OPTIMIZATION OF INJECTION MOLDING PARAMETER FOR 60:40 VIRGIN-REGRIND BLENDED POLYPROPYLENE PLASTIC MATERIAL

MUHAMMAD AFIQ BIN ABDUL RAHMAN
B091810303

BACHELOR of MANUFACTURING ENGINEERING TECHNOLOGY (PROCESS and TECHNOLOGY) with HONOURS

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Faculty of Mechanical and Manufacturing Engineering Technology

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Muhammad Afiq Bin Abdul Rahman

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MUHAMMAD AFIQ BIN ABDUL RAHMAN

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DECLARATION

I declare that this thesis entitled “Optimization of Injection Molding Parameter For 60:40 Virgin Regrind Blended 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 : MUHAMMAD AFIQ BIN ABDUL RAHMAN

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 Engineering Technology (Process and Technology) with Honours.

Signature : .....

Supervisor Name : TS SALLEH BIN ABOO HASSAN

Date : 18 JANUARY 2022

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DEDICATION

Dedicated to

my honourable father

my beloved mother

my supporting family

my friends

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 60:40 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 L8 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 samples 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 60:40 virgin-regrind material were determined. Cooling time and packing time have demostrated the most significant factors while others factors are insignificant. Cooling time at 10 second, packing time at 5 second, injection speed at 10mm/s, mold temperature at 30°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 32.2134 MPa which is not much different compared to virgin 100% material tensile strength 35 MPa. As a conclusion Polypropylene (PP) 60:40 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 60:40 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 sampel 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 bahan campuran Polipropilena (PP) 60:40 virgin-regrind telah ditentukan. Masa penyejukan dan masa pembungkusan telah menunjukkan faktor yang paling ketara manakala faktor lain adalah tidak penting. Masa penyejukan pada 10 saat, masa pembungkusan pada 5 saat, kelajuan suntikan pada 10mm/s, suhu acuan pada 30°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 32.2134 MPa yang tidak jauh berbeza jika dibandingkan dengan kekuatan tegangan bahan 100% dara 35 MPa. Kesimpulannya, bahan polypropylene (PP) 60:40 virgin-regrind amat disyorkan untuk digunakan bagi menggantikan material virgin untuk projek penjimatan kos bahan.

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LIST OF SYMBOLS AND ABBREVIATIONS

PP	-	Polypropylene
LDPE	-	Low-density polyethylene
HDPE	-	High Density Poly Ethylene
PVC	-	PolyVinyl Chloride
PMMA	-	Polymethyl Methacrylate
PC	-	Polycarbonate
PS	-	Polystyrene
ABS	-	Acrylonitrile Butadiene Styrene
PBT	-	Polybutylene terephthalate
PAI	-	Polyamide-imide
Nylon 6	-	Polycaprolactam
PA	-	Polyamide
PEEK	-	Polyetheretherketone
PK	-	Polyketone
PET	-	Polyethylene terephthalate
MFI	-	Melt Flow Index

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CHAPTER 1

INTRODUCTION

This study will explain and research about the background of study on optimization of injection molding parameters for 60:40 virgin-regrind blended Polypropylene (PP) plastic material. This study is an awareness from theories of past researchers, books, journals, an online resource. Hence, the data are obtained to classify the improvement needed for this study.

1.1 Background

Injection moulding has recently surpassed blow moulding as the most effective manufacturing method in the plastics industry, owing to its advantages of short production cycle, excellent surface quality, and ease of moulding complicated shapes. Injection moulding seems to be the most common method of making plastic goods. Many factors, including as injection temperature, mould temperature, and injection time, are critical throughout this operation and have a direct effect on product quality and price (Zhao et al., 2010). Injection moulding is suitable for mass-producing plastic products with complicated forms that require exact measurements. Molten polymer melt is injected into a mold cavity of a chosen form and allowed to solidify under high holding pressure in this operation (Shen et al., 2007).

Plastics are currently the most significant sector of production and consumption among all technological materials in terms of high volume (Ľudmila & František, 2011). Since the introduction of plastics and their increasing use in all areas of industry, this material has earned the requisite respect and a unique position on the global market for used materials.

Participating in the development of plastics has both positive and negative consequences. In terms of the climate, plastic is too harmful on the ecosystem. It takes a long time for them to decompose, and when they are burned, a large amount of harmful emissions are released. As a factor, the environmentally friendly and particularly efficient recycling of used waste from these materials is given top priority. With the rapid production of plastic goods came the issue of waste management. As a result, there was a need to make more recycled plastics, which were then used to make new ones.

