STUDY OF CAVITY SURFACE EFFECT TO THE PLASTIC FLOW

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ABSTRACT

The cavity surface of the mould will give an effect to the plastic flow during injection. The project is to experiment the effects of the various surface roughness to the plastic flow during injection. The parameters included the cavity roughness, feeding design and metering parameters. The surface roughness can be determined by surface comparator and machine by Electrical Discharge Machining (EDM) die sinking. Cavity pressure can be determined by cavity pressure sensor. Mould is designed by using 3D software and analyse by Moldflow software. Result obtained by Moldflow software need to be compared to the experimental to validate it.

ABSTRAK

Permukaan acuan akan memberi kesan kepada aliran plastik semasa suntikan. Projek ini adalah untuk mengkaji kesan pelbagai kekasaran permukaan kepada aliran plastik semasa suntikan. Parameter yang dikaji termasuk kekasaran rongga, parameter reka bentuk dan pemeteran. Kekasaran permukaan boleh ditentukan oleh perbandingan permukaan dan dimesin dengan menggunakan mesin pelepasan elektrik ‘die-sinking’. Tekanan rongga boleh ditentukan oleh alat pengesan tekanan. Acuan direka dengan menggunakan perisian 3D dan dianalisis oleh perisian Moldflow. Keputusan yang diperolehi oleh perisian Moldflow perlu dibanding dengan eksperimen sebenar untuk pengesahan.

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LIST OF SYMBOLS

^{o}C	Celcius
μ	Micron

LIST OF ABBREVIATIONS

3D	Three-dimensional
ASTM	American Society for Testing and Materials
CAD	Computer Aided Design
CPVC	Chlorinated Polyvinyl Chloride
EDM	Electrical Discharge Machining
ESC	Environmental Stress Cracking
PA	Polyamide
PE	Polyethylene
POM	Polyoxymethylene
PP	Polypropylene
PVC	Polyvinyl chloride
PVDF	Polyvinylidene fluoride
STL	STereoLithography
UV	Ultraviolet

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter is discussed about the project background, the problem statement, the objectives of the project and the project scope.

1.2 PROJECT BACKGROUND

Surface roughness plays an important role in filling the molten plastic into the cavity (Ahsan, 2009). Surface roughness are expressed as deviation of the results of various machining operations. Machined surface quality is characterized by precision manufacturing with dimensions specified by the designer. Every machining operation leaves evidence on the characteristics of machined surfaces. This evidence is in the form of micro-fine irregularities left by the cutting tool. Each type of cutting tool leaves its own pattern of individuals can be identified. This pattern is known as surface finish or surface roughness.

For this project, the main objective is to determine the effects of the various surface roughness to the plastic flow during injection. Different surface roughness gives different effects to the plastic flow. There are several parameters that should be considered and controlled which are injection pressure, surface roughness and different thickness of the film gate while constant parameter is the size of the runner. Choosing the best surface roughness is really important to produce very fine product. . Electrical Discharge Machining (EDM) Die Sinking will be used to differentiate the surface roughness based on the surface gauge comparator. There will be three different surface roughness in this project. Each one of the surface roughness will have three different gate thickness design.

1.3 PROBLEM STATEMENT

The terms surface finish and surface roughness are used very widely in industry and are generally used to quantify the smoothness of a surface finish. Surface finish could be specified in many different parameters. Due to the need for different parameters in a wide variety of machining operations, a large number of newly developed surface roughness parameters were developed (Mike, 1998). To determine the best surface roughness, there are many parameters should be considered such as injection pressure and the gate size. To overcome this problem, this research will help the manufactures to predict the correct combination of parameters without wasting their production time because the main purpose of this research is to determine the effects of cavity surface roughness to the plastic flow.

1.4 OBJECTIVE

1.4.1 The objectives of this project are:

- To determine effects of cavity surface roughness to the plastic flow.
- To determine the suitable injection parameters.
- To determine the effect of different thickness of gate to the plastic flow.

