be completed; respect with product requirement and specification. The next important task is simulation analysis to identify the best gate locations for the part which eventually shows the best design for the mold. In this research, the used of PROE and MOLDFLOW applications are completely used in determined the best gating location for plastic part.

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