UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION OF TENSILE STRENGTH VIA OPTIMAL PROCESSING PARAMETER FOR HIGH DENSITY POLYETHYLENE (HDPE) MATERIAL

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

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2017

DECLARATION

I hereby, declared this report entitled "Optimization of Tensile Strength Via Optimal Processing Parameter for High Density Polyethylene (HDPE) Plastic Material" is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Process & Technology). The member of the supervisory is as follow:

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ABSTRAK

Kajian ini bertujuan untuk mengoptimumkan kekuatan tegangan melalui parameter pemprosesan optimum menggunakan plastik Polietilena Kepadatan Tinggi (HDPE). Kaedah untuk melaksanakan projek ini bermula dari pemilihan tajuk, ulasan kesusasteraan, menentukan masalah, menguji parameter, analisis hasil, akhirnya perbincangan dan kesimpulan. Objektif percubaan ini adalah untuk mengenal pasti kesan penting faktor proses pencetakan pada kekuatan tegangan untuk bahan Plastik Polietilena Kepadatan Tinggi (HDPE) dan untuk mengoptimumkan parameter pemprosesan pengacuan. Bahan yang digunakan dalam kajian ini adalah Polietilena Kepadatan Tinggi (HDPE). Dengan menggunakan kaedah pengoptimuman Taguchi, empat faktor yang boleh dikawal iaitu Tekanan Suntikan, Tekanan Pegangan, Kelajuan Suntikan dan Masa Pegangan, masing-masing di tiga tahap diuji untuk menentukan faktor gabungan dan tahap kombinasi dalam proses pembuatan. Hasil daripada kajian ini menunjukkan bahawa kedua-dua Taguchi dan ANOVA menghasilkan pangkat yang sama iaitu D (pangkat pertama), A (pangkat ke-2), C (pangkat ketiga), dan B (pangkat ke-4). Ia juga menunjukkan bahawa faktor yang paling penting yang memberi kesan kepada kekuatan tegangan ialah Masa Pegangan dan mengoptimumkan parameter pemprosesan ialah A1B2C2D1. Faktor A (Tekanan Suntikan) dengan tahap 1 parameter iaitu 125 Mpa, Faktor 2 (Tekanan Pegangan) dengan tahap 2 iaitu 16.25 Mpa, Faktor C (Suntikan Kelajuan) dengan tahap 2 iaitu 1107.5 mm/s dan terakhir tetapi tidak sekurang-kurangnya Faktor D (Masa Pegangan) dengan tahap 1 iaitu 8s.

ABSTRACT

This study aims to optimize the tensile strength via optimal processing parameter using High Density Polyethylene (HDPE) plastic material. The method for doing this project is starting from title selection, literature review, define problems, testing parameter, result analysis, finally discussions and conclusions. The objective of this experiment is to identify the significant effect of moulding process factors on tensile strength for High Density Polyethylene (HDPE) plastic material and to optimize the moulding processing parameter. The material used in this study is High Density Polyethylene (HDPE). By utilizing the Taguchi optimization method, four controllable factor which are Injection Pressure, Holding Pressure, Injection Speed and Holding Time, each at three levels were tested to determine the optimal combination factors and levels in the manufacturing process. The result from this study shows that both of Taguchi analysis and Analysis of Variance (ANOVA) conducted produced the same rank which is D-Holding Time (1st rank), A Injection Pressure(2nd rank),C-Injection Speed (3rd rank) , and Holding Pressure(4th rank). It also shows that the most significant factor that effect the tensile strength is Holding Time and optimize processing parameter is A1B2C2D1**.** Factor A (Injection Pressure) with level 1 parameter which is 125 Mpa, Factor 2 (Holding Pressure) with level 2 which is 16.25 Mpa, Factor C (Injection Speed) with level 2 which is 1107.5mm/s and last but not least Factor D (Holding Time) with level 1 which is 8s.

DEDICATION

To my beloved parents ,Mazalan b Ayob and Jamilah bt Jaafar , and also to my beloved family and also my friends.

