UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION OF INJECTION MOLDING PROCESS ON NAME TAG PLASTIC PRODUCT

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering Technology (Product Design) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Product Design) with Honours. The member of the supervisory is as follow:

………………………………..

(Project Supervisor)

ABSTRAK

Proses pengacuan suntikan adalah satu proses yang digunakan secara meluas untuk pembuatan kompleks berbentuk produk polimer. Proses pengacuan suntikan terdiri daripada empat peringkat utama: proses plastifikasi, proses suntikan, proses pek & tahan dan proses pelemparan. Selepas proses pelemparan, menyedari bahawa dimensi bahagian adalah berbeza dari dimensi acuan yang dikehendaki, saiz produk telah menjadi lebih kecil. Pengecutan adalah satu fenomena yang berlaku semasa pemejalan bahan plastik lebur, tetapi ia juga boleh menjadi masalah utama yang sering dihadapi oleh industri plastik jika ia adalah berlebihan disebabkan oleh faktor-faktor proses parameter tanpa pengoptimuman. Kajian ini telah dibangunkan untuk menentukan faktor utama yang menjejaskan sebahagian pengecutan, dan juga untuk mengoptimumkan faktor proses parameter untuk produk tag nama. Faktor-faktor yang terlibat dalam kajian ini ialah Tekanan Suntikan, Tekanan Ketahanan, Masa Ketahanan dan Masa Penyejukan. Bahan yang dipilih untuk kajian ini adalah Acrylonitrile Butadiene Styrene (ABS) bahan plastik. Kajian ini telah direka dengan menggunakan kaedah Taguchi, pendekatan berstruktur yang biasa digunakan untuk menentukan kombinasi input yang "terbaik" untuk menghasilkan satu produk plastik. Selepas menentukan keadaan operasi bagi setiap parameter dan tahap (minimum, semasa dan maksimum), sebuah ortogon Array (OA) yang sesuai telah dipilih untuk menghasilkan bilangan minimum percubaan untuk menganggarkan kesan utama. 9 ujian telah dijalankan dan 10 sampel telah diambil dari setiap percubaan. Pemeriksaan dimensi telah dibuat dengan menggunakan Mesin Pengukuran Koordinat (CMM), untuk mendapatkan nilai purata tepat untuk mengira nilai pengecutan. Nilai pengecutan digunakan untuk mencari Nisbah Isyarat-Hingar (SN) dengan menggunakan Minitab, plot kesan utama bagi nilai purata dan nisbah SN telah diperhatikan. Hasil kajian menunjukkan hubungan antara nisbah SN dan nilai

pengecutan. Satu set faktor proses parameter yang telah dioptimumkan pada akhir pengajian ini.

ABSTRACT

Injection moulding is a widely used process for manufacturing complex shaped polymer products. An injection moulding process consists of four main stages: plastification, injection, pack & hold, and ejection. After ejection, noticed that the dimension of the part is different from the desired mould dimension, the part size becomes smaller. Shrinkage is a phenomenon which occurs during the solidification of molten plastic material, but it can also be a main problem that often faced by the plastic industry if it is excessive due to the process parameter factors without optimization. This study was developed to determine the significant factor affecting the part shrinkage, and also to optimize the process parameter factors for name tag product. The factors which involved in this study were Injection Pressure, Holding Pressure, Holding Time and Cooling Time. The selected material for this study was Acrylonitrile Butadiene Styrene (ABS) plastic material. The experiments were designed by using Taguchi method, a structured approach which commonly used for determining the "best" combination of inputs to produce a plastic product. After determining the operating conditions for each parameter and levels (minimum, current and maximum), a proper Orthogonal Array (OA) was selected to create the minimum number of trials to estimate the main effects. The 9 trials were conducted and 10 samples were collected from each trial. The dimension inspection were done by using Coordinate Measuring Machine (CMM), in order to obtain the average value accurately in order to calculate the shrinkage value. The shrinkage values were used to find the Signal-to-Noise (SN) ratios using Minitab software, the main effect plots for means and SN ratios were observed. The results showed the relationship between the SN ratios and the shrinkage value (means). A set of optimized process parameter factors were obtained at the end of study.

