OPTIMIZATION OF INJECTION MOLDING PARAMETER FOR 80:20 VIRGIN-REGRIND POLYPROPYLENE (PP) PLASTIC MATERIAL

MOHAMMAD ZULHAKIMI BIN SALIM

B091810356

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

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Mohammad Zulhakimi Bin Salim

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MOHAMMAD ZULHAKIMI BIN SALIM

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DECLARATION

I declare that this Choose an item. entitled “Optimization of Injection Molding Parameter for 80:20 Virgin-Regrind Polypropylene 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.

Signature	:	
Name	:	MOHAMMAD ZULHAKIMI BIN SALIM
Date	:	18 JANUARY 2022

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.

Signature : 

Supervisor Name : TS. SALLEH BIN ABOO HASSAN

Date : 18 JANUARY 2022

DEDICATION

First of all, my humble effort dedicated to Allah S.W.T for the opportunity to finish this project. Moreover, I also dedicate this work for my beloved parent and family especially my father Mr. Salim bin Ramli and my mother Mrs. Rohani binti Ahmad who always support and pray all day for me to strive excellence and success in study. Thank you, for always together with me from the beginning to end and make sure this report is finished.

ABSTRACT

Plastic has been a widely used as the material for most of the products in the human life. However, the rate of plastic product waste is much faster than the rate of the plastic recycling which is resulting the plastic pollution to the world environment. Plastic recycling is a common raw material used in plastic industry especially for environment preservation purposed and more importantly due to cost saving. Polypropylene (PP) is one of commonly plastic type used for bottle caps, packaging tape, cereal liners, straw and as the material of filament for 3D printings, household products such as kitchen appliances and pipes, due to its toughness and high impact resistance. Injection molding is the most common plastic shaping process for PP thermoplastic material. To optimize the injection molding parameter in 80:20 virgin regrind blended Polypropylene (PP) plastic material, five (5) process control parameters namely cooling time, packing time, injection speed, mold temperature and packing pressure each at two levels is tabulated using the L'18 orthogonal array as recommended in Taguchi Design of Experiment method. Type I specimen according to STM D638-14 speciment industry standard is produced by using the injection molding machine. Eight (8) experiments were conducted according to OA table. Three (3) speciments of each experiment trial were collected and tested to obtain the ultimate tensile strength.In total there are (24) have been tested for tensile strength reading. The results were analyzed using the S/N ratio and ANOVA approched method. Significant factors and the optimum combination of process factors setting for achieving the optimum UTS of the Polypropylene (PP) blends 80:20 virgin-regrind material were determined. There are no factors that have the most significant effect on tensile strength. Cooling time at 10 second, packing time at 5 second, injection speed at 50mm/s, mold temperature at 50°C and packing pressure at 50 MPa have resulted the optimum combination factors level according to Taguchi analysis result. The predicted tensile strength based on this optimum value is 33.94 MPa which is not much different compared to virgin 100% material tensile strength 35 MPa. As a conclusion Polypropylene (PP) 80:20 virgin-regrind material is highly recommended to be used for replacing virgin material for material cost saving project.