ACKNOWLEDGEMENT

Praise and thanks to Allah and foremost whose blessing enabled me to accomplish this project . Deepest appreciation to my dear supervisor Encik Salleh Bin Aboo Hassan for guidance ,helpful suggestion, close supervision and moral encouragement to complete this task. A special thank to my parents for their endless love and motivation and to all my lectures . My friends that help support the project , my fellow classmates . My sincerely thanks to all those whom directly or indirectly help me to complete this project

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

F	-	F Test (ANOVA)
HU	-	Highly Used
IT	-	Information Technology
LU	-	Least Used
RM	-	Malaysian Ringgit
SD	-	Standard Deviations
U	-	U Test (Mann Whitney Test)
UTS	-	Ultimate Tensile Strength
TS	-	Tensile Strength
SI	-	System of Units
Pa	-	Pascal
MPa	-	Mega Pascal
(N/m^2)	-	Newton Per Square Metre
US	-	United State
ISO	-	International Standard Operation
ASTM	-	American Society for Testing and Materials
HDPE	-	High Density Polyethylene
CNC	-	Computer Numerical Control
>	-	More than
σ	-	Stress
ϵ	-	Strain
τ	-	Torque

CHAPTER 1
INTRODUCTION

1.0 Introduction

In first section of the report, few parts will be described which are background, problem statement, and objectives of the study . Scope will discuss about parts have covered and the limitation of this project.

1.1 Background

Ultimate tensile strength (UTS), regularly shortened to tensile strength (TS) or ultimate strength is the limit of a material or structure to withstand loads having tendency to extend, rather than compressive strength, which withstands loads having tendency to decrease size. Besides that , tensile strength resists tension (being pulled separated), while compressive strength opposes compression (being pushed together). Ultimate tensile strength is measured by the maximum or greatest stress that a material can withstand while being extended or pulled before breaking. In the research of strength of materials, tensile strength, compressive strength, and shear strength can be examined autonomously

A few materials break forcefully, without plastic bend, in what is known as a fragile failure. Others, which are more bendable, including most metals, encounter some plastic disfigurement and conceivably necking before break.The UTS is normally found by carrying out a tensile test and recording the manufacturing stress

versus strain. The most astounding purpose of the stress–strain bend is the UTS. It is a focused property; in this manner its regard does not rely upon the measure of the test model. Be that as it may, it is subject to different components, for example, the planning of the model, the nearness or generally of surface deformities, and the temperature of the test condition and material.

Tensile strengths are infrequently used in the intention of ductile adherents, but they are important in brittle adherents. They are arranged for normal materials such as alloys, composite materials, ceramics, plastics, and wood. Tensile strength can be characterized for fluids and solids under specific circumstances. For instance, when a tree draws water from its underlying foundations to its upper leaves by transpiration, the segment of water is pulled upwards from the best by the attachment of the water in the xylem, and this power is transmitted down the segment by its elasticity. Pneumatic force, osmotic weight, and narrow pressure additionally has a little influence in a tree's capacity to draw up water, however this by itself would just be adequate to push the segment of water to a stature of under ten meters, and trees can develop considerably higher than that (more than 100 m).

Tensile strength is characterized as stress, which is measured as power per unit region. For some non-homogeneous materials (or for collected parts) it can be accounted for similarly as a power or as a power for every unit width. In the International System of Units (SI), the unit is the Pascal (Pa) (or regularly mega pascals (MPa), utilizing the SI prefix mega)bor, comparably to pascals , newtons per square meter (N/m^2) . A United States standard unit is pounds per square inch (lb/in^2 or psi), or kilo pounds per square inch (ksi, or in some cases kpsi), which is equivalent to 1000 psi; kilo-pounds per square inch are normally utilized as a part of one nation (US), when measuring rigid qualities.

The capacity to oppose breaking under ductile anxiety is a standout amongst the most vital and broadly measured properties of materials utilized as a part of auxiliary applications. The power per unit region (MPa or psi) required to soften a material up such a way is a definitive elasticity or rigidity at break. The rate at which a specimen is pulled separated in the test can go from (0.2 - 20) inches every moment

and will impact the outcomes. The closely resembling test to gauge malleable properties in the ISO framework is 'ISO 527'. The qualities detailed in the 'ASTM D638' and 'ISO 527' tests all in all don't shift fundamentally and either test will give great outcomes ahead of schedule in the material determination process.

