Modelling and Analysis of Mold Filling Parameters for PP and ABS Materials Using Software Simulation

Arvind Kumar Singh[1] and D.K. Singh[2]

[1]*M.Tech. Student and Corresponding Author,*

[2]*Professor,Mechanical Engineering Department,*

M.M.M. Engineering College, Gorakhpur-273010 (UP), India

Abstract

This study present moldflow simulation for identifying different effects of mold filling parameters and performance measures in the injection molding process for Acrylonitrile butadiene styrene (ABS) and polypropylene (PP) materials. The trade achieved from this work shows better mould filling strategies for Moulding process. It is concluded that the results obtained can be useful to bring about modifications in the mold filling parameters optimization for Moulding process.

1. Introduction

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 [1]. 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 [2], 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 [3, 4, 5]. 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 CATIA[6] and MOLDFLOW[7] applications are completely used in determined the best gating location for plastic part.

2. Part Design and Modeling

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 CATIA by using the Sketcher Workbench, the dimensions of the specimen were 120mm in length, 50mm in width and 1mm in thickness in the Part Design module. Fig.1. shows the original part and the solid model of the part that has been developed by using CATIA 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).
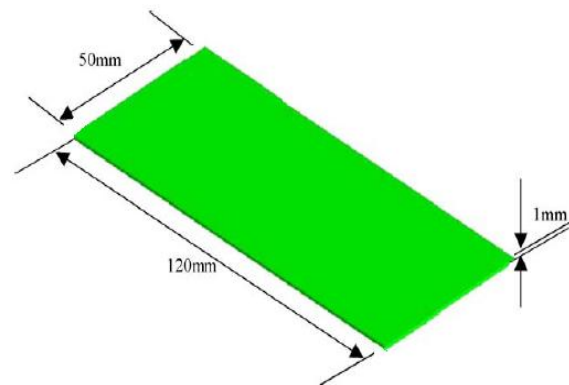

Figure 1: Mould filling testing specimen produced.

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.

3. Mold Filling Analysis Result

I. Pressure At Velocity/Pressure Switchover Result

The pressure at V/P switchover result is generated from a fill analysis, and shows the pressure distribution through the flow path inside the mold at the switchover point from velocity to pressure control. Fig.2 shows the pressure at V/P switchover result. The maximum clamp force for the first case is 80.36 MPa and second case is 34.82 MPa.

(a) **(b)**

Figure 2: pressure at v/p switchover result by MF software for first case (a) and second case (b)
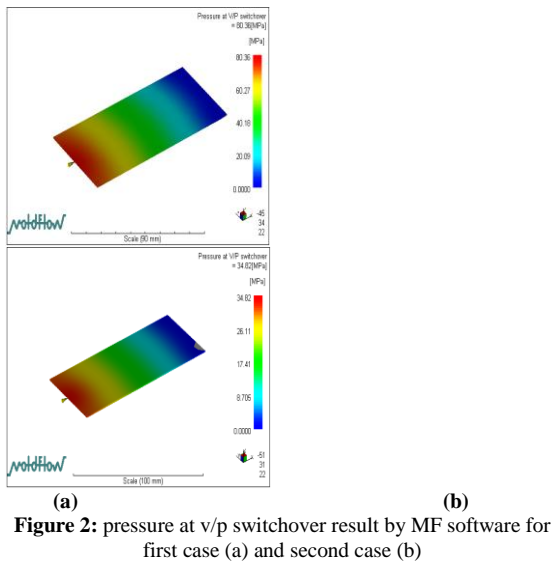
II. Bulk Temperature at End of Fill Result

Bulk temperature is used to indicate the weighted average temperature across the thickness. The temperature of polymer melts changes not only with time and location, but also with thickness during the entire injection molding cycle. It is difficult to illustrate all these changes in a single display. For these reason, Bulk temperature is used. Bulk temperature represents the energy that is transported through a particular location. It has more physical significance than a simple average temperature as the polymer melt flows. Fig.3 shows the bulk temperature at end of filling result. The bulk temperature at end of filling for the first case is 234.1^0c which is the lower Bulk temperature end of filling compared to the first case, $223.6\ ^0$c.