ABSTRAK

Plastik telah digunakan secara meluas sebagai bahan untuk kebanyakan produk dalam kehidupan manusia. Walau bagaimanapun, kadar sisa produk plastik adalah lebih cepat daripada kadar kitar semula plastik yang mengakibatkan pencemaran plastik kepada alam sekitar dunia. Kitar semula plastik adalah bahan mentah yang biasa digunakan dalam industri plastik terutamanya untuk tujuan pemeliharaan alam sekitar dan lebih penting lagi kerana penjimatan kos. Polipropilena (PP) ialah salah satu jenis plastik yang biasa digunakan untuk penutup botol, pita pembungkus, pelapik bijirin, jerami dan sebagai bahan filamen untuk cetakan 3D, produk isi rumah seperti peralatan dapur dan paip, kerana keliatan dan rintangan hentaman yang tinggi. Pengacuan suntikan adalah proses membentuk plastik yang paling biasa untuk bahan termoplastik PP. Untuk mengoptimumkan parameter pengacuan suntikan dalam bahan plastik Polipropilena (PP) campuran 80:20 virgin regrind, lima (5) parameter kawalan proses iaitu masa penyejukan, masa pembungkusan, kelajuan suntikan, suhu acuan dan tekanan pembungkusan setiap satu pada dua tahap dijadualkan menggunakan Tatasusunan ortogon L'18 seperti yang disyorkan dalam kaedah Reka Bentuk Eksperimen Taguchi. Spesimen jenis I mengikut piawaian industri spesimen STM D638-14 dihasilkan dengan menggunakan mesin pengacuan suntikan. Lapan (8) eksperimen telah dijalankan mengikut jadual OA. Tiga (3) spesimen bagi setiap percubaan eksperimen telah dikumpul dan diuji untuk mendapatkan kekuatan tegangan muktamad. Secara keseluruhannya terdapat (24) telah diuji untuk bacaan kekuatan tegangan. Keputusan dianalisis menggunakan nisbah S/N dan kaedah pendekatan ANOVA. Faktor penting dan gabungan optimum penetapan faktor proses untuk mencapai UTS optimum bagi bahan campuran Polipropilena (PP) 80:20 virgin-regrind telah ditentukan. Tiada facktor yang mempunyai kesan paling ketara terhadap kekuatan tegangan. Masa penyejukan pada 10 saat, masa pembungkusan pada 5 saat, kelajuan suntikan pada 50mm/s, suhu acuan pada 50°C dan tekanan pembungkusan pada 50 MPa telah menghasilkan tahap faktor kombinasi optimum mengikut keputusan analisis Taguchi. Kekuatan tegangan yang diramalkan berdasarkan nilai optimum ini ialah 33.94 MPa yang tidak jauh berbeza berbanding dengan kekuatan tegangan bahan 100% dara 35 MPa. Kesimpulannya, bahan polypropylene (PP) 80:20 virgin-regrind amat disyorkan untuk digunakan bagi menggantikan material virgin untuk projek penjimatan kos bahan.

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In the Name of Allah, the Most Gracious, the Most Merciful

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PP	-	Polypropylene
ABS	-	Acrylonitrile-Butadiene-Styrene
PE	-	Polyethylene
PS	-	Polystyrene
PC	-	Polycarbonate
PVC	-	Poly(vinyl chloride)
PU	-	Polyurethane
PMMA	-	Poly(methyl methacrylate)
Tg	-	Transition temperature
ASTM	-	American Society for Testing and Materials
FRP	-	Fiber-reinforced polymer
SP1	-	The Society of the Plastic Industry
C	-	Celsius
F	-	Fahrenheit
DOE	-	Design of Experiment
S/N	-	Signal-to-Noise
NB	-	Nominal Better
LB	-	Lower Better
HB	-	Higher Better
OA	-	Orthogonal Array
ANOVA	-	Analysis of variance
MPa	-	Mega Pascal
Kg	-	Kilogram
UTS	-	Ultimate Tensile Strength

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Based on this chapter, it contains several contents related about explanation of general background of research, problem statement, objectives based on the research title, what is scope of research and significant of study. This chapter is done to improve understanding about the overall structure that we can get it based on a study of the research project.

1.2 General Background

Among the most widely recognizable-world applications of technology are using polymer materials in industry. In plastic manufacturing technology, the development of plastic products in the world has led to their use in everyday human activities (Lekaviciute & Argalasova Sobotova, 2013). According to Andray, 2011, some sectors in human activities such as health, packaging, automotive, construction, textiles and agriculture are essential in human life activities. Overall, polymers such as Acrylonitrile-Butadiene-Styrene (ABS), Polyethylene (PE) and Polypropylene (PP) are among the types of polymers set with different grades used in different applications such as in high application like automotive, telecommunication, household product and aerospace. Polymers perform very fantastic as high-strength and economical materials, which bring advantages in some applications out there. But polymers are light in weight and have weakness related in machining because it acts as low machining temperature.

