"I / we admit that have read this
work and in opinion of me / we this work was adequate from
the aspect scope and quality to the significance to for Bachelor Mechanical
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FEASIBILITY STUDY ON MECHANICAL PROPERTIES OF VARIOUS VACUUM CASTING MATERIALS

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This report is submitted to the Faculty Mechanical Engineering in partial to fulfill the requirement for Bachelor Mechanical Engineering
(Design and Innovation)

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"I hereby declared that this report is a result of my own work except for the works that have been cited clearly in the references."

Signature : ……

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Date : ……

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First of all, I would like to praise Allah for giving me the strength to endure the Projek Sarjana Muda period with a great successfully. It is known that, this PSM is one of the most important subjects that must be endured by all UTeM students as a requirement to get a degree.

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ABSTRAK

Matlamat projek ini adalah untuk mengkaji kemungkinan ciri-ciri mekanikal bagi pelbagai bahan-bahan penuangan vakum. Projek ini termasuk kajian ke atas perisian CAD, teknik-teknik *'Rapid Prototyping'*, teknik-teknik *'Rapid Tooling'* seperti acuan getah silikon dan penuangan vakum, dan ujian tegang untuk spesimen daripada penuangan vakum seperti acrylonitrile butadiene styrene (ABS), polipropilena (PP), politena (PE), nilon (polyamide), dan getah. Tujuan ujian tegangan adalah untuk menentukan *'Ultimate Tensile Strength'* (UTS) dan '*Modulus Young'* (E). Daripada data ekperimen, perbandingan dengan bacaan daripada standard data akan dibuat untuk memastikan nilai ciri-ciri mekanikal untuk semua spesimen adalah betul.

ABSTRACT

This project aim is to study the mechanical properties of various vacuum casting materials. This project includes the study on CAD software, Rapid prototyping techniques, Rapid tooling techniques such as silicon rubber mold and vacuum casting, and tensile testing for the specimen from the vacuum casting materials such as acrylonitrile butadiene styrene(ABS), polypropylene(PP), polyethylene(PE), nylon (polyamide), and rubber. The purpose of the tensile test is to determine the ultimate tensile stress (UTS) and tensile modulus (E). From the data of the experiments, comparison with the theory data will be done to make sure the value of the mechanical properties for all specimens are right.

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ABBREVIATION

2D	Two-dimension
3D	Three-dimension
ABS	Acrylonitrile Butadiene Stryene
ASCII	American Standard Code for Information Interchange
ASTM	American Society for Testing and Materials
B.C	Before Century
C	Celcius
CAD	Computer Aid Design
CAE	Computer Aided Engineering
CNC	Computer Numerically Controlled
E	Young's Modulus
F	Fahrenheit
FKM	Fakulti Kejuruteraan Mekanikal
FDM	Fused Deposition Machine
HDPE	High-Density Polyethylene
IGES	Initial Graphics Exchange Specification
LDPE	Low-Density Polyethylene
LOM	Laminated Object Manufacturing
PA	Polyamide
PE	Polyethylene
PP	Polypropylene
PSM	Projek Sarjana Muda
RP	Rapid prototyping
RT	Rapid Tooling
RTV	Room Temperature Vulcanization

SLA	Stereolithography
SLS	Selective Laser Sintering
SRM	Silicone Rubber Mold
STL	Standard Triangulation Language
UTeM	Universiti Teknikal Malaysia Melaka
UTS	Ultimate Tensile Stress
UV	Ultra-violet

CHAPTER 1

INTRODUCTION

1.3 Background

'Projek Sarjana Muda' (PSM) is a compulsory for all student of UTeM in order to obtain a degree in the engineering field. From the PSM, every student will apply their subject learned from the classes into the final project. There are many applications that have to do such as theoretical, experimental, analysis, design and so on. Objective of this project is to produce professional and efficient graduate to complete engineering problem by literature and scientific study through research approach and development and through application of knowledge were studied and knowledge from some other field those concerning.

Nowadays, lots of products are produced using vacuum casting. This is because the process allows the user to evaluate moulding designs without committing to the delays and expense of production tooling. The system is capable of reproducing intricate designs with complex internal detail and surface finish comparable to injection moulded components and is suitable for producing a limited quantity of working prototypes or production parts. Small undercuts can be tolerated due to the flexibility of the silicone mould.

These final projects will focus on mechanical properties of vacuum casting material. There are several types of plastic resins that always be used in vacuum casting such as Acrylonitrile Butadiene Stryene(ABS), polypropylene, polyethylene,

nylon (polyamide), rubber and so on. Each of this material will be fabricated with the same standard shape using vacuum casting process. A tensile testing will be done on those products to examinee the mechanical properties such as tensile strength, yield and ultimate strength, modulus of elasticity and so on.