(a) **(b)**

(b) **Figure 3:** Show the Bulk temperature (end of filling) result by MF for first case (a) and second case (b)
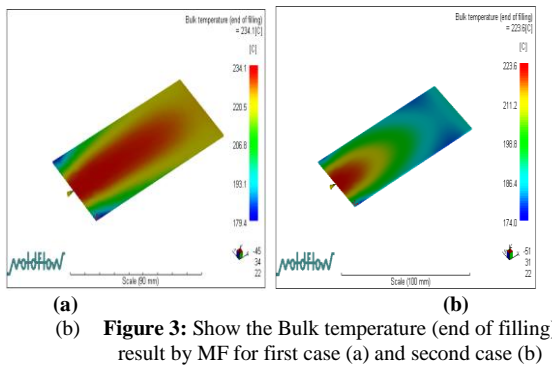
III.Clamp Force Result

The clamp force result is a time-series result which shows the force of the mold-clamp over time. The clamp force is the resultant value of the pressure distribution over the entire part. It is a history of the force resultant from filling and packing pressure that acts to open the mold.

The clamp tonnage is calculated based on the cavity area at the parting line. The clamp force is calculated in each element using the projected area on the XY plane and the pressure in that element. Clamp force can be very sensitive to balanced of fill and pack pressure. Fig.4 show the graph of the clamp force. The maximum clamp force for the first case is 41.00 tonne and second case is 27.00tonne. The clamp force rate also seen smooth for second case compare to sudden change at first case.
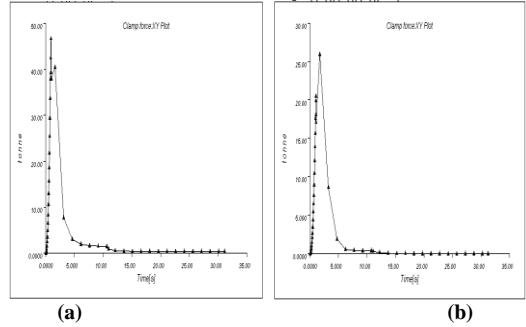

(a) **(b)**

Figure 4: Show the graph of the clamp force result by MF for first case (a) and second case (b)

IV. Fill Time Result

The fill time result shows the progression of the material into the cavity. One of the aims in selecting gate location is to ensure the flow paths in the cavity fill uniformly [25] and filling completed rapid as possible. Fig.5 shows the fill time result. The fill time for the first case is 0.9818 seconds which is the slower fill time compared to the other, 1.077 seconds.
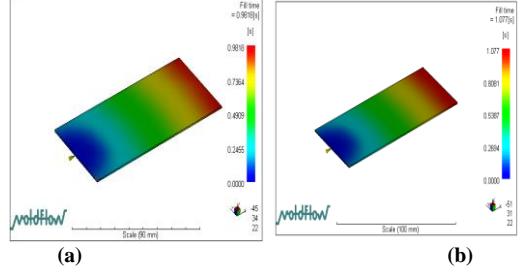

(a) **(b)**

Figure 5: Fill time analysis results by MF for first case (a) and second case (b)

The fill time result shows the position of the flow front at regular intervals as the cavity fills. The Polymer fill region result is generated at the end of a fill or over molding analysis using 3D analysis technology, and shows which elements in the model are filled with polymer melt at intervals as the cavity fills.

V. Deflection at X-Axis Component

The deflection at X-axis component result is created only if you have modeled a core, and the

Perform core shift analysis option in the fill analysis advanced options has been turned on. It shows the deflections of the core during the filling and packing phases of the molding cycle. Fig.6 show the deflection at X-axis component result. The deflection at x-axis component result for the first case is 0.1320 mm and second case is 0.0502 mm. So the minimum deflection occurs in X-axis component in second case.
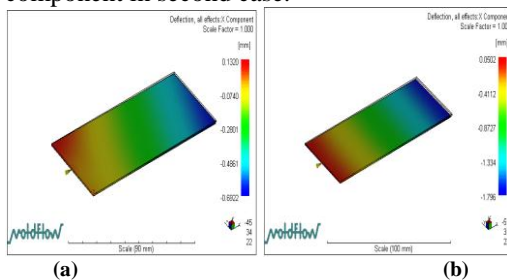

(a)   **(b)**

Figure 6: Show the deflection at x-axis component result by MF for first case (a) and second case (b)

The magnitude and distribution of pressures on the core vary considerably during filling and packing, therefore, the deflection will also vary with time. The maximum value on the legend is the maximum deflection that occurred during the filling and/or packing phases.