Although the primary material and recycled material have the same classification, the cost of some of the primary material's properties can be altered as a result of the mixing regrind materials. The advantages of recycling plastic through using the regrind material is the virgin materials will be save and reduce production cost. Other than that, With the combination of virgin materials and regrind can produce a new era of plastic for new applications. There is a possibilities that a good and quality product can made from blended materials. Moreover, it is mainly lead to minimizing the communal plastics waste (Ľudmila & František, 2011).

Experiment needed to conduct further to determine whether the coefficient relationship of tensile strength (strength and hardness) of materials can be changed with 60:40 virgin-regrind. Tensile and shore hardness tests were can be used to examine the effect of regrind applied to the raw product on the change in mechanical characteristics of plastic (František, 2011).

1.2 Problem Statement

Injection moulding has the advantages of reduce cost, high efficiency, and the capability to mass-produce huge quantity of product. It is rarely used throughout industry for the production of packaging applications, consumer goods, automotive application, medical application, industrial application and many more. Considering process circumstances have the greatest impact on the quality of injection moulded plastic product, identifying the appropriate process conditions is crucial to enhance product quality (Shen et al., 2007).

Reducing costs and keeping a high level of quality are critical aspects of every project. Materials that particularly sophisticated or specially engineered resins may be costly, thus choosing the proper plastic is important and get a strong quality and the best tensile behavior for the Polypropylene (PP) materials is we can optimize the proper use of plastic regrind and the virgin materials. Moreover, various variable elements such as process parameters, melt flow type, heat transfer effect, material properties, and mould geometry can effect the product's characteristics. The ideal mixture mixing the polymers together to generate a certain physical property is one of the most commonly used in engineering plastic mixes. Most industry has use mixed materials to particularly in automotive appliances. (Fung et al., 2003).

There's often some unused Polypropylene (PP) material that's left over from injection moulding such as scrap parts, runners, and sprues. Here is the study of 60:40 virgin-regrind blended Polypropylene (PP) material to investigate the tensile strength and is it success to reduce the material cost. But, according to (Vassallo et al., 2020) the fundamental problem with reprocessing plastics was whether when comparing to virgin material, regrind plastic performs poorly in terms of mechanical performance due to a loss of mechanical characteristics. (Suresh, 1998) says according to a general guideline that applies to most

polymers, the proportion of regrind content that may be employed without compromising material qualities is between 10% to 30%. This statement is overly broad, and the impact of each element should be investigated separately.

By reducing the cost manufactured with using regrind materials, mechanical propertiese of Polypropelene can be effected. Generally, regrind material can decrease the stength and effect many more mechanical propertiese if using too much regrind materials. In this study, by applying 60:40 virgin-regrind blended Polypropylene (PP) plastic material with appropiate process parameter will be the best result of mechanical propertiese for manufactured used.

Aside from that, decomposition of the regrind resin formed during the injection moulding process might take hundreds or even thousands of years. As a result, ecologically expect that the disposal of regrind resin is a major challenge. It has been claimed that this problem may be solved by reusing regrind resin and utilising it instead of raw resin in injection moulding new components. As a result of these methods, we may conserve the environment by reusing leftover materials and reduce the amount of garbage that being throw away. (Vassallo et al., 2020) explain that the manufacturing industry has a significant influence on the three sustainability pillars that particularly the environment. This is because manufacturing techniques have a high energy usage and carbon footprint.

Taguchi optimization method will be used as a method to optimize matrix experiment method based on an eight-step process of designing, conducting, and analysing matrix experiment data to discover the ideal values of control parameters. The main objective is to make the output variance as low as possible, even when there are noise inputs. (Shen et al., 2007) once said the upon on basis of the S/N ratio of every experiment, the Taguchi design of experiment approach is used to produce the near-optimal process and analyse the parameter impacts on the quality indices. The Taguchi method focuses on product design,

and it improves product quality as well as lowers costs through optimising product and process design.

1.3 Research Objective

The objective of research are as follows:

a) To determine the most significant factors that affect the tensile strength in Polypropylene (PP) 60:40 blend plastic dogbone specimen.

b) To optimize the parameters process of injection molding for Polypropylene (PP) 60:40 blend plastic dogbone specimen.

c) To establish the process parameters ranking from the most to the least significant factors.

d) To predict the optimum value for 60:40 virgin-regrind blended polypropylene plastic material.

e) To determine whether 60:40 virgin-regrind blended polypropylene plastic material able to maintain strength capability equally with 100% virgin Polypropylene (PP) material.