1.4.2 Impact

This research can be used in the manufacturing field for melt plastic flow examination in the case of more complicated cavities and can help when having some problems in processing because of part design. This research can help the machinist to increase the productivity and can reduce troubleshooting time.

1.5 SCOPE OF THE PROJECT

This project will be carried out by the specific software and machine in the process of designing the cavity. The research is limited to know the effect of cavity surface roughness to the plastic flow by changing the parameters such as roughness, injection parameters and types of gate. The software used are CAD modelling and , Moldflow while for the machines are milling machine and surface grinding machine.There are several limitations in this project which are:

i. Determine the best gate thickness for the film gate. Thickness of the gate plays an important role for the molten plastic to flow into the cavity. If the thickness is not suitable, the molten plastic might not fill the cavity totally. In order to know what thickness is the best, many experiments have to be conducted. Other parameters should also be considered such as injection pressure.

ii. Determine the injection pressure inside the cavity. Pressure inside the cavity can be measured by mold cavity pressure sensor only. To use the sensor some wiring need to be done and the sensor have to be embedded to the mold.

iii. The simulation software can not show exactly the defects that will occur. The software just can show the defects that might occur on the product. Real experiments have to be conducted in order to know the real defects.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will provide the article review for this final year project. The article review is about material flow, Die Sinking Electrical Discharge Machining (EDM), Injection Moulding Machine and Polypropylene (PP).

2.2 MATERIAL FLOW

2.2.1 Fundamental of Mold Flow

The material flow in mould runners can be controlled by the design and manufacturing technology of the mould as well as by the processing conditions in order to obtain the moulded parts with expected morphology, properties, shape, dimensions and surface (Bociaga, 2011). There are many parameters need to be considered in the plastic material flow but in this project, there are two parameters that need to be considered which are surface roughness and the thickness of the film gate because the other parameters are constant.

2.2.2 Surface roughness

The challenge of modern machining industries is mainly focused on the achievement of high quality, in terms of work piece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product with reduced environmental impact. Surface roughness plays an important role in many areas and is a factor of great importance in the evaluation of machining accuracy (Subramanyam, 2010). When the thickness of a cavity is decreased until the roughness is comparable to the dimension of the cavity, the effects of surface roughness become increasingly important (Ong, 2009).

Mould surface roughness effects on the cavity filling of polymer melt were investigated experimentally. With the same process parameters, the mould cavity that has a higher surface roughness will result in a smaller moulded part with higher surface roughness. This is due to the higher resistance to the flow of polymer melt during cavity filling. For the limited range of injection rate investigated, it is not significant on the surface roughness effects. When the melt temperature is kept constant, an increase in mould temperature will decrease the effects of surface roughness. When the mould temperature is kept constant, the change of melt temperature within the range allowed by the process is not significant for the surface roughness effect. (H. L. Zhang, 2008).

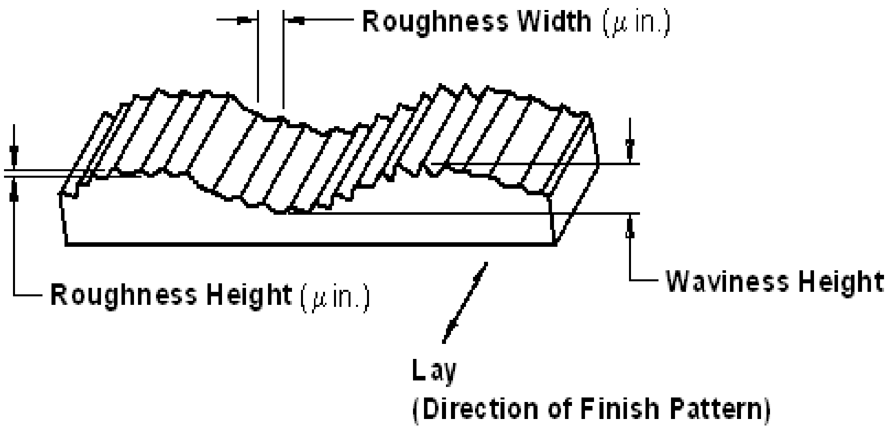

Figure 2.1: Surface characteristic and terminology

Source: Subramanyam 2010

2.2.3 Effects of cavity surface roughness

Cavity surface roughness can play a significant role in the cavity filling process. Researches show that the cavity surface roughness can influence the cavity filling process. The major reasons are:

1. Enhanced heat transfer rate. With an increase of surface roughness, the contact area between molten plastic and mould wall increases. Therefore, heat transfer between them is enhanced as heart transfer rate that is proportional to the contact surface area.