1.2 Problem Statement

Polymers commonly referred to as plastics, is wide used in design products due to their relatively low cost and good machineability. However, designers need to choose the right materials to make their quality product. To achieve the aims, mechanical properties of the materials need to be studied first before any problem or mistake occurs. For example, in the medical field, human bones can be replaced with the bones made from polymers. Hence, the designers need to study the properties of the polymer to make sure there is no any complication to the patient in the future.

1.3 Purpose Of Project

The aim of this project is to study on mechanical properties of vacuum casting material.

1.4 Objective of Project

The objectives are following:

- To study the mechanical properties of Acrylonitrile Butadiene Styrene (ABS), polypropylene (PP), polyethylene (PE), Nylon (polyamide) and rubber.
- To understand about the vacuum casting process.
- To study relations between Computer Aid Design (CAD), Rapid Prototyping (RP), Silicon Rubber Mould (SRM) and vacuum casting.
- To perform the mechanical testing for vacuum casting materials.

1.5 Scope

The scope of this project is to do literature search on standard shape for testing specimen and the material used, Rapid Prototyping (RP), Silicon Rubber Mould (SRM) and casting techniques, mechanical testing, actual material properties and database.

CHAPTER 2

POLYMERS, RAPID PROTOTYPING & CAD

2.1 AN OVERVIEW OF POLYMERS

Most plastic materials are used because they are advantageous mechanical properties at an economical cost. For this reason, the mechanical properties may be considered the most important of all the physical and chemical properties of high polymers for most applications. Thus, everyone working with such materials needs at least a basic knowledge of their mechanical behaviour and how this behaviour can be modified by the numerous structural factors that can be varied in polymers. Polymers vary from liquids and soft rubbers to very hard and rigid solids.

One of the key areas in the design process is the selection of the appropriate materials. A poor material choice can lead to failure of a part or system or to unnecessary cost. In selecting the appropriate material one must consider the following [1]:

- Material properties that will affects the part performance.
- Material processing because it will affects the manufacturing cost and therefore the final part cost.
- Material cost.
- Availability of the material. The availability of the required material can affect the production timelines. Often the small design projects, the minimum purchase size or quantity may far exceed the team's need.

The relative importance of the above four factors varies depending on the application. For example, in military and aerospace applications, pushing the material properties to their limits normally takes precedence over cost. For consumer products, lowering cost typically plays the leading role.

2.1.1 General Properties of Polymers

This section will discuss the properties associated in the rapid tooling materials such as ABS (acrylonitrile butadiene styrene), PP (polypropylene), PE (polyethylene), Nylon or polyamide (PA) and rubber.

2.1.1.1 ABS (Acrylonitrile Butadiene Styrene)

ABS possesses outstanding impact strength and high mechanical strength, which makes it so suitable for tough consumer products. Additionally, ABS has good dimensional stability and electrical insulating properties.. It finds applications in automobile and appliance components, as well as pipes and fittings. Typical application include: form-fit-function, concept modeling, feature detail, snap-fits, vacuum metallization and electroplating, investment casting and as master for RTV moldings and vacuum forming. Offered in a variety of colors. Other properties of ABS as in Table 2.1 below:

Table 2.1: Material Properties for ABS [2].

Maximum Temperature	176°F 80°C
Minimum Temperature	-4°F -20°C
Autoclavable	No
Melting Point	221°F 105°C
Tensile Strength	4,300 psi
Hardness	R110
UV Resistance	Poor
Translucent	Yes
Flexibility	Rigid

Specific Gravity	1.04

2.1.1.2 PP (polypropylene)

Polypropylene (PP), a polymer prepared catalytically from propylene which differs from HDPE by having an isostatic replacement of a hydrogen atom by a methyl group on alternate carbon atoms in the main chain. Although largely unreactive chemically the presence of the methyl groups makes Polypropylene slightly more susceptible to attack by strong oxidizing agents than HDPE. A major advantage is Polypropylene's higher temperature resistance, this makes PP particularly suitable for items such as trays, funnels, pails, bottles, carboys and instrument jars that have to be sterilized frequently for use in a clinical environment. Polypropylene is a translucent material with excellent mechanical properties and it has gradually replaced the polyethylenes for many purposes. Great chemical resistance makes Polypropylene a popular choice for plating and chemical tanks, as well as laboratory cabinetry and semi-conductor bench tops. Other properties of PP as in Table 2.2 below [2]:

Table 2.2: Material Properties for PP [2].

Maximum Temperature	275°F 135°C
Minimum Temperature	32°F 0°C
Autoclavable	Yes
Melting Point	338°F 170°C
Tensile Strength	4,500 psi
Hardness	R95
UV Resistance	Poor
Translucent	Yes
Flexibility	Rigid
Specific Gravity	0.90