Optimization of Gate, Runner and Sprue in Two-Plate Family Plastic Injection Mould

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Abstract. This paper describes the optimization size of gate, runner and sprue in two-plate family plastic injection mould. An Electronic Cash Register (ECR) plastic product was used in this study, which there are three components in electronic cast register plastic product consist of top casing, bottom casing and paper holder. The objectives of this paper are to find out the optimum size of gate, runner and sprue, to locate the optimum layout of cavities and to recognize the defect problems due to the wrong size of gate, runner and sprue. Three types of software were used in this study, which Unigraphics software as CAD tool was used to design 3D modeling, Rhinoceros software as post processing tool was used to design gate, runner and sprue and Moldex software as simulation tool was used to analyze the plastic flow. As result, some modifications were made on size of feeding system and location of cavity to eliminate the short- shot, over filling and welding line problems in two-plate family plastic injection mould.

Keywords: Computer Modeling; Flow Simulation; Optimization
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1. INTRODUCTION

The plastic injection generally has three phase processes comprising filling, packing and cooling phases. The introduction of simulation software has made a significant impact in the mould making industry with the increasing use of computers in design engineering, the amount of commercially available software on the market has also increased [1]. The ECR plastic product uses same material and colour, however different size of part. Each part has it own mould but on this research, all the parts used family mould. The difficult stage to design family mould is to decide the mould layout, injection location, size of gate, runner, sprue and location of water holes [2], [6], [7]. To investigate the flow behaviour the Moldex software as simulation software was used to analyze the plastic flow.

2. METHODOLOGY

This study started from design 3D modeling of ECR product using Unigraphic software and then the files were transferred into Rhinoceros software for post processing. In Rhinoceros software the feeding system such as gates, runners, sprues,

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waterholes and mould base were designed. Finally, Moldex software is used by importing file from Rhinoceros software. Plastic materials, processing conditions were decided before filling, packing, cooling and warpage analysis. If results do not satisfy, the modification will be done again as shown in Figure 1.

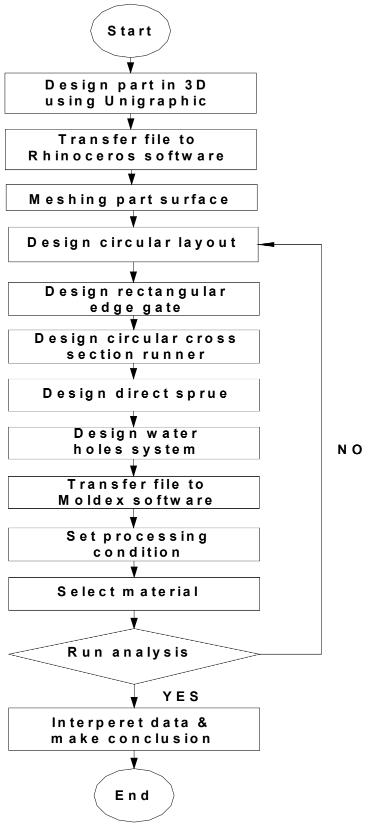
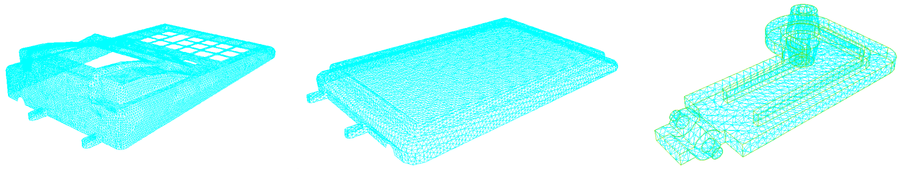


FIGURE 1. Methodology of analysis.

3. DESIGN OF TWO – PLATE MOULD

All ECR files consist of top casing, bottom casing and paper holder which they were exported from Unigraphic software to the Rhinoceros software through step one by one. The files were saved under DXF extension which it can be read by Rhinoceros software. Initially, the top casing file was opened in Rhinoceros software which it was converted from solid modeling into mesh modeling as shown in Figure 2(a). Further, Figure 2(b) shows the early stage of imported file of bottom casing from Unigraphic software to Rhinoceros software. The refine mesh of bottom casing has been made until the fine mesh of surface is achieved. The cavity surface was remained after core side had been deleted by removing the mesh. The same method was done for paper holder as shown in Figure 2(c).



(a) Top Casing (b) Bottom Casing (c) Paper Holder

FIGURE 2. Mesh modeling of ECR.

