FLAT PLASTIC PART OPTIMIZATION IN INJECTION MOULDING OF PURE POLYPROPYLENE AND POLYPROPYLENE WITH TALC USING TAGUCHI METHOD

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

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Date : 21 JUNE 2017

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Manufacturing Process) (Hons).

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(Dr. Mohd Amran bin Md Ali)

ABSTRAK

Penggunaan bahan plastik telah meningkat secara konsisten sejak 1950 dalam mencipta pelbagai produk. Pengacuan suntikan adalah mesin yang selalu digunakan untuk memproses bahan plastik. Dalam pengacuan suntikan, pemilihan parameter yang bersesuaian adalah sangat penting untuk menghasilkan produk plastik yang mempunyai kualiti yang baik dan mengikut ketepatan. Projek ini mengkaji pengoptimuman produk plastik dengan menggunakan *polypropylene* tulen dan *polypropylene with talc* sebagai bahan ujikaji. Projek ini memberi tumpuan kepada kesan parameter suntikan proses pada maklum balas iaitu berat produk dan pengecutan isipadu. Parameter yang di kaji dalam projek ini ialah suhu leburan, tekanan pegangan, masa suntikan dan masa penyejukan. Kemudian, pengoptimuman proses parameter dilakukan dengan menggunakan kaedah Taguchi dan Analisis Varians (ANOVA). Selain itu, pengoptimuman proses parameter dilakukan dengan menggunakan objektif tunggal dan multi objektif. Berat produk plastic diukur dengan menggunakan *analytical balance* manakala bagi pengecutan isipadu, nilai panjang, lebar dan ketebalan diukur menggunakan *vernier caliper*. Dari keputusan yang diperolehi, parameter yang paling penting untuk *polypropylene* dan *polypropylene with talc* adalah suhu leburan berdasardan pengoptimuman dalam proses parameter.

ABSTRACT

The utilization of plastic part has been rising consistenly since 1950 in creating various of product. Injection moulding is a common machine to processing the plastic part. In injection moulding, it is crucial to select the suitable parameter to produce plastic part with good quality and accuracy. This project studies the optimization of plastic part in injection moulding by using pure polypropylene and polypropylene with talc as the material. It focuses on the effect of injection moulding process parameter on the selected responses such as part weight and volumetric shrinkage. The parameters that have been study in this project were melting temperature, holding pressure, injection time and cooling time. Then, the optimization of process parameter was done by using Taguchi method and Analysis of Variance (ANOVA). Besides that, the optimization of process parameter was done by using single objective and multi objective. The part weight of specimen was measured by using analytical balance while for the volumetric shrinkage, the value of length, width and thickness was measured using vernier caliper. From the result obtained, the most significant parameter for polypropylene and polypropylene with talc is melting temperature based on the optimization in process parameter.

DEDICATION

To my beloved family and friends that always give encouragement along the difficult pathway in my university life:

Abu Bakar bin Awang

Rohana binti Sulaiman

Nurul Fatihah

Mohd Firdaus

Mohd Farhan Danial

Nurul Nabilah

Mohd Faez

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LIST OF ABBREVIATIONS

ANOVA	-	Analysis of Variance
CT	-	Cooling Time
DOE	-	Design of Experiment
GRA	-	Grey Relational Analysis
GRC	-	Grey Relational Coefficient
GRG	-	Grey Relational Grade
GRN	-	Grey Relational Normalization
HP	-	Holding Pressure
IM	-	Injection Moulding
IT	-	Injection Time
MeT	-	Melting Temperature
PP	-	Polypropylene
PP/Talc	-	Polypropylene with Talc
S/N Ratio	-	Signal to Noise ratio

CHAPTER 1

INTRODUCTION

This chapter explains about the background of project, problem statement, objectives, scope of project and organization chart.