2. Reduced slippage. Rougher cavity surface led to a more stable flow of molten plastic and a more cosmetically appealing surface on the moulding. It is better to create a mould with a rougher surface to prevent slippage during filling (Christian D. Smialek, 2001).
3. Effects on turbulence in the molten plastic flow. There is a relationship between tool surface finish and the level of turbulence in the melt flow by varying the process parameters such as melt and mold temperature and injection speed (C A Griffiths, 2007).

   The applications of surface roughness are in the automotive industries that often involve sliding components. Another application is in shipbuilding, specifically ship hull surfaces and propeller. The surface roughness of these components should be on the order of several micrometers for hydraulically smooth surfaces in high speed ships.

2.2.3 Film or flash gate

A film or flash gate consists of a straight runner and a gate land across either the entire length or a portion of the cavity. It is used for long flat thin walled parts and provides even filling. Shrinkage will be more uniform which is important especially for fiber reinforced thermoplastics and where warpage must be kept to a minimum.

The even cavity filling depends on the design of runner system which are the number of injection points and their locations, the shape and dimensions of runners and gates, the accuracy of runner system manufacturing and the shape and dimensions of injection moulded parts including the wall thickness and its distribution in the part (Kuldeep 2010).

The dimension of the film gate size is small, typically 0.25mm to 0.6mm thick. The gate length must also be kept small, approximately 0.6 to 1.0 mm long depend on the size and weight of the product.

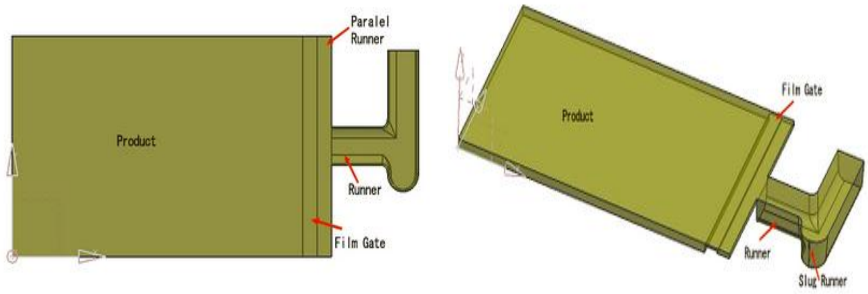

Figure 2.2: Film gate with main parts

Source: Kuldeep 2010

2.3 DIE SINKING ELECTRICAL DISCHARGE MACHINING (EDM)

2.3.1 History

The history of EDM Machining Techniques goes as far back as the 1770s when it was discovered by an English Scientist. However, Electrical Discharge Machining was not fully taken advantage of until 1943 when Russian scientists learned how the erosive effects of the technique could be controlled and used for machining purposes.

When it was originally observed by Joseph Priestly in 1770, EDM Machining was very imprecise and riddled with failures. Commercially developed in the mid 1970s, wire EDM began to be a viable technique that helped shape the metal working industry we see today. In the mid 1980s.The EDM techniques were transferred to a machine tool. This migration made EDM more widely available and appealing over traditional machining processes (Shailesh, 2010).

