OPTIMIZATION OF INJECTION MOLDING PARAMETERS FOR 70:30 VIRGIN-REGRIND (PP) PLASTIC MATERIAL

MOUMEN MAHMOUD JAZAYERLI

B091810493

BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PROCESS AND TECHNOLOGY) WITHHONOURS

2022

Faculty of Mechanical and Manufacturing Engineering Technology

OPTIMIZATION OF INJECTION MOLDING PARAMETERS FOR 70:30 VIRGIN-REGRIND (PP) PLASTIC MATERIAL

MOUMEN MAHMOUD JAZAYERLI
B091810493

SUPERVISOR: MR. SALLEH BIN ABOO HASSAN

Bachelor of Manufacturing Engineering Technology (Process & Technology) with Honours

2022

OPTIMIZATION OF INJECTION MOLDING PROCESS PARAMETERS FOR 70:30 VIRGIN-REGRIND (PP) PLASTIC MATERIAL

MOUMEN MAHMOUD JAZAYERLI

A thesis submitted

in fulfillment of the requirements for the degree of
Bachelor of Manufacturing Engineering Technology (Process & Technology) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLEARATION

I declare that this Choose an item. entitled "OPTIMIZATION OF INJECTION MOLDING PARAMETERS FOR 70:30 VIRGIN-REGRIND (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.

Signature :

Name : MOUMEN MAHMOUD JAZAYERLI

Date : 28/6/2021

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 & Technology) with Honours

Signature :

SALLEH BIN ABOO HASSAN
Pensyarah
Jabatan Teknologi Kejuruteraan Pembuatan
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka
18 Jan 2022.

Supervisor Name : Mr. Salleh Bin Aboo Hassan

Date : 18/1/2022

DEDICATION

Alhamdulillah

Praise to Allah for the strength, guidance and knowledge that was given by Allah for me to complete this study.

&

To my beloved parents and families for every support that was given to me.

&

To my supervisor, Mr. Salleh Bin Aboo Hassan for his guidance and advice in completing this research.

&

To all people who support me throughout my journey.

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 70:30 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'8 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 70:30 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 110MPa have resulted the optimum combination factors level according to Taguchi analysis result. The predicted tensile

strength based on this optimum value is 34.46 MPa which is not much different commpared to virgin 100% material tensile strength 33.06 MPa. As a conclusion Polypropylene (PP) 70:30 virgin-regrind material is highly recommended to be used for replacing virgin material for material cost savng project.

TABLE OF CONTENTS

Contents

LIST OF TABLES

LIST OF FIGURES

Chapter 1: Introduction

1.0 Introduction

In this chapter, we will get to know a clear overview of this research and the aim of this research, in addition to the Scope of Study. All this is based on multiple readings related to the same topic, which will be the basis from which we will proceed to complete and understand the rest of the research.

1.1 Background of Study

After plastic has become one of the most important materials used in the industry, this material has entered many fields, such as consumer products, medical products, electrical appliances, aerospace, packaging, building and construction, and many more fields that cannot be counted. More than 360 million tons of plastic have been produced in 2019. Plastics are manufactured through various processes, including injection molding, which is one of the most common and diverse plastic processes due to its ability to produce a complex design product at high production rates. In this process, the polymer heated and injected into the cavity of the mold, and it is cooled and solidified into the shape of the mold.

Year after year the demand for plastic material product globally has tremendously increases. Hence low-cost good quality plastic products have become a huge challenge for plastic industries nowadays to sustain. To remain competitive in plastic market industries, research study in application of blend plastic recycle material with virgin material is vital. This topic has attracted many plastics researcher worldwide in plastic manufacturing companies to investigate and publish their research study in several reputation plastic journal magazines.

Injection molding process is a very complex plastic sharping process. Knowledgeable in plastic polymer properties, injection molding machine, product mold, injection process and application of Design of Experiment (DOE) are essential for a plastic engineer to be competent with. These could help and accelerate their daily job task in improving and achieving their objectives to produce good quality product and yet at lower cost while meeting customer expectation.

Taguchi method is deployed in this final year project study. This Taguchi optimization method is become most simples and cost effective in design of experiment approach compared to other method such as full factorial and response surface. It is one of the most popular methods in manufacturing industries application in twenties centuries during process optimization project study, in which orthogonal array is generated based on experimental parameter design. Mold temperatures, packing pressure, packing time, cooling time and injection speed are the process parameters factors understudy while the mechanical tensile strength of blended Polypropylene (PP) is a response. Under Taguchi method, the higher the better-quality characteristic has been selected since the maximum tensile strength is desirable in this case study.