1.1 Background of Project

The utilization of polymers in the automotive has been rising consistently since the 1950. They were at first utilized as electrical parts and inside fittings as an advantageous minimal effort other option to conventional materials. Shaharudin et al. (2006) portrayed an accord from the engine business on the benefits of plastics utilization as economy, weight diminishment, styling potential, functional outline, new impacts, lessened upkeep, and consumption resistance. All polymers can be partitioned into 2 bunches, thermosets and thermoplastics. Thermoplastics are solids at room temperature that are liquefied or mollified by warming, set into a mould or other moulding device, and then cooled to give the craved shape. Thermoset is the materials that are made by polymers combined by chemical bonds, securing an exceedingly cross-linked polymer structure.

Polypropylene (PP) is one of thermoplastic polymer. PP is widely used in many plastics market such as for protective packaging, medical equipment and automotive industry. It is supplanting engineering plastics and metals from its applications as a result of the lower density, bring down value materials and reusing benefits. According to (Fernández et al. 2013), 55 million tonnes of polypropylene is needed to fulfil the market. The use of fillers from different sources combining in PP has been an acknowledged course to improve the mechanical properties and reduce the cost. In thermoplastic, the presence of talc as filler in PP decreases the impact strength but improves the tensile and flexural properties (Ghasemi et al. 2016).

This experiment used injection moulding machine to produce the plastic part for further testing and measurement. Injection moulding process involves by injecting the plastic materials which are pure PP and PP mix with talc into a mould. The compounded plastic material is fed into the hopper then flow into heated barrel for mixing process and forced into a two plate mould cavity. The injected plastic cools and hardens according to configuration of the mould cavity. After the product is injected, these studies continued by measuring the plastic part weight and geometrical shape by using laboratory tools.

It is crucial to select the suitable parameters for injection moulding process. Quality of moulded part is critically influenced by parameters selected. By selecting the suitable parameters, the process condition can be optimized that can produce plastic part with good quality and accuracy. According to (Lopez et al. 2016), the increasing of injection temperature parameter suggests a diminishing of the weight of material because of an expansion in particular volume of molten material. In producing plastic part, the parameter of injection moulding also important to produce good mechanical properties of plastic. For example based on research (Shaharuddin et al., 2006), uniform cooling time is essential for avoid the part from shrinkage if the part does not solidify uniformly. Throughout the injection moulding process, the important parameters need to be considered such as holding pressure, melting temperature, injection time and cooling time.

This study focuses on the flat plastic part optimization in injection moulding of pure polypropylene and polypropylene with talc using Taguchi method and ANOVA based on

different process parameter. By using different process parameter of injection moulding, the flat plastic part tends to have shrinkage and different of part weight.

1.2 Problem Statement

Plastics are broadly utilized as a contrasting option to natural materials and have turned into the most helpful part of human life. Day by day, the use of plastics is expanding due to their essential properties which are light weight, resistance to corrosion, form ability, low electricity conductivity and transparent. Injection moulding is a common machine to processing the plastic part. Processing parameter can influence the properties of the plastic although in a small amount of changes (Krishna et al. 2015).In this project, part weight and shrinkage are depends on so many factors such as injection moulding parameter. The parameter includes melting temperature, holding pressure, injection time and cooling time. These parameters were chosen in order to draw an analysis of the effect of part weight and volumetric shrinkage. Optimizations of process parameter need to be done to suggest the best optimum parameter combination to get the finest quality of product of plastic part. As stated the material for investigate in this study is pure polypropylene and polypropylene with talc. In the past years, the data and information about polypropylene is still limited regarding not so many studies been reported. According to (Lopez et al. 2016), the variety of process parameter of injection moulding in processing plastic part on part weight was examined and by expanding the injection temperature, it diminished the part weight because of an expansion of particular volume of molten material. The researcher also states that the weight of plastic part is increase when the injection temperature decreases due to the increasing of density of plastic material with a decrease in its injection temperature. Based on (Hassan, 2013) thesis, the product weight also has decreased because of the increase of the injection time. Shrinkage occurs when the density of polymer varies from processing temperature to the ambient temperature. Some causes problems by part shrinkage are sink marks or voids in plastic part and it can be reduced or eliminated by packing the cavity. The excessive part shrinkage is caused by low injection

pressure, short pack-hold time or cooling time, high melt temperature, high mould temperature and low holding pressure. So this study is important to optimize the injection moulding process parameter in order to achieve maximum part weight and minimum volumetric shrinkage.

