Faculty of Manufacturing Engineering

COMPARISON OF PROPERTIES OF POLYPROPYLENE/ FIBER GLASS IN INJECTION MOULDING PROCESS USING DIFFERENT GATE LOCATIONS

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2018

DECLARATION

I declare that this thesis entitled "Comparison of Properties of Polypropylene/Fiber Glass In Injection Moulding Process Using Different Gate Locations" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	....
Name	:	....
Date	:	....

DEDICATION

I am dedicating this work to my beloved parents Balai Anak Ramping and Terusa Anak Blalang, who always inspire and support me with their boundless love to work hard for the things that I aspire to achieve

ABSTRACT

This project investigates the mechanical properties of polypropylene filled with fiber glass in injection molding process using single and twin gate locations. The objective of this study is to compare the mechanical properties of polypropylene filled with fiberglass having the difference gate location injected by injection molding machine using Taguchi method. The investigated mechanical properties were tensile strength, modulus strength and percentage of elongation. The effect melt temperature, holding pressure, injection time and cooling time on the mechanical properties of the material were studied. L9 orthogonal arrays with 3 replications were done with 27 totals of specimens for each gate location. The result collected was optimized using Taguchi method and P-value and R-square were calculated using analysis of variance (ANOVA). According to the result analysis, it is found that single gate location shows good in tensile strength and percentage of elongation. The significant factors that affected the tensile strength are cooling time, injection time, holding pressure and melt temperature .The significant factors that affected the percentage of elongation is melt temperature followed by cooling time, holding pressure and injection time. Meanwhile, twin gate location shows the highest modulus of strength. The significant factors that affected the modulus strength are cooling time, melt temperature, holding pressure and injection time . Thus, this result shows that in twin gate location, fiberglass in polypropylene melt penetrate in between gate location, as result modulus strength in twin gate greater then single gate. Meanwhile, in single gate location, one-way flow of fiber glass in dumbbell test specimen which resulted the tensile strength and percentage of elongation higher than twin gate location

ABSTRAK

Kajian ini adalah mengenai perbezaan ciri-ciri mekanikal penambahan gentian kaca ke dalam polipropilena di proses suntikan acuan dengan mengunakan laluan tunggal dan laluan berkembar. Jadi objektif pembelajaran ini ialah untuk membandingkan ciri-ciri mekanikal penambahan gentian kaca ke dalam polipropilena yang mempunyai laluan berbeza dengan mengunakan kaedah Taguchi. Ciri-ciri mekanikal yang dikaji adalah kekuatan tegangan,modulus kekuatan, dan peratus pemanjangan. Parameter yang telah ditetapkan untuk proses suntikan plastik adalah suhu pencairan,tekanan pegangan masa suntikan, dan masa penyejukan.L9 pelbagai ortogon dengan 3 replikasi dibuat untuk 27 jumlah sample bagi setiap laluan. Hasil ujian ketegangan seterusnya dianalisis oleh perisian Minitab 17 menggunakan kaedah taguchi dan analisis ANOVA. Hasil kajian mendapati kekuatan tegangan dan peratusan pemanjangan untuk laluan tunggal adalah lebih baik dari laluan berkembar. Manakala kekuatan tegangan modulus adala lebih baik bagi laluan berkembar. Faktor signifikan yang mempengaruhi kekuatan tegangan ialah masa penyejukan diikuti masa suntikan,tekanan pegangan dan suhu pencairan.Faktor signifikan yang mempengaruhi peratusan pemanjangan ialah suhu pencairan diikuti masa penyejukan, tekanan pegangan dan masa suntikan. Faktor signifikan yang mempengaruhi kekuatan pegangan modulus ialah masa penyejukan diikuti suhu pencairan, tekanan pegangan dan masa suntikan. Oleh itu, keputusan ini menunjukkan bahawa di laluan kembar, gentian kaca dalam polipropilena mencairkan menembusi di antara lokasi gerbang, maka kekuatan modulus hasil dalam laluan kembar lebih tinggi berbanding pintu tunggal. Sementara itu, di laluan tunggal, satu arah aliran kaca serat dalam spesimen ujian dumbbell yang menghasilkan kekuatan tegangan dan peratusan pemanjangan yang lebih tinggi daripada laluan kembar.

