UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Optimization of Injection Moulding Parameter for Virgin Polypropylene (PP) Plastic Material

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BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PROCESS AND TECHNOLOGY) WITH HONOURS

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DECLARATION

I declare that this Choose an item. entitled “Optimization of Injection Molding Parameter for Virgin Polypropylene (PP) Plastic Material” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours.

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Date : 18 Jan 2022

DEDICATION

To my parents *ummi* and *baba*,

Ahmad Azli Bin Abd Aziz and Siti Hawa Bte Mohmed Noh,

With unconditional love and support in my life,

To my supervisor and lab engineer,

Mr. Salleh bin Aboo Hassan and Tc. Basri Bin Bidin,

Who had guided me along the journey to complete the report,

To my siblings and friends,

With laugh and tears,

And

For those I love the most.

ABSTRACT

Nowadays, injection moulding is very important in manufacturing industry due to its high demand. In order to sustain in the field of engineering, many research has been done. So, this thesis describes about how injection moulding parameter for polypropylene (PP) plastic material can be optimized. The mechanical property of the material has been investigated to determine the ultimate tensile strength using Taguchi method design of experiment. There are five process parameter that had been considered in this study which are cooling time, packing time, mould temperature, injection speed and packing pressure. Minitab software had been used in order to design an experiment regarding the ultimate mechanical property which is tensile strength. At the end of this study, the most significant injection moulding process parameter based on the tensile strength of virgin polypropylene (PP) has been determined by using Taguchi optimization method. The result showed that the most significant injection moulding process parameter that affect the ultimate tensile strength (UTS) is packing time. The rank of the process parameter is packing time followed by injection speed, mould temperature, cooling time and packing pressure. The combination of injection moulding process parameters is A2B1C1D1E1 where cooling time at level 2, packing time at level 1, injection speed at level 1, mould temperature at level 1 and packing pressure at level 1. The predicted value of ultimate tensile strength for Polypropylene material is 33.0642 Mpa.

ABSTRAK

Pada masa kini, suntikan acuan sangat penting dalam industri pembuatan kerana permintaannya yang tinggi. Untuk terus bertahan dalam bidang kejuruteraan, banyak penyelidikan telah dilakukan. Oleh itu, tesis ini menjelaskan bagaimana parameter pencetakan suntikan untuk bahan plastik polipropilena (PP) dapat dioptimumkan. Sifat mekanikal bahan telah disiasat untuk menentukan kekuatan tegangan utama menggunakan kaedah pengoptimuman Taguchi. Lima proses parameter telah dipilih untuk menentukan kekuatan plastik polipropilena iaitu 'cooling time', 'packing time', 'mould temperature', 'injection speed' dan 'packing pressure'. Software Minitab telah digunakan dalam penyelidikan ini untuk merangka ujikaji terhadap kekuatan bahan iaitu regangan. . Di akhir kajian ini, parameter proses pengacuan suntikan yang paling ketara berdasarkan kekuatan tegangan polipropilena dara (PP) telah ditentukan dengan menggunakan kaedah pengoptimuman Taguchi. Hasil kajian menunjukkan bahawa parameter proses pengacuan suntikan yang paling ketara yang mempengaruhi kekuatan tegangan muktamad (UTS) ialah 'packing time'. Peringkat parameter proses ialah masa 'packing time' diikuti dengan 'injection speed', 'mould temperature', 'cooling time' dan 'packing pressure'. Gabungan parameter proses pengacuan suntikan ialah A2B1C1D1E1 di mana 'cooling time. pada tahap 2, 'packing time' pada tahap 1, 'injection speed' pada tahap 1, 'mould temperature' pada tahap 1 dan 'packing pressure' pada tahap 1. Nilai ramalan kekuatan tegangan muktamad untuk bahan Polipropilena ialah 33.0642 Mpa.

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LIST OF SYMBOLS AND ABBREVIATIONS

PP	-	Polypropylene
ABS	-	Acrylonitrile-Butadiene-Styrene
LCP	-	Liquid Crystal Polymers
PBT	-	Polybutylene Terephthalate
PEEK	-	Polyaryletheretherketone
PMMA	-	Poly (methyl methacrylate)
PA	-	Polyamide
PSU/P/PPSU	-	Polyarylsulfone
PC	-	Polycarbonate
PI	-	Polyimide
POM	-	Polyoxymethylene
PPA	-	Polyphthalamide
PPS	-	Polyphenylene sulphide
PVDF	-	Polyvinylidene fluoride
TPE-E	-	Thermoplastic polyester elastomer
UHMWPE	-	Ultra-high-molecular-weight polyethylene, sometimes shortened to UH
PE	-	Polyethylene
PS	-	Polystyrene
PVC	-	Polyvinyl chloride
ABS	-	Acrylonitrile butadiene styrene
SAN	-	Styrene acrylonitrile resin

