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Plastic filling simulation comparison analysis of the gating system in injection moulding parameter

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ABSTRACT

Purpose: The paper is discussed the anticipation of the simulation software precision with the real moulding process by setting up the distinctive metering stroke separation.

Design/methodology/approach: The Inventor CAD software was used to design the product experiment and perform the simulation by applying MoldFlow application to produce the processing parameter defining for the injection moulding machines.

Findings: The results predicted by this filling simulation appears reasonable result as compared to the injected product. Prediction analysis given by the software is exceptionally valuable for the injection moulding parameter setting machines which can diminish the time of mould setup and can reduce the trial stage on the production line.

Research limitations/implications: The gating system is the most crucial part in injection moulding process and the limitation is to get the accurate filling time and injection pressure to ensure the cavity is fully filled before the material at the gate solidify.

Originality/value: Gating system configurations are utilized to optimize the filling conditions of injection moulding parts. This important element was developed for achieving product quality. The utilize of simulation software is exceptionally supportive in the model designing stage to predict the quality and process capacity for the product. This paper presents the filling simulation of the side gate system to the injection moulding parameter.

Keywords: Filling simulation, Gating system, Moulding parameter

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ANALYSIS AND MODELLING

1. Introduction

Item made of plastics are commonly utilized in electrical components, computers, consumer hardware, domestic appliances and household appliances. Gating system is very important criteria in the relation with polymer capability, product shape and mould structure which the gate selection influences the plastic flows in the cavity. Simulation result in plastic moulding contributes to optimize the manufacturing process which can lead to a considerable saving in time, cost and part quality. Model design used is very important for analysis since it will contribute the result simulation accuracy [1]. The practice of setting shot size is still required in the production of the new product. This trial activity can be diminished with the prediction by simulation result and any defects will be eliminated by improving the balance analysis of plastic flow. The use of software prediction is very useful to analyze variable processing moulding parameter for achieving the optimal result. Experiment in the mould fabrication can be replaced by using simulation software which can improve the efficiency for moulding processes [2].

The filling stage basically started from the melt flow into the product and is finished when the product volume is filled up. It is difficult to perform the moulding process optimization without utilizing the filling analysis. Design by experience, broadly utilized within the past, is entirely related to choices, both great and awful, taken by skilled personnel based on past experiences. P. Guerrier et. al reported by using a glass mould is successful method of performing a direct visual comparison of moulded parts with simulations [3]. The present study was achieved in terms of visual filling pattern and also the actual timing of the melt front during filling and packing. The simulation result analysis also can be used to determine which level of part model is built and any alteration can be done before actual fabrication.

The resulting accuracy of the software analysis is a very important requirement for the actual moulding process. Zhang et.al reported through the process of monitoring with the experiments and validation, the insufficient filling of micro features was successfully predicted [4]. This approach is very useful to predict the parts defects for micro features product. The simulation technique by any software to determine the operational reliability time and cost saving [5,6]. The purpose of this paper was to compare the results of filling time simulation analysis to the real injected part utilizing a side gating system with a different distance of metering stroke in injection moulding processing parameters.

2. Methodology

2.1. Component design and processing parameters

A component with key shaped with five hooks of 165 mm in length and 2 mm in thickness was designed. The 3D model was produced using the inventor CAD software and simulated in Moldflow Plastic Adviser (MPA) for mould flow analysis to explore the influence of various injection moulding process parameters on the filling stage. The selected resin used for the simulation was polypropylene (PP) with melt temperature at 240°C and mould temperature at 40°C. The material injection pressure used was 20 MPa.

For the experimental work, the resin material used was PP TITANPRO® PD855 by Lotte Chemical. The resin is a translucent to white coloured, polypropylene (PP) homopolymer grade. Two plate mould with single cavity was fabricated to inject the specimen to compare the simulation and the actual result using the injection moulding machine TOYO Ti-50Gx which having screw diameter 32 mm. The parameters used for experimental work were tabulated in table 1 and 20 samples were investigated for each stroke. The metering stroke distance values used were 10, 22, 30 and 32 and the result of metering stroke versus filling time were investigated and discussed.