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LIST OF ABBREVIATION, SYMBOL AND NOMENCLATURES

PP	-	Polypropylene
ANOVA	-	Analysis of Variance
UTM	-	Universal Testing Machine
DoE	-	Design of Experiment
FKP	-	Fakulti Kejuruteraan Pembuatan
MeT	-	Melt Temperature
HP	-	Holding Pressure
It	-	Injection Time
Ct	-	Cooling Time
Avg.	-	Average
%	-	Percentage
˚C	-	Degree of Celcius
MPa	-	Mega Pascal
s	-	Second
No.	-	Number
E	-	Young Modulus
F	-	Force
L	-	Original length
A	-	Area
ΔL	-	Changes in length

CHAPTER 1

INTRODUCTION

1.1 Project Background

Injection molding is known as the most important process for processing the mass production of plastic product in the complex shape and sizes with high precision. Nowadays, the production of injection molded plastic project has been increased rapidly. This is because the plastic products are relatively easy to mold into complex shapes, low in cost, lightweight and low energy requirement for processing compare to the metal (Ciofu and Mindru, 2013). Various types of plastic materials can be used to produce plastic one of them is polypropylene (PP). PP is known as one of the most popular plastic material. PP is a thermoplastic polymer resin. PP is much preferable compare to other type of plastic material because PP is easy to be processed and consumes less cost. The example of products that has been produced from PP is packaging, household appliances, etc.

In the injection molding process, the gate location should be considered when designing the mould. According to Yatish and Nagaraja (2014), the selection of gate location will affect the manner of the material flows into the mould cavity. Besides, location of the gate also affects the quality of injection molding process. Gates have a bigger impact on the final dimension of the part and its performance. When twin gate location is used the filling pattern is much better than in single gate but, it will form the weld line in the middle of parts as shown in Figure 1.1. Formation of weld line will affect the mechanical property of the part (Robert, 1994). Based on Gurjeet Singh et al., (2015), the other process parameters that affect the quality of injection molding are such as injection time, injection time, packing pressure, cooling time, packing time and melt temperature. The type of defects that always be found in injection molding are like warpage, surface blemish, voids, flash jetting,flow mark and weld line (Mohamed et al., 2007).

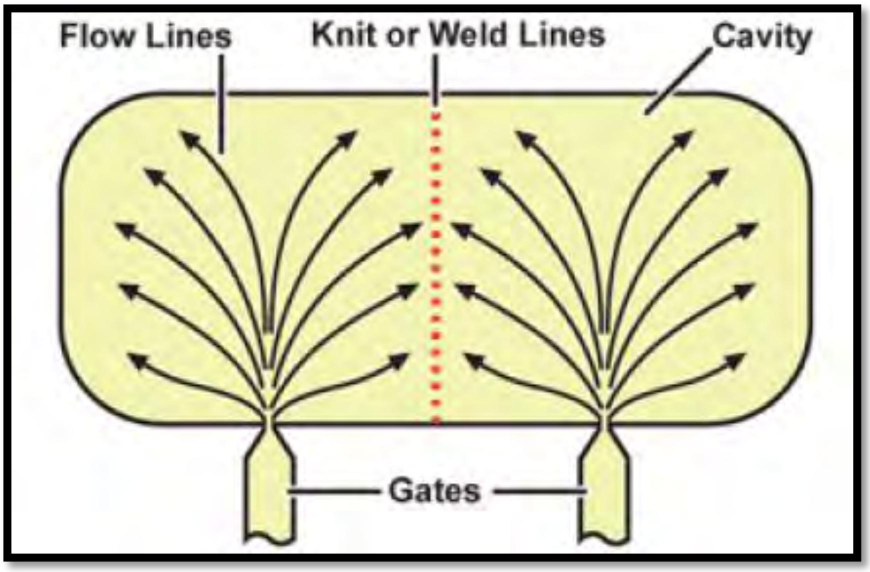

Figure 1.1: Formation of weldline (Robert, 1994)