3.1 Rectangle Edge Gate

Two sizes of rectangular edge gate need to decide which are depth and width. The depth of these parts are calculated using formula h = nt, where h is depth of gate (mm), t is wall section thickness (mm) and n is material constant [3]. Calculation from this formula the depth of top casing and bottom gate are 1.2 mm and paper holder is 1.8 mm. The width of edge gate is derived from equation 1 [4].

$$W = n \times A^{\frac{1}{2}} / 30 \qquad (1)$$

Where, W is gate width (mm); A is surface area of cavity (mm^2) and n is material constant. From calculation surface area of top casing is 84,648 mm^2, the width is 5.8 mm. Further calculation, bottom casing width is 5.9 mm and paper holder is 1.27 mm.

3.2 Circular Runner

Diameter runner was calculated by taking the weight of part from volume multiply density and distance part from centre of mould as equation 2 [4].

$$D = W^{\frac{1}{2}} \times L^{\frac{1}{4}} / 30 \qquad (2)$$

Where, D is runner diameter, W is part weight and L is distance part to centre mould. Volume of top casing was taken from Rhinoceros software is 78,202 mm^3 and the weight is 0.08 kg so the diameter of runner is 6.5 mm. Further calculation, the diameter of bottom casing is 6.7 mm and paper holder is 1.5 mm.

3.3 Sprue

The sprue size was decided by taking the thickness cavity plate mouldbase and given angle one degree from diameter 7 mm. Initial cold slug well is 7 mm and base cold slug well is 10 mm. Figure 3 shows the location of top casing, bottom casing and paper holder together with feeding system.

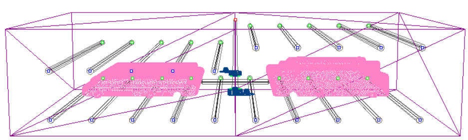


FIGURE 3. Layout of two-plate mould.

4. FILLING ANALYSIS OF TWO – PLATE MOULD

Result from filling analysis shows that the total filling period is 1.041 seconds. At the stage, 100% there were two results where the top casing was short shot and the plastic cannot flow to the impression of paper holder as shown in Figure 4.

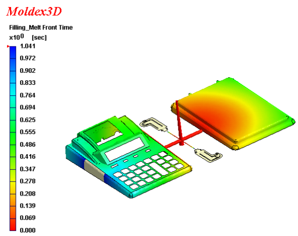


FIGURE 4. Filling process

The top casing was redesigned because of the meeting area of flow front situated at side body, as result a welding line was developed on that area as shown in Figure 5. Welding line is the result of a flow front, which easily breaks up into two separate parts. When the two fronts meet, they try to welding back together again so as result form a single front line which it can be easily broken down [5].

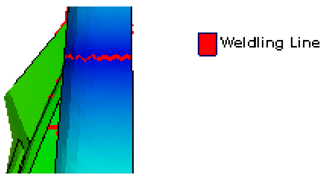


FIGURE 5. Welding line at top casing

4.1 Modification on Two-Plate Mould

Modification was done on gate of bottom casing by decreasing 25% from 5.9 mm to 4.3 mm and runner from 6.7 mm to 5 mm due to over filling. Location of paper holder was moved from 50 mm from center of mould to 25 mm and increase runner size by 25%. A set of groove was added on surface of top casing to ensure the plastic flow toward corner of top casing as shown in Figure 6.

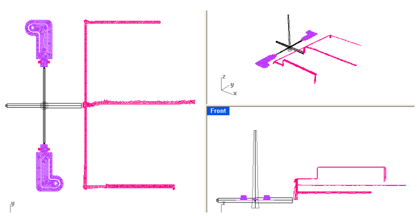


FIGURE 6. Modification of Two-Plate mould.

4.2 Filling process after Modification

Result from filling analysis after modification shows the melt of plastic of three components were balance on each other. The total filling melt front time is 7.804×10^{-1} seconds. The welding line has been eliminated on the centre side body of top casing and as result melt plastic flows towards on the corner as shown in Figure 7.

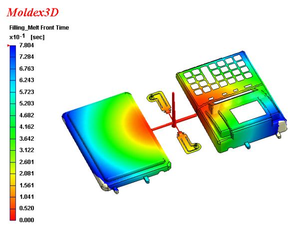


FIGURE **7.** Filling process after modification

5. DISCUSSION

The size of runner of paper holder was increased and shifted to eliminate the unfilling. Gate and runner of bottom casing were decreased due to the over filling. Top casing was redesigned by adding a set of groove on the top surface of top casing to eliminate the welding line. As the result the welding line on centre side body of top casing was eliminated. From results it was found that the size of gate and runner in two-plate mould for paper holder increased by 25% due to the short shot problem and gate and runner for bottom casing reduced by 25% due to the over filling.

6. CONCLUSION

This study was success on analyzing the flow of plastic materials in two-plate mould. The modifications was done on layout of cavities and feeding system as result improved the quality of the product. Furthermore, the defects of plastic product on short shot, over filling and welding line were eliminated before the actual mould is fabricated.

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