2.2. Gating system

The gating system is the main opening in a mould construction which causes the injection of molten plastic into the parts. Different designs of gating are used for different applications. A good gating system normally relies on the number of the cavity to be injected which is basically a single cavity chosen frequently. A larger gate area will decrease both the filling time and gate velocity.

Types of gate design and injection process parameters will crucially influence the actual part quality. This design using rectangular gate 1 mm (H) x 2 mm (W) and 2 mm in length. Improper design of the gate will lead to the turbulent flow of molten plastic into the parts, which normally produced geometrical defects such as short shots or sink mark. Optimization of gate design can be achieved by using rounding corners of the gate that will result from the flow evenly into the parts [7,8]. A low gate velocity will lead to high air entrapment and porosity. On the other hand, low flow rate will result in poor casting surface and a short filling time gives a good surface finish. Xie et.al presented the gate size is very important element for the filling behavior. The undersized gate will produce jetting and filling speed becomes slowly which normally produced short shot

products. If the gate is sufficient size to the product; the filling speed, flow stability and integrity of products will all be improved [9].

A gate design in moulding is important to ensure the polymer flows with fast speed and conveys good liquidity in the filling stage. The gate must also remain open long enough for additional material to be injected into the cavity to compensate for shrinkage. Zhang et.al reported that reduction of gate size increases the flow length and cooling rate but the filling time increases tremendously with the increasing of cavity thickness [10]. It also suggested that the micro gate should be designed thinner than the cavity thickness in order to prevent possible back flow. The selection of the gate system is very important because the geometry of gating could contribute to the significant causes of defects in injection moulding process. The side gate system utilized for this study using standard two-plate mould as appeared in Figure 1. This gate as shown in Figure 1 is the foremost type of gate being utilized because it is simple to manufacture but required adequate moulding pressure to anticipate the gate to solidify which can influence the flow of melting material entering into the cavity.

Fig. 1. Side gate

3. Results and discussions

3.1. Shot size progression

In the moulding cycle, shot size is normally determined by molten resin weight during injection process. The ordinary practice, size of shot estimate ought to be between 10% and 70% of the machine capacity. For new part moulding, continuously start with short-shots, at that point steadily increment the shot measure until all portion cavities are 80-90% filled. The potential of part over packing and flashing can be reduced by using this method.

The screw position should be observed and utilized to set the exchange point. Once the gate solidifies, any extra material will pack the gating system frameworks, which normally affected the part ejection and sprue removal. Figure 2 is used for setting up the shot size with simulation injection filling time.

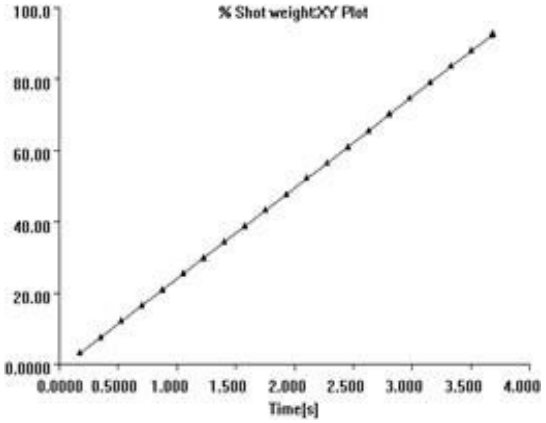


Fig. 2. Shot size amount/Metering stroke vs. filling time

3.2. Processing parameters

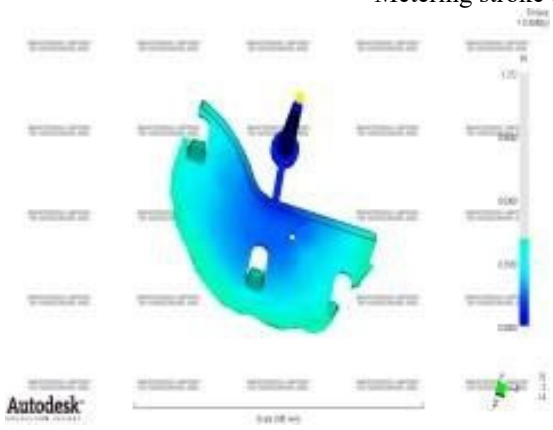
The processing parameters of melt temperature, injection pressure, temperature, and packing pressure will contribute to the product quality. All these moulding factors will allow an impact on the thermoplastics properties and the entire product physical. Lopez et.al focused on the application of DOE in a complex part because it has an integrated hinge which analyzed the variation of process parameters. It is reported that complex parts can produced different behavior and showed the increase of injection temperature is different to the expected results [11]. For this study the injection pressure, melt temperature, mould temperature and packing pressure are utilized for parameter setting as appeared in Table 1.

