UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF INJECTION MOULDING PARAMETERS ON MATERIAL CHARACTERISTIC OF TWO PLATE MOULD WITH DIFFERENT MATERIAL USING FLOW ANALYSIS

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Process) (Hons.)

by

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TAJUK: **Effect of Injection Moulding Parameters on Material Characteristic of Two Plate Mould with Different Materials Using Flow Analysis**

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process) (Hons.). The member of the supervisory is as follow:

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(Project Supervisor)

ABSTRAK

Pada masa kini, bahan-bahan plastik adalah salah satu bahan yang paling penting dimana mempunyai permintaan yang tinggi dalam mewujudkan pelbagai produk. Dalam pengacuan suntikan, proses parameter memainkan elemen penting kerana ia memberi kesan kepada kualiti produk. Projek ini mengkaji tentang kesan parameter pengacuan suntikan pada ciri-ciri bahan dua plat acuan dengan bahan yang berbeza dengan menggunakan analisis aliran. Ia memberi tumpuan kepada kesan parameter pengacuan suntikan pada setiap tindak balas produk iaitu *volumetric shrinkage at ejection, fill time, in-cavity residual stress* dan *deflection* dengan menggunakan *Moldflow* simulation *software*. Parameter yang telah dipilih dalam kajian ini ialah *mould temperature, melt temperature, injection time* dan *cooling time*. Kemudian, parameter di optimumkan bagi setiap tindak balas dengan menggunakan *Taguchi method* dan *Analysis of Variance (ANOVA).* Bahagian plastic yang dipanggil *dumbbell* juga telah direka oleh perisian *CATIA*. Bahan yang digunakan dalam projek ini adalah Polypropylene (PP) dan Polypropylene yang dipenuhi Talc. Ia didapati bahawa, nilai terendah bagi setiap tindak balas untuk bahan PP menunjukkan *deflection* pada uji kaji ke 9, *fill time* pada uji kaji pertama, *volumetric shrinkage* pada uji kaji pertama dan *residual stress* pada uji kaji ke 3. Manakala bagi PP dipenuhi Talc menunjukkan nilai yang paling rendah bagi *fill time* pada uji kaji pertama, *deflection* pada uji kaji ke 8, *volumetric shrinkage* pada uji kaji ke 7 dan *residual stress* pada uji kaji ke 3. Melalui ANOVA, ia menunjukkan bahawa melt temperature adalah parameter yang memainkan peranan penting bagi proses pengacuan suntikan.

ABSTRACT

Nowadays, plastic materials are one of the most important materials having high demand in creating various products. In injection moulding, process parameters play an important element since it give an impact to the quality of the product. This project studies the effect of injection moulding parameters on material characteristic of two plate mould with different material using flow analysis. It focuses on the effect of injection moulding parameters on the each response which are volumetric shrinkage at ejection, fill time, in-cavity residual stress and deflection by using Moldflow simulation software. The parameters that have been selected in this study were melt temperature, mould temperature, injection time and cooling time. Then optimization of parameters for each response was find by using Taguchi method and Analysis of Variance (ANOVA). The dumbbell of plastic part was designed by CATIA software. The material used in this project are Polypropylene (PP) and Polypropylene filled Talc. It is found that, the lowest value of each response for material PP shows deflection at run 9, fill time at run 1, volumetric shrinkage at run 1 and residual stress at run 3. While for PP filled Talc shows the lowest value of fill time at run 1, deflection at run 8, volumetric shrinkage at run 7 and residual stress at run 3. Through ANOVA, it shows that melt temperature is the significant parameter for injection moulding process.

DEDICATION

All the hard work is only for you :

Abd Rahman bin Omar

Pajariah binti Samsi

Nurezzatul Hajar

Farah Faezah

Muhammad Khairul Iman

Nur Najiha Azwa

Muhammad Fakrul Iqbal

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AMI	-	Autodesk Moldflow Insight
ANOVA	-	Analysis of Variance
CAD	-	Computer Aided Design
DOE	-	Design of experiment
HDPE	-	High Density Polyethylene
LDPE	-	Low Density Polyethylene
MFR	-	Mass flow rate
PA	-	Polyamides
PE	-	Polyethylene
PP	-	Polypropylene
S/N Ratio	-	Signal to noise ratio

CHAPTER 1
INTRODUCTION

This section explains about background, objective, problem statement and the scope of the final year project. Then, ends up with the organisation of this final year report. Background discusses about the injection moulding machine, plastic material and the software used. While the objective mentions about the mission that needed to be achieved for this project and the scope covers everything what is supposed to perform in this project.

