Observation of Polypropylene (PP) Melt Flow on Microchannel Using Polymethyl Methacrylate (PMMA) Mold

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The flow of melted plastic in microparts is an interesting area to discover. Many studies have been conducted to understand the phenomena of polymer flow in microplastic parts. One type of study is the visualization of melted polymer flow. This work focuses on the observation of the micro-flow of melted Polypropylene (PP) using transparent polymethyl methacrylate (PMMA) mold. A PMMA mold with 0.5, 0.8, and 1.0 mm diameter channels were fabricated and injected with melted PP using a custom made vertical plastic injection molding machine. The flow of the melted PP can be clearly seen through the PMMA transparent mold. The result of the experimental are compared with a result from finite element analysis (FEA) software, MoldFlow Part Advisor. The result shows a good agreement for 1.0 and 0.8 mm channels, but not for the 0.5 mm. It can be concluded that, the analysis software is not capable of predicting the flow for 0.5 mm channel and less.

Keywords Flow visualization; Polymethyl methacrylate (PMMA) mold; Polypropylene (PP); Vertical injection molding machine.

INTRODUCTION

Injection molding is very important and popular in polymer processing technology for mass production of complex plastic parts with excellent dimensional tolerance. This process is widely used in industries to produce molded products with high productivity and high precision at low cost. It is a process of forming plastic into a desired shape by forcing the plastic melt under pressure and specific temperature into a cavity [1].

Microinjection molding is a branch of injection molding, dedicated to the fabrication of microscale plastic components [2]. This process is getting more attention nowadays, and determination of different technological issues for its processing has become more interesting [3]. Although the process cycles are still the same, there is a complex interplay between the melted plastic flow, processing conditions, mold, machine, and material properties. The combination of all these factors determines the successful output of the microplastic part.

A lot of work has been done to investigate the polymer flow inside the mould cavity. Bociga and Jaruga [4] have explained the method that can be used to observe the polymer flow in injection mould. Melt flow in injection mould can be distinguished in the following ways:

1. Moulds with transparent cavity walls;
2. Short shots;
3. Gate magnetization method;
4. Pigment as flow marker;
5. Filler as flow marker.

Sato and Yokoi [5] listed down the requirements for a visualization mold with windows to observe the melt flow dynamically inside the cavity:

1. The nonmetal material of the transparent windows should have little influence on the melt flow inside the cavity;
2. The melt behavior can be observed continuously from the gate to the end of the cavity;
3. The visualization mold should have the same cavity as practical molds;
4. The melt can be observed from the side and the front of the flow;
5. The mold has high durability.

In their work, they developed a visualization mold to observe a polymer flow of rectangular cavity for a dual in-line package. The gate was located at the center of the shorter side of the rectangular cavity, which made the melt flow symmetric and facilitated the observation and the image analyses. The window was made of quartz glass to achieve high durability, enough to withstand standard molding conditions such as temperature of about 180°C and pressure of about 8 MPa.

Yokoi et al. [1] developed a system to measure the flow front position dynamically, to observed flow front area, and to track the flow automatically. The developed tracking system allows observation of the flow front behavior at flow front velocities up to 350 mm/s. Dynamic visualization technique also been used by Yang and Yokoi [6] to analyze the flow behavior of core material in a plastic sandwich injection molding. This study demonstrated that the visualization technique is an effective method for analysis of the core flow behavior in sandwich molding injection.

Dvorak et al. [7] observed the melted polymer flow during injection stage with the use of mould with transparent