1.4 Scope of Research

Limitation of this research are as follow:

a) The study will identify the tensile strength of the blended materials which is 60:40 virgin-regrind blended where the raw material is Polypropylene (PP).

b) Testing speciment is produce by using Haitan VE 300 injection molding machine.

c) Testing sample specimen is in dogbone D368.

1.5 Importance of Study

Quality and cost control is an important aspect of any production company. Since products are particularly specialised or specially formulated resins, can be pricey, we need to choose the right plastic to get the most value for money. The proper use of plastic regrind is the only way to do this. Scrap pieces, runners, and sprues are common examples of leftover thermoplastic content left over from injection moulding. Despite the fact that this material has already been processed, it may be reused (within specific terms and way). This waste is gathered and ground into even small granules, a process known as plastic "regrind."

Recgrind is an excellent way to save costs, maximise resource efficiency, and reduce the use of natural resources. These are all fantastic advantages, but there is one stipulation: Regrind is not suitable for highly critical applications. The fine detail and accuracy needed for these types of projects cannot withstand the slight variation introduced by regrind.

The amount of plastic regrind that may be used, and also how it can affect the primary material's characteristics. Variables include resin type and how the regrind was initially handled, regrind granule size or any contaminants on the regrind such as dust, dirt, liquid, and so on.

The most important aims is to self –understanding regarding this study and can be referred by plastic manufactured industry that produce table plastic, plastic chair,pallet and many more to minimize material cost of the product. This study paper can be a guide for industry that need to use regrind material to decrease their manufacturing cost by viewing this study complete full data to prove that if 60:40 blended Polypropylene plastic materials can be replaced instead used 100% virgin material. There are huge saving in cost for manufacturing company can save.

CHAPTER 2

LITERATURE REVIEW

This chapter is an overview of the previous scientific findings that relate to injection moulding and the factor parameter that need to be optimize. This work was carried out to study the best optimization with using Taguchi optimization method to figure out what the ideal values of control parameters that need to be focus on.

2.1 Injection Molding Machine

2.1.1 History of Injection Molding

Two brothers, John and Isaiah Hyatt, pioneered plastic injection molding in the late 1800s, developing the first machines in 1872. While the technology was primitive by today's standards, it inspired the development of an embryonic plastic manufacturing sector, which produced combs, buttons, and other small plastic objects. Injection molding has been the most significant manufacturing technique in the plastics industry for many years due to its benefits of quick production cycles, good surface quality, and ease of molding complex shapes. (Fung et al., 2003).

In 1903, two German physicist, Arthur Eichengrun and Theodore Becker, produced soluble versions of cellulose acetate that were far less combustible than prior alternatives. While the 1930s had been a trying decade for many people, it was a time of enormous progress for the plastics sector. The thermoplastics polyolefins, polystyrene, and polyvinyl chloride are some of the most extensively utilised. (Park & Nguyen, 2014) said in their journal those two German physicist made a big improvement for the plastics industry,

injection molding has been the most preferred method for creating plastic objects high reliability and manufacturing cost.

2.1.2 Application of Injection Molding

Plastic injection molding is used to manufacture a wide range of items in industries such as aviation, automotive, and electronic device. The major reasons for their appeal are distinctive qualities such as the capacity to make complicated components, low weight, corrosion resistance, and simplicity of production compared to traditional materials. In today's world, plastic items are a must. Plastic may be molded into a variety of products with a variety of uses. In the manufacturing process, injection molding is among the procedures for making plastic injection moulds in which molten polymer is pushed into a relatively cold chamber for the desired form, after which the heated melt can rest and solidify (Fadzly et al., 2019). Injection moulding is used to make wire spools, packaging, bottle caps, automobile components, electrical component, medical goods as well as some musical instruments (parts of them) and other plastic products. The most frequent method of component manufacture is injection moulding. It's perfect for mass-producing the same product in large quantities. Injection moulding has several advantages, including repeatable high tolerance, high production rates, the flexibility to employ a wide range of materials, minimum waste losses, less requirement for post-moulding finishing, and cheap labour costs. Some disadvantages of this approach include the high cost of designing mold able components, the possibility for high operating costs, and the massive cost of equipment investment.

Plastics are presently the most significant sector of production and consumption among all technological materials in terms of volume. Since the introduction of plastics and their increasing usage in all areas of industry, this material has earned the requisite respect and a distinctive position on the global market for used materials. All thermoplastics, certain