1.1 Background

Nowadays, plastic materials are one of the important materials having high demand in creating various products. To produce a product by using plastic material, it can be formed by using various processes such as moulding, shaping and forming process. But in moulding process, the demand for using injection moulding process is higher since the cost is low (Tábi et al., 2015). Besides of the cost, injection moulding is widely used due to its productivity in producing product and it also has ability to making a complex shapes (Ciofu & Mindru, 2013). For examples, many internal and external components parts of car nowadays produce from plastic materials (Ciofu & Mindru, 2013). Not only that, plastic industry can be used in clothing, packaging, electronics and any others.

Injection moulding is a process to make a parts or product from thermoplastic and thermosetting plastic where the shape of product is followed the mould (Kamaruddin, Khan, & Foong, 2010). Thermoplastic is widely used due to price is cheap. This material is easily soften when heated and back to the original condition when it cooled. Thermoplastic can give similar property as a metal when it heated repeatedly and cooled. While for the mould, usually, the toolmakers will make the mould that design by industrial engineer. The mould is usually made from aluminium or steel. To design the mould, the designer is usually used various Computer Aided Design (CAD) software such as AutoCAD, Solidworks, CATIA and Unigraphic software (Amran Ali, 2006).

In designing a mould, gate design is very important. In other word, in order to get a good injection moulding, the gate positioning must be good location. The location of gate is importance because between the runner and the cavity is a transition zone. The position of gate gives a result to the appearance and the properties of finished part (John P.Beaumont, 2007). To have a successful injection moulding is not based on the gate design only, but part design, mould design and the processing parameter also play an important role (John P.Beaumont, 2007).

In an injection moulding process, the parameter plays an important role in production of plastic, thus the control of process parameter is essential (Singh, Pradhan, & Verma, 2015). The process parameter such as melt temperature, mould temperature, injection time, cooling time and so on need to be optimized in order to have a lower value on response such as deflection, residual stress, fill time and shrinkage.

Autodesk Moldflow software is one of the flow analysis simulation software that can help to reduce the number of plastic defects (Lau & Azuddin, 2013). By using this software, plastic part and injection moulding process can be optimized by showing the changes on wall thickness, gate location and type of plastic materials that affect manufacturability. Further, nowadays, design of experiment (DOE) is used as method to achieve good quality of plastic product by minimizing the plastic defect. One of the DOE method is using Taguchi Method and help by Analysis of Variance (ANOVA), where it will give an output that can solve the problem.

This project uses flow analysis simulation software to simulate the mould having single gate and twin gate. The injection moulding parameters such as melt temperature, mould temperature, cooling time and also injection time are optimized on the reducing the output of the responses such as shrinkage, deflection, residual stress and filling time. The DOE method using Taguchi and ANOVA are implemented to design the experimental matrix and to optimize the level of input parameter. Meanwhile, ANOVA is needed to find the most significant parameter affected the responses.

1.2 Problem Statement

In injection moulding process, process parameter plays an important element since it give an impact to the quality of the product and the productivity of injection moulding. This research investigates and analyses the effect of mould temperature, melt temperature, injection time and cooling time on the response of deflection, shrinkage, fill time and residual stress of two plate mould. To overcome this problem, moldflow simulation software is used to optimize the process parameter in order to reduce the response in an injection moulding process. Design of Experiment is used to find the optimum parameter.

1.3 Objective

The main objective for this study is to reduce the effect of processing parameters on volume matrix shrinkage, warpage deflection, residual stress and filling time in two plate injection mould that having single and twin gate by using flow analysis simulation software.

i. To design plastic part having single and twin gate for dumbbell plastic injection mould.
ii. To investigate the input parameters in an injection moulding such as melt temperature, mould temperature, cooling time and injection time on the output

responses such as volume matrix shrinkage, warpage deflection, residual stress and filling time.

iii. To optimize the processing parameters by using Taguchi Method and Analysis of Variance (ANOVA).