DEDICATION

This thesis is dedicated to my beloved family, my supervisor En Salleh bin Aboo Hassan and all my fellow friends for their guidance and help to complete the Final Year Project successfully.

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Firstly, I would like to express my sincere appreciation to my supervisor, Encik Salleh bin Aboo Hassan for his guidance, patience and encouragement. Thanks for spending your precious time to teach me and guide me for the project. A special thank to my friend, Ivy King Chien Chien who always helped me, guided me and supported me all the time although she was also busy in her final year project. Without Encik Salleh and Ivy, I would never able to complete this project on time.

I would like to express my gratitude to my parents and my family for giving me support and encouragement. Not to forget my fellow friends who always support me when I faced difficulties and problems. I am also thanks to the lecturers and technicians who had borrowed me the machine instruments and laboratories, and guided me while doing the experiments for the project.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ABS	Acrylonitrile-Butadiene-Styrene
ANOVA	Analysis of Variance
CAB	Cellulose Acetate Butyrate
CMM	Coordinate Measuring Machine
DOE	Design of Experiment
GF	Glass Fiber
HDPE	High-Density Polyethylene
LDPE	Low-Density Polyethylene
OA	Orthogonal Array
OAPEC	Organization of Arab Petroleum Exporting Countries
PBT	Polybutylene Terephthalate
PC	Polycarbonate
PEEK	Polyetheretherketone
PET	Polyethylene Terephthalate
PPO	Polyphenylene Oxide
PVC	Polyvinyl Chloride
PVC-P	Plasticized Polyvinyl Chloride
PVC-U	Polyvinyl Chloride Unplasticized
SAN	Styrene Acrylonitrile
SN ratio	Signal-to-Noise ratio
TPE	Thermoplastic Elastomers

CHAPTER 1

INTRODUCTION

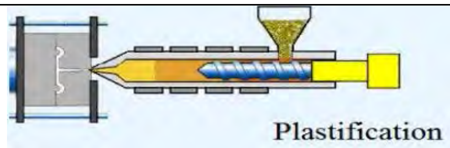
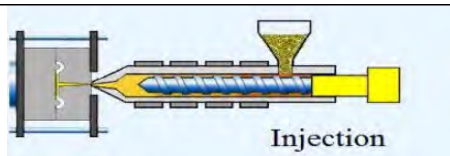
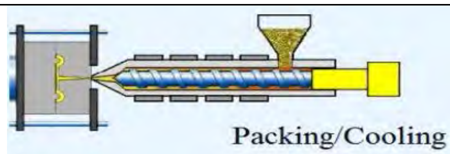
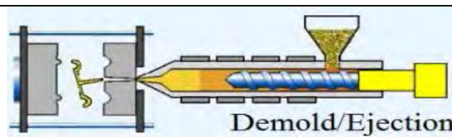
1.0 Overview

This chapter explained about the basic knowledge of injection moulding process and project title. Besides that, this chapter also described the project background, the problem statement, objectives and the scope of this study.

1.1 Introduction

In the current market, there are many products made from plastic due to the inexpensive price and attractive appearance. These plastic products were made by using the technique of injection moulding process. Injection moulding is a manufacturing process which commonly applied in industry field. It is a process of fabricating thin-wall plastic products by injecting the molten plastic material into a mould, then ejected the plastic products from the mould after cooling down. The shape of the plastic product can be simple or complex, it also can be flexible or hard, thick or thin, and the size will not be a problem for the injection moulding process. To set up a mould, it can take few minutes or hours to maintain the process in stable. Typically, the cycle time for injection moulding process will be taken only a few seconds or few minutes to produce one part. The injection moulding machine consists of three main parts, they are injection unit, the mould assembly and the clamping unit. The injection moulding process consists of four main steps to complete one cycle of a production; the following table describes an overview of the injection moulding process:

Table 1.1: Overview of Injection Moulding Process

Step 1		The plastic pellets (raw materials) are fed into the barrel through a hopper. The pellets are then transported forward when the reciprocating screw is turning.
Step 2		The plastic pellets are melted by the external pressure from the narrow space in barrel, the friction inside the barrel and the additional heat from the heater bands which are surrounded the barrel. The molten material flow into the nozzle, the screw is then pushed forward to inject the molten material into the mould cavity.
Step 3		The reciprocating screw holds and pack s the molten material in the time set in order to ensure the molten part was completely solidified when the mould opens. The cooling process is then proceed when the holding time ends.
Step 4		After cooling process, the injected material is fully solidified. The mould opens eject the product by using the ejector pins. One cycle of production completes and repeats to produce the next product.

There are various types of plastic materials used in the injection moulding process, such as Polypropylene, Polystyrene, Polyethylene and other plastic materials. Acrylonitrile-Butadiene-Styrene (ABS) $(C_8H_8)_x \cdot (C_4H_6)_y \cdot (C_3H_3N)_z)$ is one of the popular amorphous thermoplastic which is commonly used in injection moulding process. It is opaque, high resist to heat and chemicals, and even able to maintain high durability at low temperature. Each material has different physical and chemical properties which may affect the setting of process parameters in an injection moulding machine. The process parameters such as mould temperature, injection pressure and injection speed. Therefore, the process parameters are needed to be optimized based on the material properties in order to produce a part with good quality.

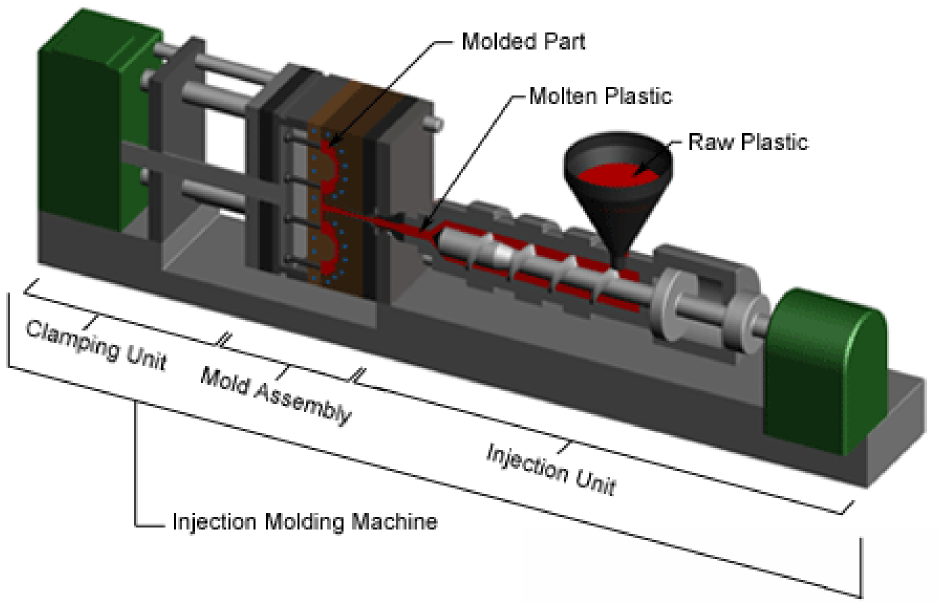


Figure 1.1: Injection Moulding Machine Overview.

Figure 1.2: Plastic Pellets for Injection Moulding Process.