PET	-	Polyethylene terephthalate
PP-at	-	Atactical Polypropylene
PP-it	-	Isotactical Polypropylene
PP-st	-	Syndiotactical Polypropylene
S/N	-	Signal-to-Noise ratio
ANOVA	-	Analysis of variance
Kg	-	Kilogram
OA	-	Orthogonal array
UTS	-	Ultimate tensile strength
Mpa	-	Mega pascal
°C	-	Degree celcius
Mm/s	-	Milimeter per second
s	-	Second
Smaller-the-better		$S/N = -10*\log(\Sigma(Y2)/n)$
Larger-the-better		$S/N = -10*\log(\Sigma(1/Y2)/n$
Nominal-the-better		$S/N = -10*\log(s2)$

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CHAPTER 1

INTRODUCTION

1.1 Background

Injection molding is a process used in plastic products manufacture. Although this is a simple task, many steps towards creating the finished product have been taken. Injection molding is a manufacturing process used to create components from plastic materials both thermoplastic and thermoset. It is one of the main methods in which plastics are converted to usable items. An injection moulding machine can be major or minor but can operate generally the same way. Injection molding uses a raw plastic material in the form of pellets or granules. The granules and pellets will be melted in the feed hopper and then injected into a mold cavity through the barrel which has been designed according to the desired shape. The mold is then opened and the part is ejected.

In the injection moulding process, different raw plastics materials may be used. Phenolics, melamine, rubber, elastomers and polyester are most often processed through injection molding machines. These materials can be multiple colours and may rely on which properties, including elasticity, are used to produce different products. Hardness and versatilityof the final product are needed in order achieve certain characteristic based on customer's demand.

There has been increased interest in monitoring all aspects of the plastic injection molding parameters. The process parameter such as granule temperature, injection pressure, mold temperature, injection time, holding pressure, holding time, cooling time

and cooling pressure are very important for engineers to improve the productivity of the injection molding process as it affected the quality of the final product. However, the optimum process parameters can only be determined by expert's experience and skills on handling the machine and trials-and-errors technique needed. This surely consume more time as there are no guarantee that it is the required process parameters.

In order to determine the optimum process parameters in this study, Taguchi method is used as it is well-known as a technique which provides a systematic and efficient methodology for process optimization. There are many methods to determine the optimum process parameters but Taguchi method seems to be the best method in this study as it essential for simplifies experimental by using orthogonal arrays to determine the parameters affecting the process. Taguchi developed a system to analyse how various parameters influence the mean and variation of the process output characteristic and how well the process works.

1.2 Problem Statement

In manufacturing industries, the cost of material has been the main concern from time to time. To sustain in market, manufacturer must figure out a way to reduce the cost of the material in order to meet customer's expectation as they only think of the cheapest budget as possible but high-quality material. In plastic industry, the quality of tensile strength has always been customer's concern. In order to achieve customer's expectation in mechanical strength specifically in ultimate tensile strength has to be achieved. This study is essential to be conducted.

Figure 1: Example of Polypropylene product

1.3 Research Objective

The main objectives of the study consist:

1) To determine the most significant injection molding process parameter based on the tensile strength for virgin Polypropylene (PP) material.
2) To rank the process parameter for virgin Polypropylene (PP).
3) To optimize the combination of injection molding process parameter for virgin polypropylene (PP).
4) To predict the optimum value of ultimate tensile strength for virgin Polypropylene (PP) in injection moulding process.

1.4 Scope of Research

The scope of this research are as follows:

1) Material virgin polypropylene (PP).

2) Process injection molding.

3) Moulding process parameter under study are cooling time, packing/holding time, packing/holding pressure, injection speed and mold temperature.

4) Taguchi optimization method deployed in this .

5) The ultimate tensile strength of Polypropylene (PP) material.

1.5 Significant/Importance of study

Plastic injection molding is a very important process nowadays as it includes in most of our daily essential. The study on improving its productivity has become manufacturer's top priority in order to satisfies customer's need. So, the main focus in this study is to optimize the process of injection molding in order to achieve the highest tensile strength. It is very significant as a guideline in plastic industry on how to produce a better quality product besides can reduce the cost of manufacture. This is also enhanced and increased my knowledge in plastic technology for my future career field.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter will explain about the background of injection molding. This also include the information about process, parameter and defect of plastic injection molding. The characteristic of the polypropylene had been studied in order to give deeper understanding about the material. Thus, design experiment of this research also being explored.