VI. Deflection at Y-Axis Component

The deflection at Y-axis component result is created only if you have modeled a core, and the Perform core shift analysis option in the fill analysis advanced options has been turned on. It shows the deflections of the core during the filling and packing phases of the molding cycle. Fig.7 shows the deflection at Y-axis component result. The deflection at Y-axis component result for the first case is 0.000017 mm and second case is -0.000001 mm. So the minimum deflection occurs in Y-axis component in second case.
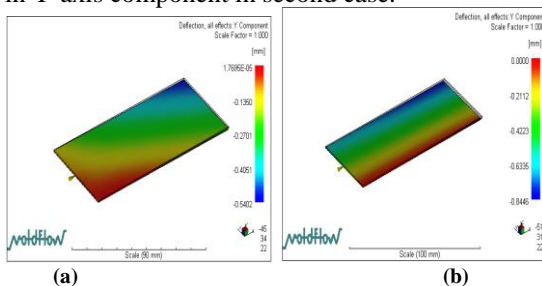

(a)   **(b)**

Figure 7: Show the deflection at x-axis component result by MF for first case (a) and second case (b)

The magnitude and distribution of pressures on the core vary considerably during filling and packing, therefore, the deflection will also vary with time. The maximum value on the legend is the maximum deflection that occurred during the filling and/or packing phases.

VII.

DEFLECTION AT Z-Axis COMPONENT

The deflection at Z-axis component result is created only if you have modeled a core, and the perform core shift analysis option in the fill analysis advanced options has been turned on. It shows the deflections of the core during the filling and packing phases of the molding cycle. Fig.8 shows the deflection at Z-axis component result. The deflection at y-axis component result for the first case is 0.0037 mm and second case is 0.0137 mm. So the minimum deflection occurs in Z-axis component in second case.
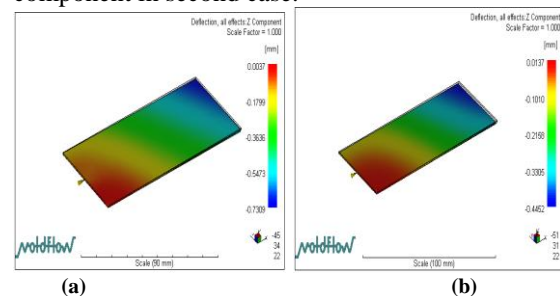

(a)   **(b)**

Figure 8: Show the deflection at z-axis component result by MF for first case (a) and second case (b)

The magnitude and distribution of pressures on the core vary considerably during filling and packing, therefore, the deflection will also vary with time. The maximum value on the legend is the maximum deflection that occurred during the filling and/or packing phases.

VIII. Average Velocity Result

The average velocity result shows the average magnitude of velocity of the polymer inside the mold cavity over time. The magnitude of the flow velocity is a straight average through the thickness (but only the melt is considered, not the frozen layer).The average velocity result can be used to determine areas with a high flow rate. High velocity values for a particular model section could indicate a high flow rate, meaning there could be filling problems such as over packing or flash. This could also mean that polymer flow is unbalanced, where polymer flows fast through one section and flows slowly through another section of the part. Fig.9 shows the average velocity result. The average velocity for the first case is 12.10 seconds which is the slower fill time compared to the other, 10.74 seconds.
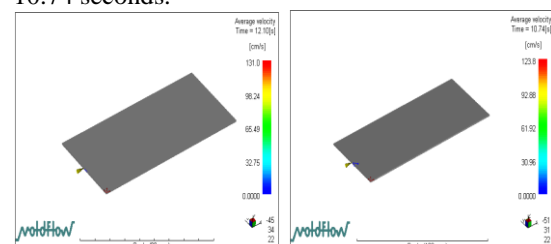
(a)   (b)

Figure 9: Average velocity results by MF for first case (a) and second case (b)

6. CONCLUSIONS

Based on the moldflow simulation results, conclusions have been drawn in Table 1.1. Conclusions for the Moulding process can be summarized as follows:

Table 1.1: SUMMARY RESULTS OF MOLD FILLING ANALYSIS

MOLD FILLING ANALYSIS	ABS	PP
Pressure Switchover Result	80.36 MPa	34.82 MPa
Bulk Temperature At End Of Fill Result	234.1^0c	223.6^0c
Fill time	0.9818 seconds	1.077 seconds
Clamp force	41.00 tonne	27.00 tonne
Deflection at x-axis component	0.1320 mm	0.0502 mm
Deflection at y-axis component	0.000017 mm	-0.000001 mm
Deflection at z-axis component	0.0037 mm	0.0137 mm
Average Velocity Result	12.10 seconds	10.74 seconds

After the introduction and knowledge of all the details and concepts with moldflow simulation we can finally conclude that moldflow simulation is a very popular and important technology in the field of Moulding process.

10. References

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