Plastics come with various special features such as inexpensive materials, very light and durable as well as easy to find produced to be a variety of products that can be used in various operations. Consequently, plastic production which has been increasing day by day in the market over the last 60 years. However, some problems also arise due to the current level of plastic use and disposal in the world is not well controlled. The properties of polymer have been upgraded in this day where it is recyclable in the industries. Therefore, it becomes more preferred material. The global amount of plastic waste will increase or increase from 260 million tons per year in 2016 to 460 million tons per year in 2030 if plastic demand cannot be control for current trajectory. The reuse of materials can not only save the Earth's natural resources, but recycled polymers can be done well as virgin polymers at a lower cost. Recycle polymer always being priority in the manufacturing industries because it will reduce cost material and also showing a good quality material. To produce or obtain better performance on the mechanical properties of the polymer such as hardness, tensile strength and impact strength of recycled polymers, the improvement of recycled polymer processing must be done by various methods in industries. Therefore, recycled processing and materials need to be tested first before being realized in the applications to identify the quality level of the recycled polymers. There are many methods processing used to recycled polymer in industry and injection molding is known as the process of producing recycled polymers.

1.3 Problem Statement

Polypropylene (PP) can be molded in many ways so that it can be used easily in applications and due to the flexible shape of Polypropylene (PP) it is called plastic steel. Polypropylene (PP) have many advantages which have made it such as popular material for manufacturing who can apply it to many uses for example good in mechanical properties, high impact resistance and high tensile strength. Also, Polypropylene (PP) is already used in

advance technology cause to its durability and low cost. But high production of plastic in industries causing the usage of plastic material are also increasing. If the usage did not in control very smart, causing the more the discard. Exposure of plastic products to high temperatures for a certain period has resulted in the leakage of toxic chemicals into food, beverages, and water. Through this problem, some companies have worked hard to conduct a 'life cycle' study to determine how long the Polypropylene (PP) can last and how much Polypropylene (PP) can possibly be recycled from raw materials to the final stages of waste management. This is because Polypropylene (PP) has the potential as a sustainable product.

More importantly, recycling Polypropylene (PP) can minimize waste and save cost because of the short lifespan of PP made packaging. The mixing of virgin Polypropylene (PP) in Polypropylene (PP) recycling up to over 50% is to ensure that the new products produced become stronger and stronger such as play equipment. Under such circumstances, the cost per unit of production of Polypropylene (PP) recycled products will be lower and reasonable. This makes the Polypropylene (PP) recycling process very effective and orderly as well as improving the quality of recycled Polypropylene (PP) and indirectly the demand for recycled Polypropylene (PP) in the market becomes greater. On term on the mechanical properties, its very important to make sure the quality of the recycled Polypropylene (PP) to reach better material or product in industries. Moreover, recycling material can reduce the cost directly but with this material will face some problem which is mixing raw material and recycled material may reducing mechanical properties like tensile strength. Therefore, we need to study how to improve mechanical properties with different parameter setting that resulting on tensile strength values where using virgin-regrind Polypropylene (PP) material.

1.4 Research Objective

Based on this project, we have identified some acceptable objectives as shown as the following.

i. To determine the most significant factors that affect the tensile strength for 80:20 virgin-regrind Polypropylene, (PP) material.

ii. To identify the best combination of optimum injection parameter for maximum tensile strength using 80:20 virgin-regrind Polypropylene, (PP) material.

iii. To establish the process factors ranking which effecting on tensile strength.

iv. To predict optimum value of best combination parameter which effecting on tensile strength.

v. To determine whether blend ratio for 80:20 virgin-regrind Polypropylene, (PP) material able to maintain tensile strength quality equally with 100% virgin Polypropylene (PP).

1.5 Scope of Research

The scope for this research is show as the following.

i. Material blend virgin/recycle 80:20 Polypropylene, (PP).

ii. Injection molding process using Haitan VE 300 injection molding machine.

iii. Tensile strength as a main response of the study.

iv. The test specimen for this study is dog bone D368.