2.1 History of Injection Molding Machine

The plastic injection forming method was invented and patented in 1872. the first molding machine. The inventors of this machine used to shape buttons, pegs and similar objects were Isaiah and John Hyatt. This was the start of the production of plastics. Initially, injection molding machine is all about basic mechanism process. German scientists have been able to enhance the process by creating soluble cellulose acetate forms, which have produced least flammable solutions.

While World War II affected civilization, it was also a period of economic progress and prosperity. At the time, there was substantial demand from various industries, such as warfare, aeroplanes and automotive engineering. In order to provide affordable, but quality materials and parts on a large scale the plastics production industry needed to deliver. Nevertheless, some industries remained unfavourable after the Second World War. Some

products such as rubber were significantly insufficient and thus demand for an inexpensive option of plastics, was even stronger

After the war and the entire post-war industrial revolution plastic injection molding and plastic materials remained common. As cost-efficient production of quality parts on a large scale has always been a major benefit of this manufacturing process, it has become an important part of the modern economy.

2.1.1 Injection Molding Machine

Injection moulding is a method of production for the manufacture of plastic components. Heated plastic fluid is injected into a mould at high pressure and the opposite of the desired shape. The mould is made of steel or aluminium through the contours of the finished product. Injection moulding serves to produce the types of components, such as cartons of plastic milk, cans, bottle caps, car dashboards, pocket combs and the most available plastic items

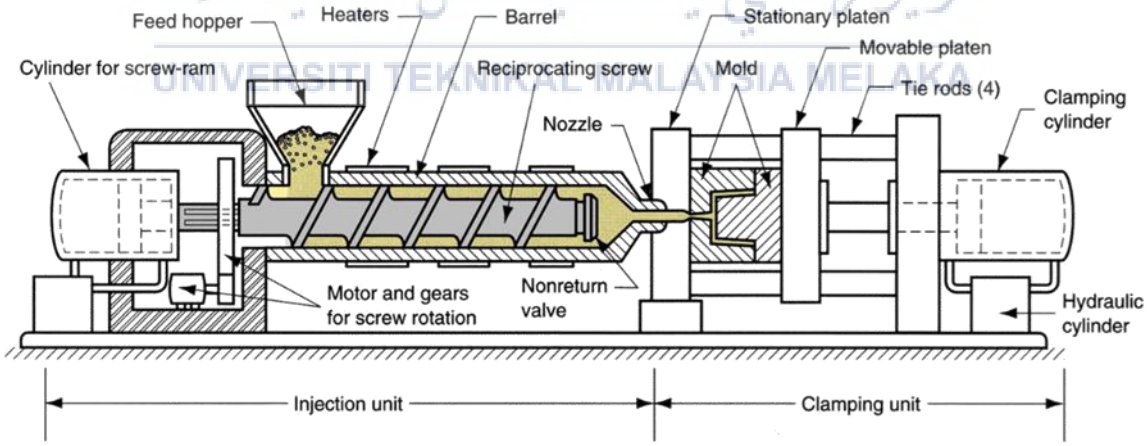

Figure 2: Injection moulding machine

Injection molding is a cyclic process. The cycle times can be between 10 and 100 seconds and are regulated by the melted plastics cooling time. The melted plastic is made of plastic hard pellets which are fed into the injection moulding machine hopper. Pellets or

plastic powder are melted inside the press and a nozzle (like a syringe) is pushed into the mould by the force of a long screw within a heated container.

The mold is finally filled and the plastic is cooled in the mold. The cold plastic is therefore separated from the liquid plastic in the screw. The screw is stopped as more pellets are melted by the heater around the cylinder and the screw in the cylinder. The mould then opens, usually halfway, and the cooled solid plastic portion is expelled while the mould is again closed and ready for the next molten of plastic shot.

2.1.2 Injection Molding Process

The injection molding requires the injection of a high-pressure polymer into a mold. The different parts are very short in this process. It usually takes 2 seconds to 2 minutes to mold the entire process. The cycle consists of four stages. These phases include the stages of clamping, injection, cooling and ejection. In the analysis of the component design, tool development and efficient manufacture of plastic molded products the various stages of the injection molding process are carefully studied. There are several factors and configurations, but the basic method is the same.

2.1.2.1 Clamping

The two halves of the mould must first firmly be clamped by the clamping device before the material is injected into the mould. The injection moulding machine is connected to every half and one half of the mould is allowed to slide. The mould halves are pushed together by hydraulically driven clamping unit, which exerts adequate force to firmly hold the mould during the injection. The time it takes to close and tighten the mould depends on the machine – bigger machines (with higher tightening forces) can take longer. The dry cycle time of the system will approximate this time.