



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**INVESTIGATION ON MECHANICAL PROPERTIES OF
PLASTIC PRODUCT FOR TWO PLATE FAMILY MOULD**

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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.....

(Dr. Mohd Amran Bin Md Ali)

DECLARATION

I hereby, declared this report entitled “Investigation on Mechanical Properties of Plastic Product for Two-Plate Family Mould” is the results of my own research except as cited in references.

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ABSTRAK

Produk plastik digunakan secara meluas dalam kehidupan seharian kerana ianya ringan, murah dan mempunyai ciri-ciri menarik. Proses acuan suntikan digunakan dalam projek ini kerana ia boleh menghasilkan empat sampel ujian mekanikal. Dalam usaha untuk mendapatkan ciri-ciri yang diinginkan, parameter acuan suntikan mestilah dioptimumkan. Oleh itu, objektif utama kajian ini ialah untuk mencari kesan parameter proses acuan suntikan terhadap ciri-ciri mekanikal. Projek ini dimulakan dengan mengenal pasti parameter-parameter untuk proses acuan suntikan seperti suhu acuan, suhu lebur, masa suntikan dan masa penyejukan. Langkah seterusnya ialah dengan mencipta pelbagai ortagon sebagai data experiment dengan menggunakan kaedah Taguchi. Kemudian, spesimen diuji mengikut ujian mekanikal mereka iaitu ujian tegangan, ujian lenturan, ujian kekerasan dan ujian hentaman. Data yang diperolehi daripada setiap ujian mekanikal dikumpul dan dianalisis dengan menggunakan Nisbah isyarat -kepada- hingar (S / N) untuk menentukan parameter optimum untuk setiap jawapan dan Analisis Varian (ANOVA) untuk melihat parameter mana yang paling penting untuk setiap jawapan . Ia didapati bahawa parameter yang paling penting yang menjejaskan kekuatan tegangan ialah suhu leburan . Untuk kekuatan lenturan, parameter yang paling penting yang terlibat adalah masa penyejukan . Sementara itu, bagi kekerasan dan kesan, parameter yang mempengaruhi ialah suhu acuan. Oleh itu, pengamal industri dan penyelidik boleh membuat pilihan set parameter dalam menghasilkan sifat mekanikal yang tinggi produk plastik.

ABSTRACT

Plastic products are widely used in our daily life due to their lightweight, low cost, and competitive desirable properties. Injection moulding is used in this project because it can produce four mechanical testing samples. In order to achieve desired properties, the parameters of injection moulding must be optimized. Therefore the main objective of this study is to find out the effect of injection moulding parameters on mechanical properties for two-plate family mould. This project is done by identifying the parameters of injection moulding such as mould temperature, melt temperature, injection time and cooling time. This project begins with creating orthogonal array of nine runs as experimental data by using Taguchi method. Then, the specimens are tested according to their mechanical testing which are tensile test, flexural test, hardness test and impact test. The data from each of mechanical testing are collected and analyzed further using Signal-To-Noise Ratio (S/N) to determine the optimum parameters for each response and Analysis of Variance (ANOVA) to see which parameters are the most significant to each response. It is found that the most significant parameter that affected tensile strength is melt temperature. For flexural strength, the most significant parameter affected is cooling time. Meanwhile, for hardness and impact, the most significant parameter affected is mould temperature. Thus, industrial practitioners and researchers can make choices which set of parameters are optimized in producing high mechanical properties of plastic products.

DEDICATION

To my beloved parents, Mohd Zin Bin Ujang and Muinah Binti Omar, my lovely siblings, Noor Fazleen Binti Mohd Zin, Noor Ashikin Binti Mohd Zin, Noor Farhana Binti Mohd Zin and my one and only youngest sister Nur 'Ain Amira Binti Mohd Zin and to all my friends, your guide and prayers are my motivational and driving source.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ASTM	-	American Society for Testing and Materials
DoE	-	Design of Experiment
ANOVA	-	Analysis of Variance
RSM	-	Response Surface Method
PP	-	Polypropylene
ISO	-	International Organization for Standardizations
PVC	-	Polyvinyl chloride
PTFE	-	Polytetrafluoroethylene
UTM	-	Universal testing machine
S/N	-	Signal to noise
°C	-	Degree Celsius
Pa	-	Pascal
J	-	Joule

CHAPTER 1

INTRODUCTION

Chapter 1 discusses about the introduction of this project. In this section, a study about the investigation on mechanical properties for plastic product of two plate family mould is held. The topic discussed are background, problem statement, objectives, scope of study and organisation of final year project.

1.1 Background

Müller et al. (2014) stated that the consumption of plastic materials has gone up by more than 250% since 1995, and is still rising. There are lots of new materials and technical improvements enlarge in this field of application of the material. Materials such as glass, metal or paper are used more and more frequently. Merely in the polymer processing, the need for using injection moulding is higher since the price is really competitive. Injection moulding is applied because of its straightforward operation which can produce complex form.