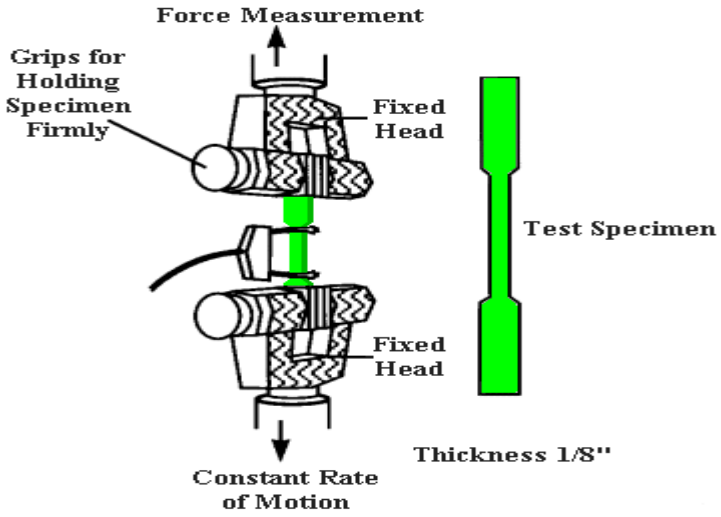


Figure 1.1:Tensile Testing

1.2 Problem Statement

The problem in the area of factory-made plastic product are fronting constraint of the tensile strength. The problem statement reports the need for adjusting and optimizes the tensile strength in plastics materials for HDPE material. For the conventional method , it is trial and error method to find the suitable parameter . This method is time consuming and does not cost effective. Moreover, this method takes time to determine the significant factors that affected the tensile strength of the plastic part. Taguchi Design of experiment method was utilized in this study and the process factors was analyzed . Besides , the analysis of the Taguchi and Analysis of Variance (ANOVA) results with wrong approach was affected the decision making . Therefore , the factors level was investigate . It was affected the dimension of the product.

1.3 Objectives

The purpose of the study is to optimize the tensile strength for the High Density Polyethylene (HDPE) plastic material In order to achieve those objective, threre are several study objective need to be conducted :

a) To determine the significant factor affecting the tensile strength of the part
b) To optimize the process parameter factors for the HDPE materials.

1.4 Work Scope

The scope is the guidelines for the reader to areas that have or have not been covered. It is impossible to investigate everything in the study and project.Therefore , the study will cover primarily on the scopes are :

a) Material used in this project is High Density Polyethylene (HDPE).
b) Plastic injection molding process is focused in this research study.
c) Taguchi and Analysis of Variance (ANOVA) method is used to analyze the data
d) Dog bone specimen will be selected for this process evaluation

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter provides a detailed of tensile strength , High Density Polyethylene (HDPE) materials , process and the material properties . The process factors involve and the materials that used in this project will be included in this chapter . Besides that, this chapter also includes the history and information about Taguchi Design of Experiment method.

2.1 Plastic Materials

2.1.1 Introduction

In interpretation of N.Ravi Kumar , CH.ranga Rao, P.Sarikant, B.Raghava Rao (2015) contemplated , thermoplastics has preference of option framework materials than thermoset networks . These incorporated the time span of usability , strength , post framing , and reuse contemplations . Thermoplastic polymers have long-chain particles that don't frame chemicals bond with others. At the point when these polymers being liquefied and afterward solidify , it can be warm to soften for reuse reason . Consequently , thermosetting polymers are costly than thermoplastics (Ramlee,2007).

2.1.2 Definition of Plastic

A simplistic meaning of plastic an unpredictable gathering of engineered that is equipped for being shape . Douglas M.Bryce (1997) expressed that , plastic can be as three stage , strong, fluid and something amongst strong and fluid.

Fundamentally expressed, a plastic is a characteristic polymer, open in some sap shape got frame from the basic polymerized tar. These structures can be glue like gums of liquid for inserting, covering, and cement holding, or they can be overlaid, shaped, or framed shapes, including film, sheet, or bigger mass shapes. (Charles et.al, 2003).

Plastic materials include a reliably expanding dissemination of the city and mechanical waste going into the landfill. Inferable from the gigantic measure of plastic squanders and ecological weight, reusing of plastics has transformed into a staggering subject in the present plastics industry.

Advancement of innovations for diminishing plastic waste, which are agreeable from the ecological perspective and are gainful, has wound up being an extreme test because of the complexities trademark in the reuse of polymers. Setting up perfect process for the reuse/reusing of plastic materials, along these lines, remains a general test in the new century. (Kumar and Singh, 2013).

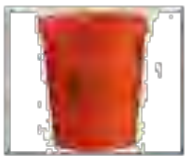
2.1.3 Classification of Plastic

Polyethylene Terephthalate sometimes absorbs odours and flavours from foods and drinks that are stored in them. Items made from this plastic are **commonly recycled**. PET(E) plastic is used to make many common household items like beverage bottles, medicine jars, rope, clothing and carpet fibre.

High-Density Polyethylene products are very safe and are not known to transmit any chemicals into foods or drinks. HDPE products are **commonly recycled**. Items made from this plastic include containers for milk, motor oil, shampoos and conditioners, soap bottles, detergents, and bleaches. It is NEVER safe to reuse an HDPE bottle as a food or drink container if it didn't originally contain food or drink.

