INFLUENCE OF FEEDING SYSTEM IN INJECTION MOULDING FOR LOWER WASHER OF A BEARING

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Abstract

Optimisation of cycle time, avoid scrap and manual interface plays a vital role in manufacturing of plastic parts to improve the productivity of the process and at the time it should not affect the quality of the final product. This paper describes the influence of gate location and size through a repeated number of analyses which is carried out by plastic flow advisor software to reduce fill time, scrap and automatic degating. The process parameters like fill time, shrinkage, weld lines, pressure drop, and air traps are analysed by simulation in successive trials. Experimental verification has been done with new optimised gate location with designed mould in injection moulding machine. The results showed an improvement in fill time from 1.64 sec to 1.2 sec with increase in injection pressure by 15 MPa. Shrinkage and air traps were reduced minimising trouble shooting defeats.

Index Terms: *Plastic Injection mould, Mould Flow Plastic Advisor, Feeding system, Submarine gate, Nylon 6/6 30% GF*

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1. INTRODUCTION

The injection moulding process involves the injection of a polymer melt into a mould, where the polymer melt, cools and solidifies to form a plastic product. The process comprises filling, packing, and cooling phases. The typical process cycle time in injection moulding machine varies from several seconds to tens of seconds depending on the part weight, part thickness, material properties and the machine settings specific to a given process. Process control of injection moulding has a direct impact on the final part quality and the economics of the process. In the injection moulding processes, gate location is very important design parameter with is in the relation with polymer capability, part shape and dimension, mould structure and mould condition, the selection of gate location influences the manner in which plastic flows in to the mould cavity. In order to set the processing parameters, conventional trial and error method is followed which is many times inadequate and unpractical for complex parts. The placement of a gate in an injection mould is one of the most important variables in mould design and the quality of the product is greatly affected by the gate location. Thus the objective of this paper is to design the feeding system that ensures the better part quality to design and manufacturing the injection mould for lower washer of a bearing.

2. PART DETAILS

The bearing material of Nylon 6/6 GF30 which has an excellent balance of properties which make it an ideal material for metal replacement in applications such as automotive parts, industrial valves, railway tie insulators, and other industry uses whose design requirements include high strength, toughness, and weight reduction. The part is designed for four impression injection moulds and volume of the component is 32.12cm3, with the density of 1.35 gm/cc and the shrinkage of the part is 0.6%. The CAD model of the part is shown in the Fig1.

Fig 1 CAD Model of Lower washer

3. GATE LOCATION

Since the part is designed for multi-impression mould and circular profile part allows us to design only submarine gate for feeding. A submarine gate is used in two-plate mould construction. An angled, tapered tunnel is machined from the end of the runner to the cavity, just below the parting line. A submarine gate is often located into the side of an ejector pin on the non-visible side of the part. To de-gate, the tunnel requires a good taper and must be free to bend. Typical gate sizes 0.8 mm to 1.5 mm, for glass reinforced materials sizes could be larger shown in Fig 2.

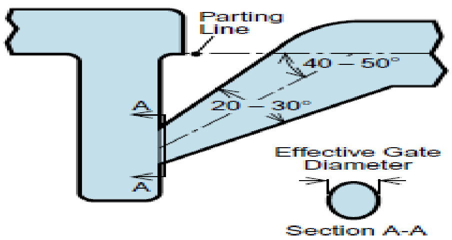


Fig 2 Submarine Gate

Flow simulation in plastic advisor for component suggests the best gate location for the selected material properties. The simulation rates the model areas for their suitability for injection location where the worst position is classified as least suitability for an injection location in red colour and the best position is classified as the most suitable in blue colour. The input for plastic advisor software is given in the Table 1 and the gate location examines these five aspects of the part.

1. Process ability.
2. Minimum Pressure.
3. Geometric Resistance (Over packing).
4. Thickness.
5. Flow resistance areas

Table 1 Input Details for plastic Advisor

Material	PA6,6 GF 30%
Pressure	180 Mpa
Density	1.35 gm./cc
Melt Temperature	280°C
Manufacturer	G E Plastics
Mould Temp	80°C

Since it is a multi-impression mould and circular component only submarine gate can be used for feeding. A submarine gate is used in two-plate mould construction. An angled, tapered tunnel is machined from the end of the runner to the cavity, just below the parting line. A sub-gate is often located into the side of an ejector pin on the non-visible side of the part when appearance is important. To de-gate, the tunnel requires a good taper and must be free to bend. Typical gate sizes 0.8 mm to 1.5 mm, for glass reinforced materials sizes could be larger. Cold sprue with submarine gate was used for analysis. Part is simulated for four cavities where single occurrence will be considered for Simulation. The gate is located on the highly recommended area (blue colour) shown in Fig 3. The gates are given across the surface of the washer, where it is the only possibility because other recommended area damages the part dimensions and others are impossible to manufacture the feeding system.