1.2 Problem Statement

Polypropylene is one of the most common commodity plastics processed by injection molding machine and it is used in a variety of applications including packaging for consumer products, and plastic parts for various industries including the automotive industry. Compared to many other plastics, Polypropylene has good tensile strength - about 4800 psi. This allows products made of Polypropylene to withstand heavy loads, despite their light weight.

With the rising costs of raw materials and in order to reduce the cost of production, we can use composites of virgin Polypropylene and regrind Polypropylene. Thus, getting the final products at a cheaper price for the customers. But on the other hand, when we blend regrind plastic with virgin plastic, the mechanical properties of the part deteriorate. Therefore, it is necessary to conduct studies and experiments to achieve the maximum tensile strength for 70:30 virgin-regrind (PP) Polypropylene products by controlling the various parameters of the plastic injection process. Mold temperature, cooling time, injection speed, packing pressure, and packing time are all parameters that must be properly under study to obtain the best quality.

1.3 Objectives

The objectives that we should achieve in this research are:

1- To determine the most significant factor that affect the tensile strength in 70:30 virgin-regrind Polypropylene (PP) plastic products.

2- To rank the process factors that influence tensile strength.

3- To establish the optimum process setting to achieve the maximum tensile strength using 70:30 virgin-regrind Polypropylene (PP) plastic products.

4- To predict optimum value of tensile strength at optimum parameters using MiniTab software.

5- To compare between the tensile strength of 70:30 virgin-regrind Polypropylene (PP) and virgin Polypropylene (PP).

1.4 Scope of Project

To achieve the objectives, following scopes are formed.

1- The study will focus on the injection moulding process and its related parameters to reach high tensile strength products.

2- The material used in the research is 70:30 virgin-regrind (PP) Polypropylene.

3- Study using the Taguchi method to find out the most important parameters that affect the tensile strength.

1.5 Significant/Importance of Study

The importance of this research is summarized in several points:

1- Reduce the cost of some plastic products by blending recycled materials with virgin materials.

2- Providing useful information about the injection molding process and about the different types of plastics, especially Polypropylene (PP).

3- Studying and finding the most important parameter in improving the injection molding process, which gives better results in the industry.

4- Learn about one of the quality control methods, the Taguchi method, which can be used in many fiel

Chapter 2: Literature Review

2.0 Introduction

This chapter includes an overview of the injection molding process from its inception and development, details of the injection machine, its working mechanism, related parameters, the resulting defects, the causes of these defects, and how to avoid them.

In addition, this chapter will include a discussion about plastics and their applications, the different classifications of plastics and their uses, including thermoplastics and thermosetting plastics. This will be followed by a focus on Polypropylene, waste plastic recycling, and the impact of recycling on mechanical properties. Finally, we will address one of the ways to improve quality, which is the Taguchi method, which we will apply in this research.

2.1 Plastic Injection Molding Machine

In theory, the injection molding process is straightforward. Melt the plastic, inject it into a mold, allow it to cool, and then release the finished product, but this is a more complicated process. The injection unit and clamping unit are the two main sections of a typical injection molding machine, and their parts are explained below. Figure 2.1.

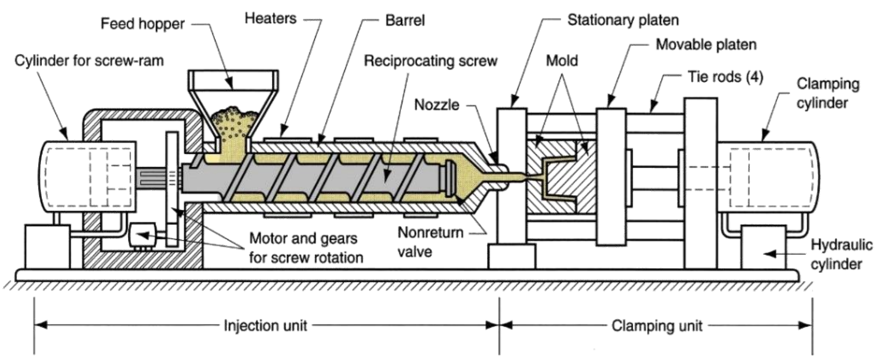

Figure 2. 1 Plastic Injection Molding Machine.

2.1.1 Injection Unit

The injection unit in the injection molding machine is responsible for melting the plastic granules and converting them into a semi liquid material ready for injection in the mold. The injection unit consists of several parts. Starting with the Hopper that is used to feed plastic granules, the process may be done manually or automatically. Also, the Hopper Dryer that is used to get rid of the moisture contained in the raw materials, as it must be dry to avoid deflects. Another important part of the injection unit is the Barrel that contains the Screw, which is rotated by a Hydraulic Motor, as this screw rotates and pushes the plastic forward. Surrounding the barrel, heaters gradually heat the plastic until it melts. At the front of the barrel there is the Nozzle which the melted plastic passes through, and the mold is injected.