1.6 Significant / Important of Study

The significant of study of this research are:

i. Self-understanding regarding this study which can be referred by plastic industry to making the products like chair and plastic pallet with good quality tensile strength.

ii. The findings of this study may give information to the student especially about the injection molding machine and plastic material.

iii. The results of this study also, may help students to know what are best parameters process design which giving effects to the tensile strength of PP material by using Taguchi method.

iv. To prove that 80:20 virgin-recycle Polypropylene (PP) plastic is capable to maintain tensile strength as 100% virgin Polypropylene (PP).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The entire study of the study chapter provides an overview of the conceptual concept of injection molding parameters for virgin-regrind plastics. This chapter that focusing on some information such as general background, material, machine, process, and Taguchi design which get in from journal. There few main sources are taken such as journal article and books to write this chapter.

2.2 Background Polymer

One of very important class of materials which is polymers form because without its the life seems very difficult. According to (Namazi, 2017), a large class of materials is polymers where it has many small molecules as called monomers combined to form long chains and most of product and goods using in a lot that we use in every day. Because of rapid increase in demand for new manufacturing products, the new material is introduced. Polymers are new materials, and their effect on these days is almost incalculable. The word of polymers or also called “macromolecule” is taken from the classical Greek poly meaning "many" and meres meaning "part". Usually, polymer molecule bound together with covalent bonds and has many structural units, and the molecular weight is very high where it begins between 10000 to 1000000 g/mol. There are two major type of polymers which know as thermoplastic and thermosets.

2.2.1 Classification of Plastic

Plastic is divided in three classes of plastic that are elastomers, duroplastics and thermoplastics. In practice, classification is made according to several different prospective. As shown in Figure 2.1, those plastic having a separate category where for thermoplastics it is classified in structural-related physical terms, elastomers as in chemical terms which related double bond, and duroplastics related to process pressure (Eyerer, 2010).