The metering stroke distance was set at range between 10 to 32 mm on the lowest to the highest stroke respectively while the other parameters such as injection pressure, melt temperature, mould temperature and packing pressure are kept constant for the complete study. The actual part portion at that point is compared to the prediction by the simulation produced as in Figures 3 and 4. It was found that the portion is incompletely filled on the stroke position at 22 mm, whereas at the stroke distance of 32 mm, it was completely filled.

Table 1.
Injection moulding parameters

Part No	Injection pressure, MPa	Melt temperature, °C	Mould temperature, °C	Metering stroke distance, mm	Machine screw diameter, mm	Packing pressure, MPa
1	20	240	40	10	32	16
2	20	240	40	22	32	16
3	20	240	40	30	32	16
4	20	240	40	32	32	16

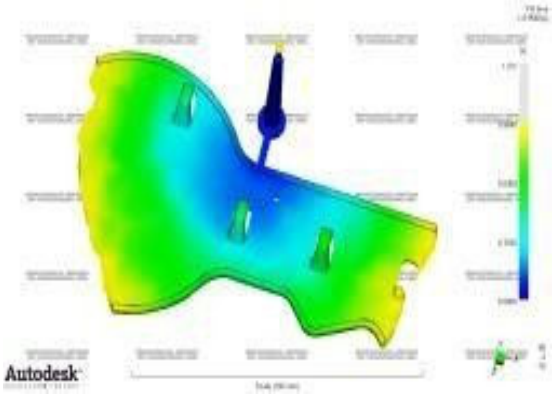
Metering stroke distance = 10 mm



Fill time – 0.424 second

Actual injected part

Metering Stroke Distance = 22 mm



Fill time – 0.954 second

Actual injected part

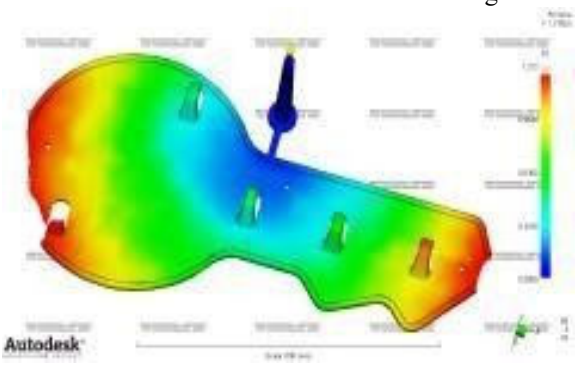
Fig. 3. Result of metering stroke distance vs. filling time

4. Conclusions

The filling analysis is carried out to predict the filling state of the flow in the mould cavity and the quality of the product after the filling stage. The filling time will be comparing to the minimal injection pressure which is sensible for the time of filling. The parameters setting too will contribute the finest result whether the melt flow in the cavity is balanced or not during the flow process.

The early stage in recognizing the parts defects will be based on the simulation result before any alteration of the part model can be taken. The MoldFlow simulation software provides a very useful result to study and analyze the processing parameters affect to the injected parts. The result validation will confirm that the processing parameter optimization and gating system contribute to the quality of the moulded profile.