Every plastic product has its own properties depending on the application of the product. The properties that usually to be investigated are mechanical properties because each mechanical properties determine the performance of the plastic product. Therefore, several testing methods need to be conducted in order to obtain optimum mechanical

properties. The testing standard that related with mechanical properties are tensile test (ASTM D638), flexural test (ASTM D790), impact test (ASTM D6110) and hardness test (ASTM D785).

Injection moulding has been regarded as one of important process that can produce plastic product for industry. Thermoplastic material such as polypropylene, polyvinyl chloride and etc are widely used because it can be moulded into various shape (Huszar et al., 2015)

When demand of multi-functional parts increasing, it leads to production of parts which consist of polymer with different function. Injection moulding by using two plate family mould consists of several different shape which produces different plastic product is efficient (Nagel & Heinrich, 2012). Each product in the family can have different mechanical properties. Family mould is widely used because of its advantages due it can produce many plastic products into one mould. In designing plastic injection mould, location gate design and size of runner are very important for plastic products quality. The number of gate also affects the quality of plastic product produced. Besides the mould design, parameters of injection moulding processes also play an important role in producing quality plastic products (Chan, Pinfold, Kwong, & Szeto, 2014).

Parameters that are needed to be controlled such as injection time, mould temperature, cooling time and melt temperature. Every input parameter affects the products that want to be produced. The optimum parameter of each of the mechanical properties such as tensile strength, impact strength, flexural strength and hardness can be obtained using the data that have been collected and can be analysed by using various of design of experiments (DOE) such as full factorial method, Taguchi method, response surface method (RSM) and analysis of variance (ANOVA).

Therefore, this project focuses on the study which is related to two plate of family mould. The effect of input processing parameters on mechanical properties of plastic products for two plate family mould is investigated. Taguchi method is used to design the experimental

matrix. Then, the test samples performed such as tensile, flexural, impact and hardness are produced by using injection moulding machine for evaluate the mechanical properties. The result obtained will be analyse by using ANOVA analysis to determine which parameter is the optimum.

1.2 Problem Statement

Family mould can produced plastic product of different size and volume. Therefore, by using plastic injection moulding as main process, the best parameters need to be investigated to obtain the optimum mechanical properties. The plastic injection moulding parameters that are needed to be optimized including melting temperature, mould temperature, injection time and cooling time. Whereby, the responses of this project to be investigated are mechanical properties. The mechanical properties that to be tested are tensile strength, flexural strength, impact strength and hardness. To obtain the best input parameters for every output responses, design of experiment using Taguchi and ANOVA analysis are used.

1.3 Objective

The main objective of this project is to find out the effect of injection moulding process parameters on mechanical properties of plastic product for two plate family mould

- i. To identify the input parameters of injection moulding such as melt temperature, mould temperature, cooling time and injection time on the mechanical properties.
- ii. To investigate the mechanical properties of the plastic product injected from injection moulding such as tensile test, impact test, flexural test and hardness test.
- iii. To optimize the input parameters on mechanical properties of plastic product using Taguchi method and ANOVA analysis.

1.4 Scope of study

This study is to investigate the effect of input parameters of injection moulding such as melt temperature, mould temperature, cooling time and injection time on the mechanical properties by conducting several testing such as tensile test (ASTM D638), flexural test (ASTM D790), impact test (ASTM D6110) and hardness test (ASTM D785) on product from two plate family mould which have different shape and size. The shape and size is according to the standard for each of the mechanical testing. The material that is used for injection moulding is polypropylene, PP. The data obtained from the testing will be analysed by using Taguchi method and analysis of variance (ANOVA).

1.5 Organisation of Final Year Project

This final year project consists of several chapters to be completed. Chapter 1 until Chapter 3 are needed to be completed for Final Year Project 1 and Chapter 4 & 5 for Final Year Project 2. Chapter 1 explains about introduction of this final year project. It consist of background of study, problem statement, objectives, scope of study and organisation of project. Then Chapter 2 provides the literature review about the study. It will discuss the component that are related to the study. Chapter 3 then concentrates about the methodology of this study. In this chapter, the method for the experiment and the parameters involved will be mentioned in detail. In other word, chapter 3 is a preparation phase before conducting any testing. Then the data will be collected and analysed in chapter 4 and will be discussed in chapter 5.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews about injection moulding and its operation, injection moulding parameters, type of mould, plastic material, polymer testing and the software used to analyse the data that have been collected. These components of the literature review give information and as a guidance to complete this project.

2.1 Injection Moulding

According to Gerd and Walter, (2008) injection moulding is one of the important process to produce plastic parts. They also mentioned that there is no need for finishing operations. So, this makes injection moulding process suitable for mass production. Barnie and Martin, (2001) stated that injection moulding has been used in United States since 1930's, They have learnt or gain knowledge about injection moulding process by trial and error until they have improved the process until now.

Injection moulding is a manufacturing process to produce parts from thermoplastic and thermosetting plastic materials. Based on Figure 2.1, material is heated and fed into the barrel, mixed and forced into the mould where it cools and hardens to produce a shape. The mould material is usually made from either steel or aluminium depending on the application.