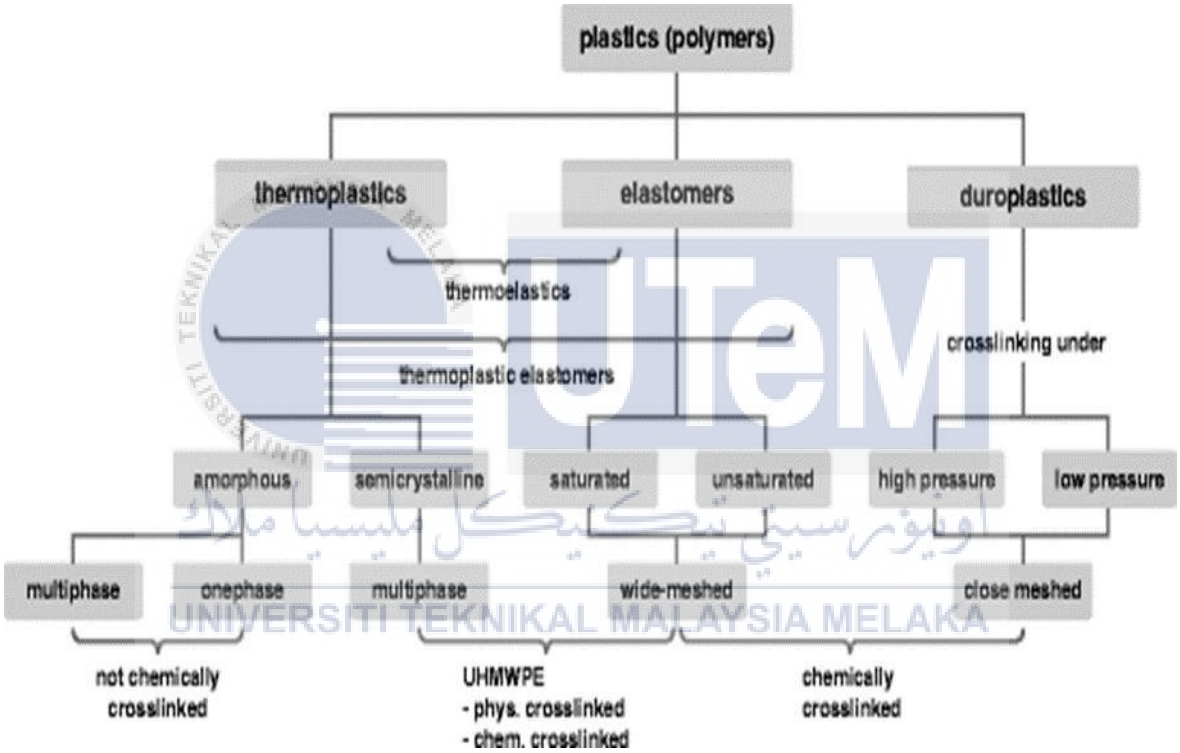

Figure 2.1: Classification of Plastics (Eyerer, 2010)

2.2.2 Thermoplastic

Plastic classifications are based on two groups, namely thermoplastic and thermoset plastics. These groups have different ways because they are depending on the type of plastics reacting to heat. A thermoplastic material is a non-crosslinked polymer with a high molecular weight. For thermoplastics, they can change being soft when heated and being harden when cooled. According to (Eyerer, 2010) said that thermoplastics are plastics not connected until

their decomposition temperature. Figure 2.2 shows how changes occur to the molecule caused by changes in the melting temperature of thermoplastics. The viscous liquid can be processed in this thermoplastic state. Any number of times are repeating at meltdown, solidification, and crystallization.

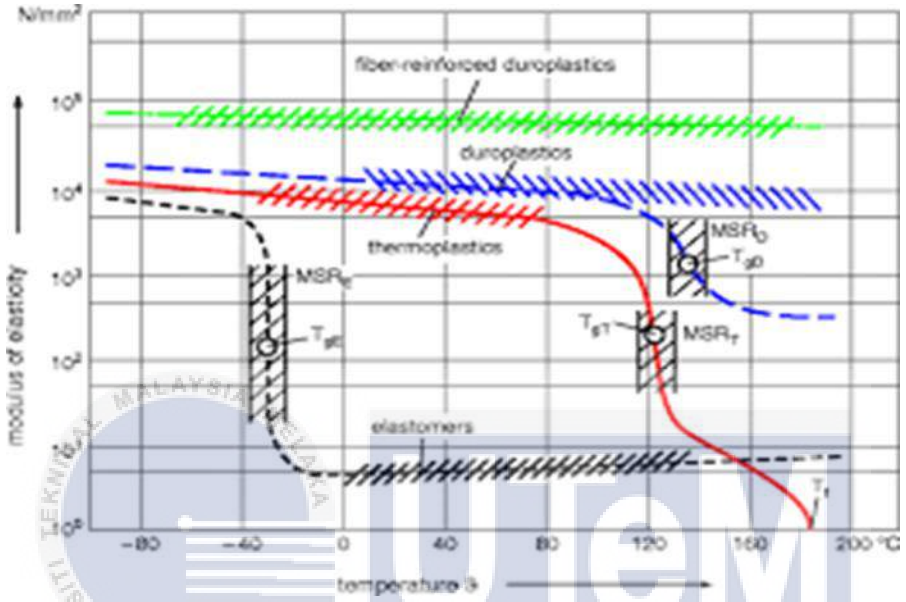

Figure 2.2: Temperature-dependence of The Modulus of Elasticity (Young's modulus) of Plastics (Eyerer, 2010)

Moreover, when heat is applied to a thermoplastic, the molecules will react to not join chemically and most of the thermoplastic molecules are slightly branched. However, Van Der Waal force means the molecule has a weak attraction and its main function is to be held together by a thermoplastic chain so that long molecules clump together. Also, thermoplastic material consists of individual molecules, molecular weight is influencing properties of thermoplastics. As example, as the molecular weight of the thermoplastic increases, its tensile strength, impact strength, and fatigue strength (the material's ability to withstand constant pressure) will also increase.

Thermoplastic can be recycled without changing their physical properties. Thermoplastic materials provide different performance benefits, but most materials provide