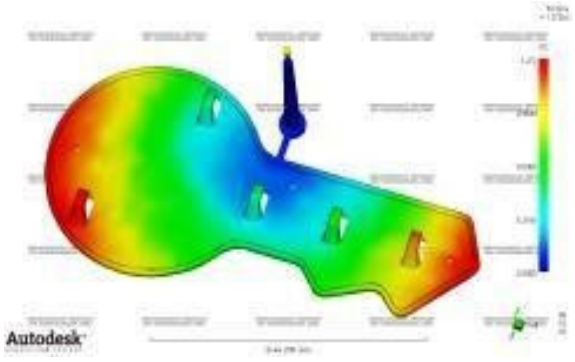
Metering Stroke Distance = 30 mm



Fill time – 1.219 second

Actual injected part

Metering Stroke Distance = 32 mm



Fill time – 1.272 second

Actual injected part

Fig. 4. Result of metering stroke distance vs. filling time

The simulation result will too diminish reducing the fabricating cost and the quality of injection mould parts can be improved, which brings the superior economic advantage for the trade. The simulation outcome prediction generated from software is exceptionally valuable to decide the setting processing parameter on the mould.

The findings will make a difference for determining the actual injection process parameter, decrease production time, trial activity, and mould design. The appropriate parameter setting on the injection machines will ensure the moulding product quality which this can be provided by the simulation prediction for mould industry solutions.

Additional information

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References

[1] Z. Huamin (ed.), Computer Modeling for Injection Molding: Simulation, Optimization, and Control, John Wiley & Sons, New Yersey, 2013.

[2] H. Mao, Y. Wang, D. Yang, Study of injection molding process simulation and mold design of automotive back door panel, Journal of Mechanical Science and Technology 36 (2022) 2331-2344. DOI: https://doi.org/10.1007/s12206-022-0415-0

[3] P. Guerrier, G. Tosello, J.H. Hattel, Flow visualization and simulation of the filling process during injection molding, CIRP Journal of Manufacturing Science and Technology 16 (2016) 12-20. DOI: https://doi.org/10.1016/j.cirpj.2016.08.002

[4] H. Zhang, F. Fang, M. Gilchrist, N. Zhang, Precision replication of micro features using micro injection moulding: Process simulation and validation, Materials and Design 177 (2019) 107829. DOI: https://doi.org/10.1016/j.matdes.2019.107829

[5] O. Hrevtsev, N. Selivanova, P. Popovych, L. Poberezhny, V. Sakhno, O.Shevchuk, L. Poberezhna, I. Murovanyi, A. Hrytsanchuk, O. Romanyshyn, Simulation of thermomechanical processes in disc brakes of wheeled vehicles, Journal of Achievements in Materials and Manufacturing Engineering 104/1 (2021) 11-20. DOI: https://doi.org/10.5604/01.3001.0014.8482

[6] C.-Y. Chung, S.-S. Hwang, S.-C. Chen, M.-C. Lai, Effects of Injection Molding Process Parameters on the Chemical Foaming Behavior of Polypropylene and Polystyrene, Polymers 13/14 (2021) 2331. DOI: https://doi.org/10.3390/polym13142331

[7] M. Moayyedian, K. Abhary, R. Marian, Gate design and filling process analysis of the cavity in injection molding process, Advances in Manufacturing 4/2 (2016) 123-133. DOI: https://doi.org/10.1007/s40436-016-0138-5

[8] M. Moayyedian, K. Abhary, R. Marian, Improved gate system for scrap reduction in injection molding processes. Procedia Manufacturing 2 (2015) 246-250. DOI: https://doi.org/10.1016/j.promfg.2015.07.043

[9] P. Xie, F. Guo, Z. Jiao, Y. Ding, W. Yang, Effect of gate size on the melt filling behavior and residual stress of injection moulded parts, Materials and Design 53 (2014) 366-372. DOI: https://doi.org/10.1016/j.matdes.2013.06.071

[10] N. Zhang, Q. Su, S.Y. Choi, M. Gilchrist, Effects of gate design and cavity thickness on filling, morphology and mechanical properties of microinjection mouldings, Materials and Design 83 (2015) 835-847. DOI: https://doi.org/10.1016/j.matdes.2015.06.012

[11] A. López, J. Aisa, A. Martinez, D. Mercado, Injection moulding parameters influence on weight quality of complex parts by means of DOE application: Case study, Measurement 90 (2016) 349-356. DOI: https://doi.org/10.1016/j.measurement.2016.04.072