1.4 Scope

This project uses two plate injection mould. The plastic product has different number of gate which one of the part plastic part used one gate system and the other part used two gate. The experimental matrix and optimization input level of this experiment used Taguchi Method and Analysis of Variance (ANOVA). For the design of mould, Computer Aided Design (CAD) software is used. Plastic materials used was Polypropylene and Polypropylene added with talc that available in Moldflow software. From the simulation result, data are analysed using Taguchi design in order to determine the significant parameter to the output responses such as volume matrix shrinkage, warpage deflection, residual stress and filling time.

1.5 Organisation of Final Year Project

i. Chapter 1 is an Introduction chapter that explains about the background of this project, the problem and objective that must be achieved by follow the scope that has been identify.

ii. Chapter 2 is a Literature Review that explains on related to this project that has been done by various previous researcher.

iii. Chapter 3 is a Methodology is an overview of study which explain on how the project is done by discussing the process and method that to be used.

iv. Chapter 4 is a Result and Discussion that explains on the result of data that has been get from the software.

v. Chapter 5 is a Conclusion and Recommendation is an overview of the overall of project that has been done.

CHAPTER 2
LITERATURE REVIEW

This chapter basically reviews about the theory of plastic injection moulding process. It discusses about type of plastic material used, type of gate and flow analysis simulation software.

2.1 Injection Moulding Machine

The idea of plastic injection moulding was initially created by John Wesley Hyatt in 1868, in light of test from an organization looking for an option material for ivory. The main material accessible for preparing were thermosets. Polystyrene was initially grown financially by BASF in 1930 and later in the United States by Dow Chemical in 1937. These days, present day injection moulding was conceived. Numerous consider the reciprocating screw the absolute most critical commitment that changed the plastics business in the twentieth century (Cybulski, 2009).

Injection moulding as shown in Figure 2.1 is a process to make a parts or product from thermoplastic and thermosetting plastic where the shape of product is followed the mould. It is done by the polymer that inserted to heated chamber by hopper. Later, the material will be heated since the screw at the barrel produce shear to heat the material. As the polymer melt with the constant pressure, the polymer then pumped out to the mould by the reciprocating screw (Andrisano,2011). Polymer will be inserted to mould through the sprue bushing then polymer flow to the gate by runner system. The

pressure must be constant to ensure the polymer did not flowing back out the cavity until the gate is solidify.

During the cooling part of the cycle after the gate has solidified, plastication happens. Plastication is the procedure of melting material and setting up the following shot. The material starts in the hopper and enters the barrel through the feed throat. The food throat must be cooled to keep plastic pellets from melting from the barrel heat. At the front of the screw is the non-return valve which permits the screw to go about as both an extruder and a plunger (Rutkauskas & Bargelis, 2007). At the point when the screw is moving in reverse to manufacture a shot, the non-return assembly permits material to flow in front of the screw making a melt pool or shot. During injection, the non-return get together keeps the shot from flowing once more into the screw areas. When the shot has been assembled and the cooling time has timed out, the mould opens.

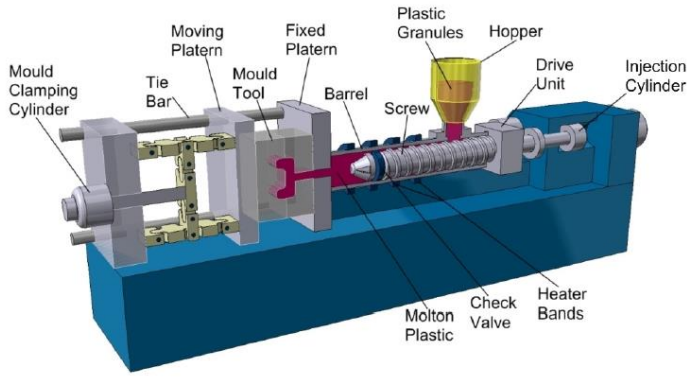

Figure 2. 1 : Injection Moulding Machine (Groover, 2010)

2.2 Injection Moulding Machine Component

Injection moulding component machine consist of hopper, barrel, screw and the nozzle.