Polyvinyl Chloride is **sometimes recycled**. PVC is used for all kinds of pipes and tiles, but is most commonly found in plumbing pipes. This kind of plastic should not come in contact with food items as it can be harmful if ingested.

Low-Density Polyethylene is **sometimes recycled**. It is a very healthy plastic that tends to be both durable and flexible. Items such as cling-film, sandwich bags, squeezable bottles, and plastic grocery bags are made from LDPE.



Polypropylene is **occasionally recycled**. PP is strong and can usually withstand higher temperatures. It is used to make lunch boxes, margarine containers, yogurt pots, syrup bottles, prescription bottles. Plastic bottle caps are often made from PP.

Polystyrene is **commonly recycled**, but is difficult to do. Items such as disposable coffee cups, plastic food boxes, plastic cutlery and packing foam are made from PS.

Code 7 is used to designate miscellaneous types of plastic not defined by the other six codes. **Polycarbonate** and **Polylactide** are included in this category. These types of plastics are **difficult to recycle**. Polycarbonate (PC) is used in baby bottles, compact discs, and medical storage containers.

Table 2.1: Types of Plastics and Their Properties

Plastic Type	General Properties	Common Household Uses
 Polyethylene	-Worthy gas & wetness barrier properties -High heat confrontation -'Clear' -'Hard' -'Tough'	-Mineral Water, sparkling drink and beer bottles -Pre-equipped food salvers and frying bags -Boil in the bag food bags Soft drink and water bottles -Fibre for clothing and carpets
 High Density Polyethylene	-Admirable wetness barrier properties -Admirable chemical resistance -Firm to semi-plastic and durable -Easy-going waxy apparent -Penetrable to gas -HDPE films fold to the touch -Pigmented bottles stress resistant	-Cleanser, bleach and fabric conditioner flasks - Goodies food containers and cereal box linings -Milk and non-carbonated drinks bottles -Toys, buckets, rigid pipes, crates, plant pots -Plastic wood, garden furniture -Wheeled refuse bins , compost containers
 Polyvinyl Chloride	-Admirable transparency -Solid, rigid (flexible when plasticized) -Decent chemical resistance -Time-consuming term steadiness -Decent enduring ability	-Credit cards -Carpet back-up and other floor casing -Window and door edgings, trenches -Pipes and fixtures, wire and cable covering -Manmade leather products

	-Steady electrical properties -Little gas penetrability	
 Low Density Polyethylene	-Hard and stretchy -Waxy surface -Soft – abrasions effortlessly -Decent transparency -Small melting point -Steady electrical assets -Good wetness barrier assets	-Films, fertilizer bags, waste sacks -Wrapping films, bubble covering Flexible bottles -Thick spending bags (clothes and produce) -Wire and cable requests Some bottle tops
 Polypropylene	-Admirable chemical resistance -Great melting point -Solid, but stretchy -Waxy surface -Luminous -Strong	-Most bottle clippings -Ketchup and syrup bottles -Yoghurt and some margarine ampules -Potato crisp bags, biscuit packages Crates, plant pots, drinking straws -Hinged lunch boxes, chilled containers -Fabric/ carpet fibers, heavy duty bags/tarpaulins
 Polystyrene	-Pure to impervious -Shiny surface -Rigid or fizzed -Solid -Breakable -High clearness	-Yoghurt containers, egg boxes Fast food trays -Video cases -Marketing cups and disposable -cutlery Seed trays -Coat pegs -Low cost breakable toys

	There are different polymers that have an extensive variety of employments, especially in building segments. They are related to the number 7 and OTHER (or a triangle with numbers from 7 to 19).	-'Nylon (PA)' -'Acrylonitrile butadiene styrene (ABS)' -'Polycarbonate (PC)' -Coated or multi-material varied polymers

2.1.4 High Density Polyethylene(HDPE)

2.1.4.1 Introduction of High Density Polyethylene (HDPE)

A few makers are creating wood– thermoplastic composites from reused materials. In just 10 years, the utilization of plastics and fiber–thermoplastic composites for decking has developed to around 6% of the outside decking market (Smith and Carter, 1999). Bigger markets inside the building business could be created, for example, the material market, however absence of toughness execution information and hesitance of home manufacturers to use undemonstrated items have hampered advertise improvement.

Thermoplastics have a few good qualities as segments in composites, including recyclability, malleably high particular quality and modulus, ease, low thickness, and low contact amid grating (Rietveld and Simon, 1992). Wood– polymer composites have magnificent dimensional strength under dampness introduction and better growths and termite protection (Maldas and Kokta, 1991 ; Verhey et al., 2001). Mechanical properties of (HDPE with calcium carbonate, fiber glass and lignocellulose)