2.1.2 Clamping Unit

The clamping unit supports the mold, keeps it closed during injection, opens, and closes the mold as quickly as possible, allows for part ejection, and protects the mold from damage. Hydraulic clamps, hydraulically actuated toggle (mechanical), electrically actuated toggle, and hydromechanical clamps are the four types of clamps. Every clamp has a stationary platen as well as a movable platen. The stationary platen has a hole through which the nozzle contacts the sprue bushing because it supports the mold's core or A side. The sprue bushing is typically surrounded by a locating ring that aligns the mold with the nozzle. When the mold has a hot manifold, the stationary platen is frequently water cooled. While supporting the B side of the mold, the moving platen moves horizontally to open and close the mold, applies clamping force to the mold, and houses the ejector system. The two platens align the mold's two halves, minimizing wear on contacting surfaces. Four tie bars usually support and align these platens. When the moving platen travels to open or close the mold, it is also guided by these tie bars. As the forces that hold the mold closed also stretch the tie bars, tie-bar adjustments are used to realign the platens on a regular basis (Tzy-Cherng, 1992).

2.1.3 History of Injection Molding Machine

In 1860s the game of billiard was widespread in America, and billiard balls were made from elephant ivory, and therefore it was necessary to kill a lot of elephants to get ivory and make billiard balls, which caused the killing of large numbers of elephants and this animal became endangered. The billiard makers then felt this was so dangerous and it was imperative that elephant ivory be replaced with other materials .After several years of research and experiments, brothers John and Isaiah Hayat succeeded in discovering an alternative material, which is celluloid, and thy built first injection molding machine. (Figure 2.2)

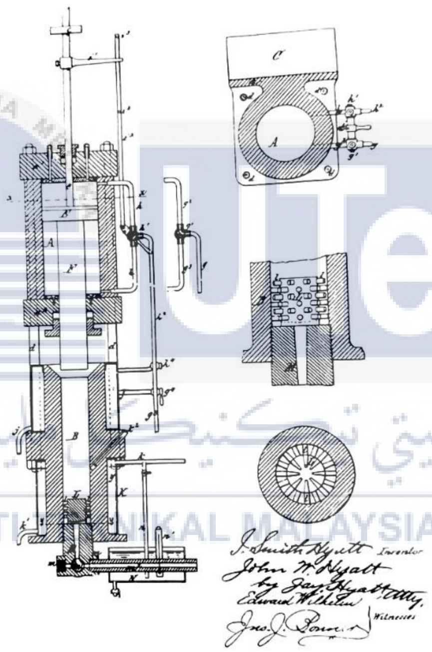

Figure 2. 2 Hyatt Brothers' First Injection Molding Machine 1872.

From the beginning of the twentieth century, various plastics such as Bakelite, vinyl, and others were discovered, and the plastics industry began to develop. In the 1930s, the German engineer Eichengrun developed the Hayat brothers' machine and introduced a newer model of injection molding machines (Figure 2.3).

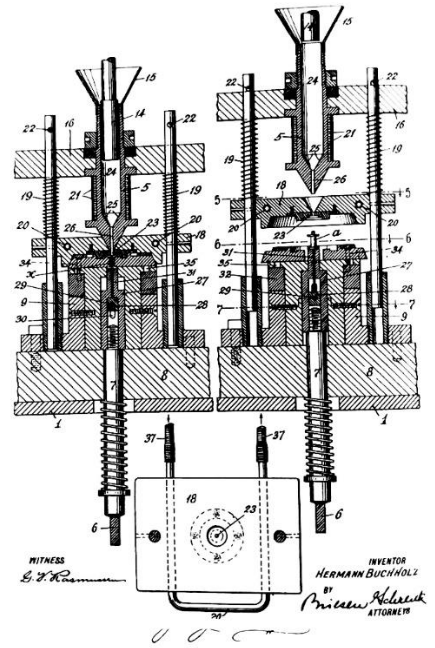

Figure 2. 3 Eichengrun Buchholz Injection Molder 1931.