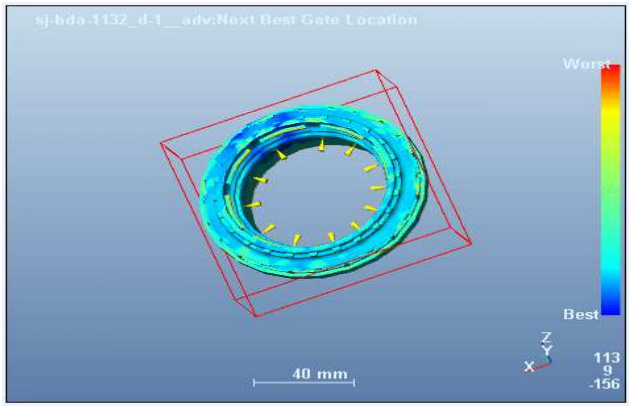


Fig 3 Best Gate location selection

4. SHRINKAGE

Sink marks are developed in the part in the region of thick features such as ribs or bosses in the adjacent wall of the part. The presence of such a feature creates an effectively thicker region that cools more slowly than neighbouring regions. Shrinkage occurs because of longer hold time, low pressure, and short cooling time or with sprue less hot runners. Fig 4 suggests that the part shrinkage will be within 0.02 mm to 0.14 mm and this factor is incorporated in designing the core and cavity block.

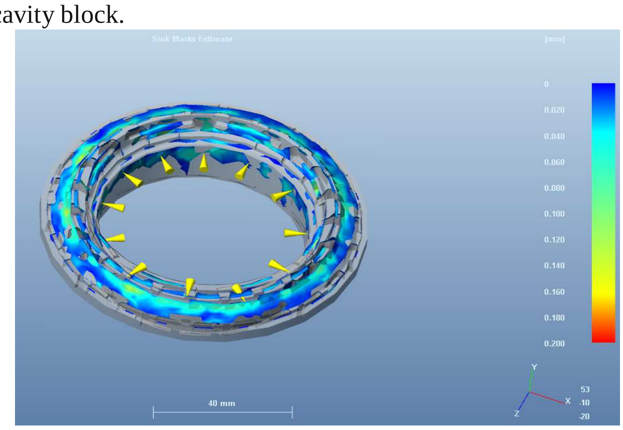


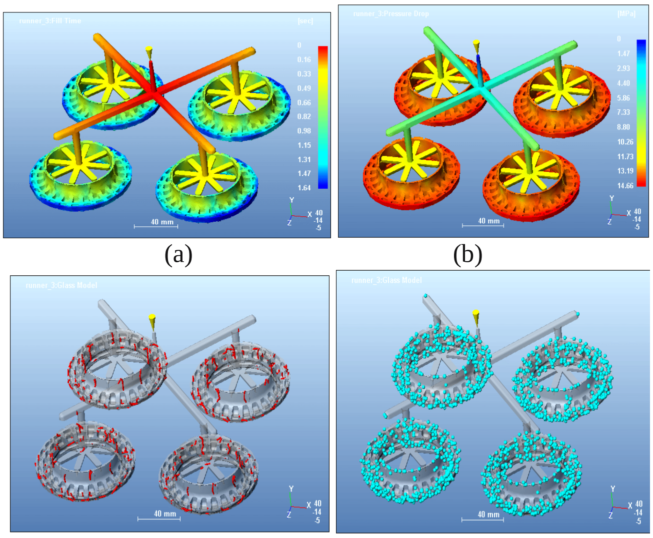
Fig 4 Part Shrinkage

5. MOULD FLOW RESULTS

The mould flow Simulation is done repeatedly and best three trials are show and the possible is selected for manufacturing based on fill time and air traps.

5.1 First Trail

Feeding system is designed and simulated with 8 Gates, 2 mm diameter gate size and runner width of 6mm in first trail shown in Fig 5, where the part fills in 1.64 sec with pressure of 14.66 Mpa where air traps and sink marks are maximum, which leads defects in the component and more over ejection is quite difficult as 2 mm gates tears the component surface because of shear force caused by Pins.