1.2 Project Background

Injection moulding process is a manufacturing process which can be applied by using different materials such as glasses, metals, thermoplastic and thermosetting plastic. Plastic injection moulding is the most common mass production process due to the low cost materials used in that process. However, different plastic materials have the different properties such as melting point, heat resistance, crystalline percentage and others, which are required to take into consideration when running an injection moulding process. This is because these properties will cause the occurs of defect if the injection moulding process parameters are not optimized. The main problem that usually faced by injection moulding process is shrinkage problem. Shrinkage is a phenomenon which occurs during the solidification of molten material, as the dimensions of solidified part is smaller than the size of mould cavity. This phenomenon could affect the product quality if its percentage value is too high when the injection moulding is not optimized. An excessive shrinkage can be detected from the warpage of the plastic product. In order to minimize the shrinkage and warpage problems, researchers had contributed several methods for the improvement. They had applied Taguchi Method and Signal-to-Noise ratio to obtain the optimized process parameters. Taguchi Method was developed by Dr.Genichi Taguchi, a Japanese engineer of Nippon Telephones and Telegraph Company. This method applies a set of Orthogonal Arrays in order to set the minimum experiment to be conducted, which could provide the most information of all the factors that affect the performance parameter. While Signal-to-Noise ratios, a log function of desired outputs will be applied to analyse the experimental and also to predict the optimum results.

1.3 Problem Statement

The reason for this study is to address the need for controlling and minimize the part of shrinkage formation in plastic materials for name tag product. Shrinkage is a major problem when dealing with plastic injection moulding. Shrinkage could affect the quality of moulded product. In this shrinkage study, we focused only on the ABS plastic shrinkage problem which could be affected by many factors which could caused lower quality of product in terms of dimension and well-finished surfaces. There were many process factors that were required to be considered during an injection moulding process, such as barrel temperature, mould temperature, injection speed, holding pressure and more. These factors were analysed and optimized in order to produce a good quality with less shrinkage moulded part.

1.4 Research Objectives

The objectives of this research study are:

i. To determine the significant factors affecting the part shrinkage.
ii. To optimize the process parameter factors for name tag product.

1.5 Scope

For the purpose of addressing the need to control and minimize the part of shrinkage formation, we were only focused on shrinkage problem of one product, that was UTeM name tag holder. The main process that involved in this study was the injection moulding process, there was no other additional process involved in this study. An electrical injection moulding machine (ZHAFIR Plastic Machinery VE1200 ton) was used along this project to evaluate the shrinkage problem study. ABS (Acrylonitrile Butadiene Styrene) was the only selected plastic material and it was evaluated for this study. In order to ease the process, Taguchi Method was applied as Design of

Experiment (DOE) for this study for analysing the data observed. The dimensions of the name tag holder such as length was recorded and also been measured for the calculation of the product's shrinkage percentage. To measure the dimensions precisely, CONTURA G2 Coordinate Measuring Machine (CMM) was used for the measuring process along this study.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter had covered the literature review of the project study. In this chapter, the literature review had introduced about the history of injection moulding, and also reviewed the topics such as injection moulding process, plastic defects, plastic material, Taguchi method and part shrinkage.

2.1 History of Injection Moulding

Injection moulding was a great invention for the human being to make many kinds of product. Reviewing the history, it was started with Jons Jacob Berzelius, who generated the first condensation polymer – polyester. In 1861, a British named Alexander Parkes invented the first profitable plastic, he called it "Parkesine", and also demostrated it at 1862 International Exhibition in London. John Wesley Hyatt, an American inventor, he had combined the cellulose nitrate and camphor for the purpose of replacing the ivory in a billiard ball, a plastic material named "Celluloid" was born in the year 1868. After four years, John Wesley Hyatt and his brother Isaiah had patented the first injection moulding machine. People had described that the working of this first injection moulding machine just like a hypodermic needle because a plunger was used to inject the material.In 1909, a type of plastic called phenolformaldehyde plastic was discovered by Leo Hendrik from Belgium. This substance was first controlled by Leo and became usable on a large scale. During the 1930s, the major vinyl thermoplastics such as polystyrene, PVC and polyolefins, were in the initial development stage. In 1938,