1.3 Objective

This main objective of this project is flat plastic part optimization in injection moulding of pure polypropylene and polypropylene with talc using Taguchi method and ANOVA. To achieve the main objectives of this project, three sub-objectives are designate:

1. To investigate the injection moulding process parameters such as holding pressure, melting temperature, injection time and cooling time.
2. To measure the part weight and volumetric shrinkage
3. To optimize the parameter of injection moulding using Taguchi method and ANOVA.

1.4 Scope of Project

The scope of this project is to optimize process parameter of injection moulding on flat plastic part weight and geometrical shape. To perform machining, the suitable parameters need to be considered as the most important thing. The parameters setting are holding pressure, melting temperature, injection time and cooling time. For machining process of pure polypropylene and polypropylene with talc, the process produce three of plastic part based on different process parameters of injection moulding. The experiment conducted by inspecting the shrinkage and part weight of plastic part. Optimize and analyses are done by using Taguchi method and ANOVA.

1.5 Report organization

In this report there are five chapters overall that should be done for this project. For chapter 1, it introduces of research that contain about information of material and machine used which is polypropylene and talc as material and injection moulding as machine. Chapter 1 also explain the objective, problem statement of project, and scope. Chapter 2 discusses the literature review of some researcher. This include of parameter, shrinkage and part weight of material based on other researcher experiment. The best parameter of machine can be concluded for this project. Chapter 3 explains the methodology of experiment. This chapter presents the design of experiment which explains the method, apparatus, material and procedure for data analysis. Chapter 4 describes the result and discussion. The data of project are shown in this chapter. Then the discussion of project will be prepared to show the behaviour of plastic part according to the process parameter of injection moulding based on the results of plastic part shrinkage and part weight . Lastly, chapter 5 is about conclusion and recommendation. In this chapter, the part weight and shrinkage of plastic part will be concluded and the best parameter for machine while processing the plastic part can be optimize.

CHAPTER 2

LITERATURE REVIEW

This chapter explains the information regarding on the project including plastic injection moulding process, plastic materials and design of experiment. The information is gathered from different resources in order to comprehend the concept and valuable data for the project.

2.1 Plastic Injection Moulding

(Elsheikhi et al. 2016) stated the machine that widely used in processing plastic in manufacturing industry is injection moulding. (Fischer, 2012) declared that two general types of plastic material are usually used in injection moulding which are thermoset and thermoplastic. Injection moulding is a shape forming process in which forced the molten metal or plastic into aluminium, ceramic, or steel according part designated and squeezed under high pressure and temperature. Injection moulding process mainly employed in the production of solid product such as in automotive industry that works on body part of car.

The injection moulding is greatly favoured in manufacturing industry since it can delivered complicated-moulded plastic part with good dimensional accuracy and short process duration.

Table 2.1 demonstrate the characteristics of injection moulding process and others moulding process.

Table 2.1 : Characteristic injection moulding compared to other injection moulding (Kalpakjian et al. 2008)

Process	Characteristics
Extrusion	Long uniform, solid or hollow, simple or complex cross-sections
Injection moulding	Complex shapes of various size and with fine detail: high production rates
Structural foam moulding	Large parts with high stiffness-to-weight ratio: low production rates
Blow moulding	Hollow thin-walled parts of various sizes: high production rates
Rotational moulding	Large hollow shapes of relatively simple design: low production
Thermoforming	Shallow or deep cavities, medium production rates, low tooling cost
Compression moulding	Parts similar to impression –die forging: medium production rates
Transfer moulding	More complex parts than in compression moulding
Casting	Simple or intricate shapes, made with flexible moulds
Processing of reinforced plastics	Long cycle times dimensional tolerances

2.2 Process of Injection Moulding

(Hassan, 2013) stated the plastic injection moulding is a cyclic process. The plastic injection moulding process produces bigger quantities of part of high quality with incredible accuracy in less production time. Plastic material as granules is melted until sufficiently soft to be infused under pressure to fill a mould. The material is exactly duplicated according to the design of mould. Once the plastic injection moulding has cooled adequately to solidify, the injection mould opens discharging the part. Figure 2.1 show the schematic diagram of injection moulding.