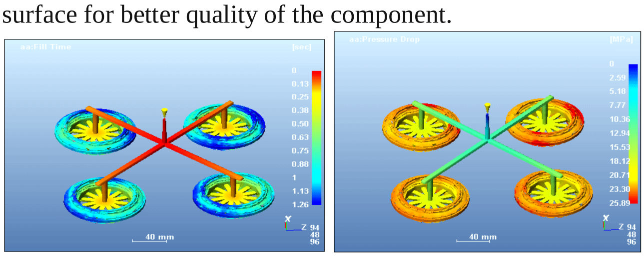


(a) (b) (c) (d)

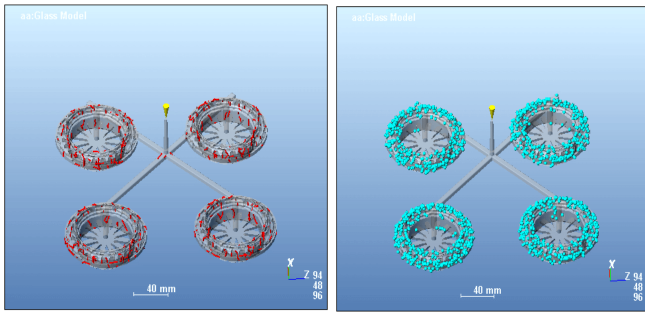
Fig 5 Flow Simulation with 8 Gates and 2mm dia. for a) Fill Time b) Pressure Drop c) Weld lines d) Air Traps

5.2 Second Trail

Since the results obtained in first trail are not satisfactory, feeding system is redesigned and simulated with 12 Gates, 1.6 mm diameter and runner width of 6mm shown in Fig 6, where the part fills in 1.26 sec with pressure of 25.5 Mpa where air traps are less, but weld line are marginally high. Since the results were better than the previous trail, there is a scope for further optimising the gate sizes for less tear on the component surface for better quality of the component.



(a) (b)

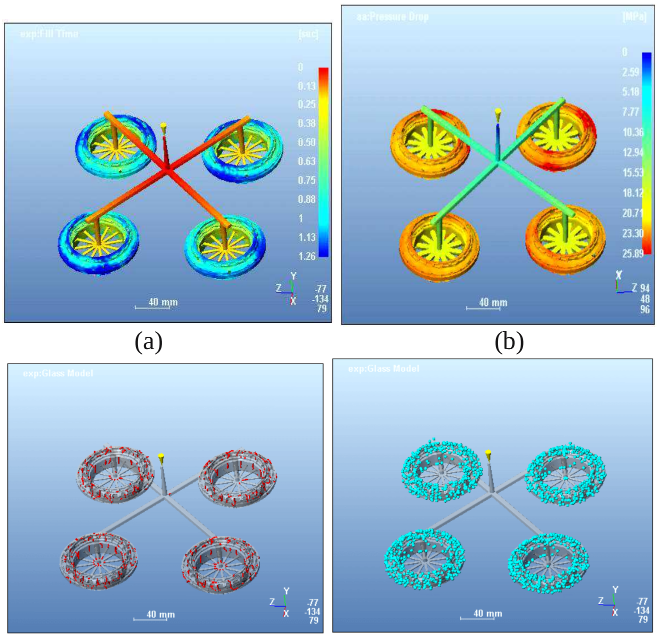


(c) (d)

Fig 6 Flow Simulation with 12 Gates and 1.6mm dia. for a) Fill Time b) Pressure Drop c) Weld lines d) Air Traps

5.3 Third Trail

Results obtained from second trail can be further optimized by changing only the gate size and simulated with 12 Gates, 1.2 mm diameter gate and runner width 3mm, shown in Fig 7, where the part fills in 1.2 sec with pressure of 29.46 Mpa, even though the pressure is relatively high compared to previous, it is manageable and since the gate diameter is 1.2mm the part is automatically ejected as the cross section of gate is minimum with very less tear on the component surface. Even though the air traps are more, it can be minimised with air vents in cavity insert during manufacturing.



(a) (b) (c) (d)

Fig 7 Flow Simulation with 12 Gates and 1.2mm dia. for a) Fill Time b) Pressure Drop c) Weld lines d) Air Traps

CONCLUSIONS

Analysing the above three results with a comparative study, the analysis for optimum gate and runner location was discussed, defects like air traps and weld lines were minimized in the flow simulation. Gate is designed in best location for easy manufacturing and defects less component where automatic degating is possible. From the three trails in the Table 2, even though pressure increases, it is well within the safe range and fill time comes down which will increase the production rate. Flow simulation for different gate size and locations were analysed flaws like weld lines and air traps were minimised to produce defect less component Air traps can be minimized by providing air vents in core and cavity inserts, weld lines can be controlled by monitoring injection pressure, barrel speed and maintaining the mould temperature. Trial three is considered for design since fill time, air traps are minimum and ejection is easy and automatic.

Table 2 Mould flow Results Comparison

	1st Trail	2nd Trail	3rd Trail
Fill time	1.64 sec	1.26 Sec	1.20 Sec
Pressure	14.66 Mpa	25.5 Mpa	29.46 Mpa
Temp flow	295 C	295 C	295 C
Air Traps	More	More	Acceptable
Weld lines	More	Minimum	More
Ejection	Difficult and Complex	Difficult and Complex	Easy and Automatic

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BIOGRAPHIES

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