Then, during the Second World War, the plastics industry became more popular, and more plastic materials were discovered. In 1946, the American inventor James Hendry made a revolution in the world of the plastics industry by inventing the first screw injection molding machine with an auger design which is like the injection molding machines that exist today. (Figure 2.4)

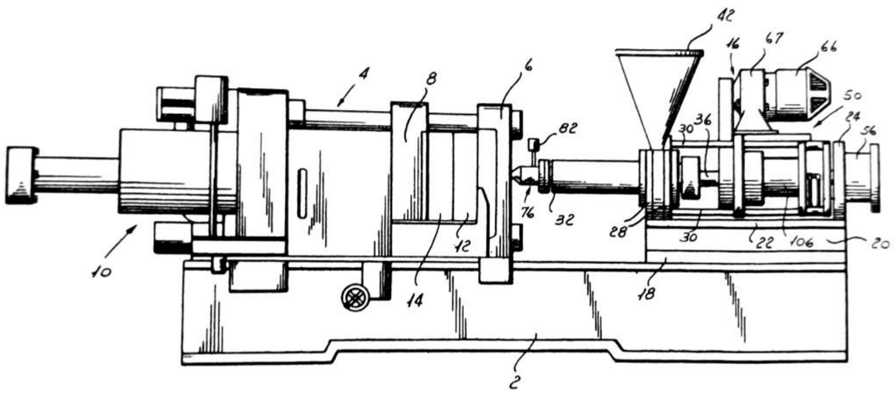

Figure 2. 4 First Screw Injection Molding Machine 1946.

Today's version of the plastic injection molding machine is controlled by a computer. It injects hot plastic into a mold, cool the plastic, and eject automatically. Today's injection molding machines make the mass production of plastic components easy and cost-effective.

Figure 2. 5 Modern Injection Molding Machine

2.1.4 Injection Molding Process

The process begins from the injection unit by placing the plastic pellets in the hopper and then proceeds to the barrel where it is carried forward by the screw. Inside the barrel, the screw rotates by a hydraulic motor, this screw pushes the plastic pellets forward while it is heated by Heating bands in addition to the frictional heat, which cause the plastic to gradually heat up until it melts when it reaches the front of the barrel. When the plastic totally melts in front of the screw, the screw stop rotating and it pushes the plastic through the nozzle like a syringe piston, and within seconds the empty part of the mold (cavity) is injected. Then the plastic solidifies in less than a minute, the mold opens, and the part is ejected. The mold closes again, and the process is repeated (Figure 2.6).

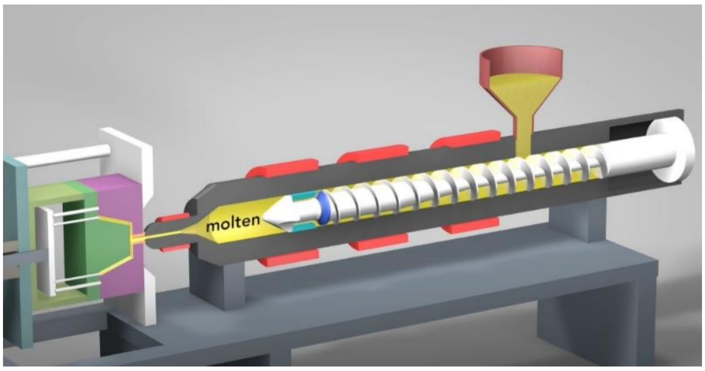

Figure 2. 6 Injection Molding Process

The screw has flights which have different diameters along the shaft, it pushes the plastic forward and helps to have homogeneous material, in addition to generate frictional heat.

In the head of the screw there is a non-return valve to prevent backflow of the plastic material to maintain the effectiveness of the injection pressure. (Figure 2.7)

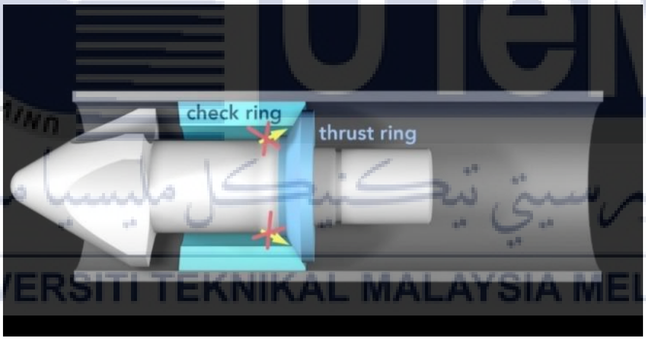

Figure 2. 7 Non-Return Valve of The Screw

2.1.5 Process Parameter Factors

To control the quality of the final products, there are several parameters related to the injection process that must be known and controlled in an optimal way. These parameters are adjustable during the injection molding process and directly influence the quality of the products. These parameters are categorized into groups as follow: temperatures (melting temperature, mould temperature), pressures (injection pressure, holding pressure, clamping force), times (injection