2.3.2 Fundamental

Electrical discharge machining (EDM) is one of the earliest non-traditional machining processes. EDM process is based on thermoelectric energy between the workpiece and an electrode (Kuldeep 2010). Electro-Discharge Machining (EDM) is a metal removal process by means of electrical energy released by spark discharges occurred between an electrode and the workpiece with electrical conductivity to produce a desired -shaped form in a work-piece. The electrode is moved downward toward the work material until the spark gap that is the nearest distance between both electrodes small enough so that the impressed voltage is great enough to ionize the dielectric. Short duration discharges measured in microseconds are generated in a liquid dielectric gap, which separates tool and work piece. The material in the form of debris is removed with the erosive effect of the electrical discharges from tool and work piece. EDM does not make direct contact between the electrode and the work piece where it can eliminate mechanical stresses chatter and vibration problems during machining (Anand, 2010). EDM Die-sink uses a copper or graphite to produce an electrode that is a reversed shape of the final product.

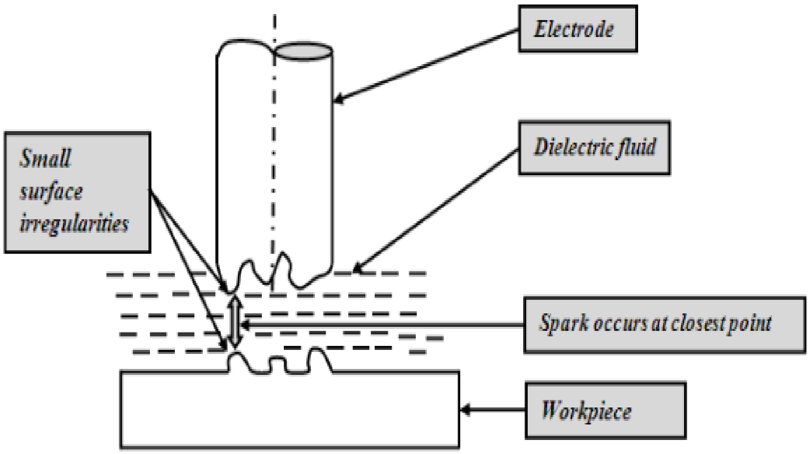

Figure 2.3: Working principle of EDM

Source: Kuldeep 2010

2.3.3 Applications

Die sinking electrical discharge machining (EDM) is one of the most widely used techniques for the fabrication of die and mold cavities which are finally used for mass production of metals and polymer products by replication such as die casting and injection molding. In any replication process, it is expected that the quality mold will faithfully duplicate its shape and surface texture (Ahsan, 2009). EDM process find application in various fields such as the automotive, medical, aerospace, electrical and electronic industries.

2.4 INJECTION MOULDING MACHINE

2.4.1 Fundamental

In recent years, plastic injection moulds are widely used for producing products in various areas, such as aerospace, automotive, medical, electronics, and toys. The quality of these products depends on the moulding parameters chosen. However, as the wall thickness of plastic parts decreases, the injection moulding operation becomes more difficult. During the production process, numerous factors cause defects in the products, such as warpage, shrinkage, sink marks, and residual stress, which are detrimental to the quality and accuracy of the products. Therefore, it is crucial that the influencing factors are kept under control during the moulding procedure (Cebeli Ozek, 2012).

The injection moulding process requires the use of an injection moulding machine, raw plastic material and a mould. These machines consist of two basic parts, an injection unit and a clamping unit. The plastic is melted in the injection moulding machine and then injected into the mould, where it cools and solidifies into the final part. In this process, hot molten polymer is forced into a cold empty cavity of a desired shape and is then allowed to solidify under a high holding pressure. The entire injection moulding cycle can be divided into three stages: filling, post-filling and mould opening.

The injection moulding industry, the setting of machine process parameters has crucial effects on the quality of products. Injection moulding manufacturers have to obtain the optimal conditions for process parameters before they can produce faster, cheaper and better quality product. Unsuitable machine process parameter settings can cause production and quality problems, long cycle times and high production costs. Final optimal process parameter setting is one of the most important steps in injection moulding for improving the quality of moulded products Injection moulding processes are affected by numerous parameters and it is not possible to identify the effects of all these parameters. Therefore it is necessary to select the parameters that have major effects on the output.