1.2 Problem Statement

In injection molding process, the quality of product and the proper working of the mold are significantly affected by the gate location. The gate location will influence the manner of the polymer flows into the mold cavity (Shen et al., 2007). Gate location is one of the causes that affected the mechanical properties of the plastic products (Yatish and Nagaraja, 2014). The product quality can be improved by determining the better gate location. Hence, in this study the differences of gate location between single gate and twin gate are investigated. The flow front of molten plastic meets together can cause weld line marks in twin gate as compare to the single gate. Formation of weld line will affect the mechanical property of the part (Robert, 1994). Therefore, the tensile test will be used to compare the mechanical properties of single gate and twin gate location. Type of material is going to be used is polypropylene filled with fiber glass. By addition of other material such as fiber glass to the polypropylene, the mechanical properties of polypropylene may be changed.

1.3 Objectives

The main objective of this study is to compare the mechanical properties of polypropylene filled with fiber glass having the different gate location injected by injection molding process using Taguchi method

There are three sub objectives of this study, which are:

1. To investigate the effect of all responses such as tensile strength, tensile modulus and percent of elongation on each gate location.
2. To identify the most important injection molding process parameters such as melt temperature, holding pressure, injection time and cooling time on mechanical properties using analysis of variance (ANOVA).
3. To validate the optimised mechanical properties result through run of optimum parameters using Taguchi method.

1.4 Scope of Study

The scope of this study will cover on the analysis of the mechanical properties of plastic part by using injection molding process. Universal Tensile Strength machine is used to investigate the mechanical properties of the injected plastic part. The material selected for this study is polypropylene filled with fiber glass. The limitation of this project is the analysis for the gate location is only conducted by using twin gate and single gate location only. For optimization process, design of experiment (DOE) using Taguchi method and analysis of variance (ANOVA) are used to find the optimum parameters for the output responses.

1.5 Organization of the report

This master project report consists of several chapters to be completed. Chapter 1 until chapter 3 need to be completed in Master Project 1 meanwhile chapter 4 and 5 will be completed in Master Project 2. In chapter 1, introduction of the project such as background, objective and scope of study is discussed. Then, chapter 2 discusses the literature review of the study such as introduction of injection molding, mechanical properties, tensile testing, etc. Chapter 3 discusses the methodology of study which elaborates in details about the parameters selected and the procedures needed to carry out the experiment. Chapter 4 presents the data and results obtained through the experiment. Lastly, chapter 5 concludes the findings of study and recommendations for the future improvement.

CHAPTER 2

LITERATURE REVIEW

2.1 Injection Molding

Injection molding is a process of manufacturing the plastic parts based on the required specification by melting the plastic pellets and forcing it under certain pressure into sprue, runner, gate and reach to mold cavity. According to Shakkarwal and Yadav (2013), over 32% of plastic parts is produced by the injection molding process. This is due to the ability of injection molding in producing complex geometry shape with accurate dimension

Jain et al., (2003) stated that injection molding is widely used in industries such as medical, automotive and electronic sector to manufacture large amount of the plastic part. Besides, plastic injection molding also able to produce good dimensional intricate shape of the part and can be produced in finished state. Thus, injection molding process indirectly provide many advantages such as short product cycle, good mechanical properties, light weight, high quality part surfaces and low cost. Hence, it is becoming increasingly in today's plastic production industries

2.1.1 Injection molding machine

Typical injection molding as shown in Figure 1 consists of five major elements which are an injections unit, hydraulic system, mold system, clamping system and control system.