Some of the potential parameters for an injection moulding process might be the material drying temperature, injection pressure, barrel temperature, injection time, pack pressure, holding pressure, cooling time, mould temperature, injection speed and others. In moulding industry, the machine set-up technician will choose the inputs of machine process parameters and the outputs will depend on the product drawing and customer requirements (S. Rajalingam, 2012).

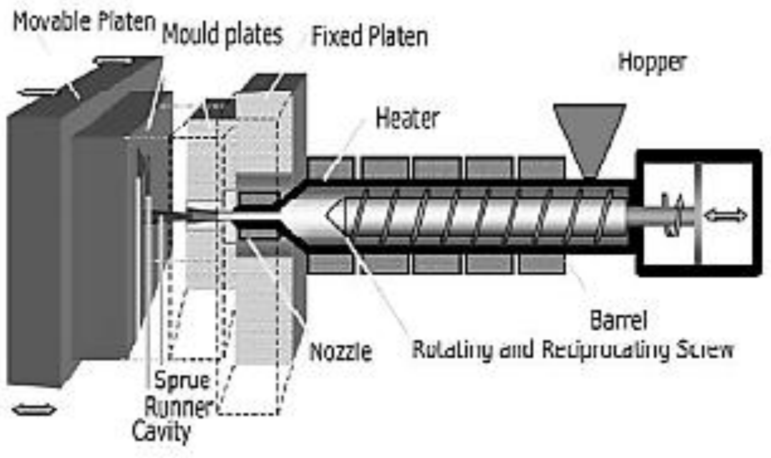

Figure 2.4: Injection molding machine with reciprocating screw

Source: S. Rajalingam 2012

In injection moulding process, cavity pressure is the key factor to the product's quality and efficiency. If the cavity pressure can be momentarily measured and monitored, it will provide evidence for the setup of V=P changeover and the end of packing process, and so will help to cut the cost, shorten the moulding period, save the mould and reduce the energy consumption. In the meantime, the study of cavity pressure and melt flow characteristics during injection moulding can provide useful data for evaluating the polymer's process ability in injection moulding and designing the process technology. Some progress has been made in the simulation and control of the cavity pressure (Wu Hong-wu, 2007).

Manual ejection of the mould also added some variability into the process. Several parts were plastically deformed while being removed, and gates and runners were occasionally broken as well. If flatness were an important criterion being considered, manual ejection would have caused a major effect on the response. In addition, manual ejection caused some variability in the cooling time of the part. This is because the mould cannot be removed and opened manually in a consistent amount of time (A. Ghose, M. Montero, D. Odell).

2.4.2 Defects

In the injection molding process, hot melt of plastic is forced into a cold empty cavity of desired shape called mold. Then, the hot melt is allowed to solidify. Solidified net shape product is ejected out of the mold upon opening. Although the process is simple, prediction of final part quality is a complex phenomenon due to the numerous processing variables. Common defects in injection molding process can be classified in to two ways. They are:

1. Dimensional related
2. Attribute related

Dimensional related defects can be controlled by correcting the mold dimensions. But, attribute related defects are generally dependent on the processing parameters. Some of the common attribute related defects are splay marks, sink marks, voids, weld/meld lines, poor surface finish, air traps and burn marks. (D. Mathivanan, 2010).

2.4.3 Mould project in plastic injection mould industries

In the local mould-making industries, a large quantity of data is always involved in every mould project. Mould data consist of data from the plastic product, the mould design, mould manufacturing and mould testing. Additional data for every mould project would also include the information of the costs involved in that particular mould project.

The workflow of a mould project can be categorized into three main areas which are mould design, mould manufacturing and mould testing. Within each of these main areas, they can be broken down into stages and subsequently, be broken down further into phases, within each stage. Figure 2.5 shows a general flowchart to depict the main stages of a mould project in a typical mould-making industry. It can be seen that if the start of the mould project were successful, it would then proceed on to have an initial design stage followed by a detailed design stage. After the mould design, the tool start can begin and the components are manufactured and assembled. The assembled mould