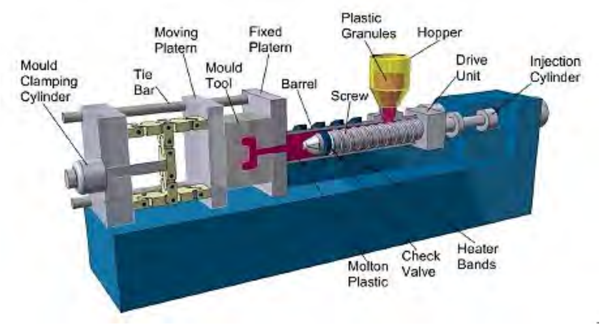

Figure 2.1: Injection molding machine (Rutland, 2007)

2.1.1.1 Injection unit

Injection unit basically consists of hopper, screw, barrel and injection nozzle (Teklehaimanot, 2011).

a) Hopper

- In the injection molding process the plastic materials are supplied in the form of a small pellet. Hence, hopper is used as the holder for the plastic pellets. After that, the pellets are gravity fed to the barrel

b) Barrel

- The main function of the barrel is to give support to the screw

c) Reciprocating screw

- Reciprocating screw is used for compressing, melting and conveying the plastic pellets. Generally, the screw is divided into three zones which are feeding zone, transition zone and metering zone. In feeding zone, there will be no changes made to the plastic pellet. Then pellets will be transferred to the transition zone. In the transition zone melting process of the pellet will be occurring and the molten plastic will be transferred to the metering zone. In metering zone the molten plastic is ready for injection. Figure 2.2 shows the three zones in screw.

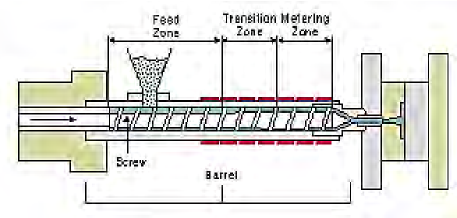

Figure 2.2: Screw Zones (Ruthland,2007)

d) Nozzle

- The nozzle is used in connecting the barrel to the sprue bushing to form a seal between the mold and barrel. The nozzle temperature must be set to the melt temperature.

2.1.1.2 Clamping unit

Clamping unit is the part of machine that carries, closed and open the mould. It provides the force required keeping the mould closed during the injection phase and it ejected the moulding plastic part once the mould is opened. The clamp unit consist of three plates or platens (Robert, 1994):

I. A stationary platen on which is mounted the half of the mould that contain runner and sprue bush.

II. A moveable plate on which is mounted the other half of the mould (the one that contains the ejection system.)

III. The tail plate.

The tie bars are used to connect all three platens together.

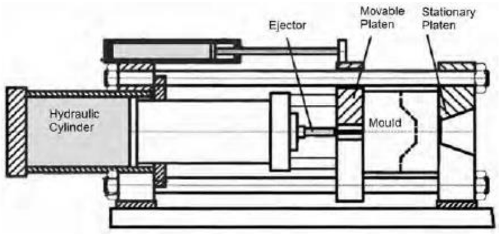

Figure 2.3: Clamping unit of injection moulding machine (Funda, 2014)

2.1.1.3 Injection Molding Mould

In the injection moulding process the mould is usually in form of cavity whereby the molten polymer is injected and solidified. Basically, mould comprises of two halves which is known as stationary half and movable half. These two halves were mounted to the mould of the clamping unit of the injection molding machine. The movable half is to eject finish part. Mould is placed in between stationary plate and the moveable plate. There are two types of mould in injection molding which are two-plate mould and three-plate mould (Osswald et al., 2008).

Table 2.1: Component in the mould (Osswald et al., 2008)

Component	Function
Cavity	Cavity is molded by eradicating the metal from the mating surfaces of the two halves. The moulds can have a single cavity or multiple cavities.
Sprue	Sprue is used to lead the melt material from the nozzle into the mould. Basically the sprue is act as the inlet channel to transfer molten material from the heating chamber into the runner system.
Runner	Runner is used to lead the melt material from the sprue to the multiple mould cavities. Runner is used as the channels to connect the sprue bush to the cavity gates. There are two types of runner system which are cold and hot.
Gates	The gate is the melts' point of entry into the mold cavity. When the injection pressure is removed, gate is used to prevent the material from flowing out.
Ejection system	Ejection system is used to eject the moulded part from the cavity. When the mould is open, the ejector pins that built into the movable plate are used to push the part out of the mould