# MECHANICAL PROPERTIES OF JUTE FIBER POLYESTER HYBRID COMPOSITE REINFORCED WITH RICE HUSK


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**in fulfillment of the requirements for the degree of**
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TAJUK: **MECHANICAL PROPERTIES OF JUTE FIBER POLYESTER HYBRID COMPOSITE REINFORCED WITH RICE HUSK**

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## DEDICATION

In the Name of Allah, the Most Gracious, the Most Merciful for providing permission and blessing, my Creator, my Sustainer, for everything I received since the beginning of my life and I have undergone my Bachelor Degree Project II. Thank you, appreciation, to the Universiti Teknikal Malaysia (UTeM) for providing the research platform. I would like to thanks my supervisor, Dr. Najiyah Safwa Binti Khashi'ie and my co-supervisor, Ts.Dr Khairum Bin Hamzah for all of their guidance and useful advise in completing my Project Sarjana Muda report

## ABSTRACT

In order to protect the environment by using biodegradable materials, natural fibers have become more frequently used in composites. Due to their high specific strength and modulus, fiber reinforced polymer-based hybrid composites have been employed in numerous industrial applications for a very long time. Since there are numerous natural fibers accessible, it was decided to investigate using jute, a natural fiber with polyester resin reinforced with rice husk. The strength and lightness of natural fibers are matched by their affordability. Therefore, theobjective of the present study is to investigate the mechanical properties of jute fiber polyester resin hybrid composite reinforced with rice husk. This project will be carried out by the fabrication of the materialsusing the hand lay-up technique into five different ratio which are 20:80, 40:60, 50:50, 60:40 and 80:20. Then, the cutting of fabricated materials by using CNC router machine according to the ASTM standards. After completely done the cutting process,it will test through tensile, flexural, and impact tests to determine the mechanical propertiesof the samples. The collected data were analyzed using statistical analysis. Based on the tensile, flexural, impact and water absorption test of jute fiber polyester resin hybrid composite reinforced with rice husk according to the testing standard ASTM D3039, ASTM D790, ASTM D6110 and ASTM D570 respectively. Then, a one-way analysis of variance (ANOVA) was applied to analyze the tensile strength and elasticity,flexural load of maximum force and maximum stress, impact strength and water absorption of the jute fiber polyester resin hybrid composite reinforced with rice husk.

# *ABSTRAK*

Untuk melindungi alam sekitar dengan menggunakan bahan biodegradasi, serat semula jadi lebih sering digunakan dalam komposit. Oleh kerana kekuatan dan modulus spesifik mereka yang tinggi, jut komposit hibrid berasaskan polimer bertetulang gentian telah digunakan dalam banyak aplikasi industri untuk waktu yang sangat lama. Oleh kerana terdapat banyak serat semula jadi yang dapat diakses, diputuskan untuk menyelidiki penggunaan rami, jut semula jadi dengan resin poliester yang diperkuat dengan sekam padi. Kekuatan dan ringan serat semula jadi dipadankan dengan kemampuan mereka. Oleh itu, objektif kajian ini adalah untuk menyiasat sifat mekanikal komposit resin poliester serat rami yang diperkuat dengan sekam padi. Projek ini akan dilaksanakan dengan fabrikasi bahan menggunakan teknik pemasangan tangan menjadi lima nisbah berbeza iaitu 20:80, 40:60, 50:50, 60:40 dan 80:20. Kemudian, pemotongan bahan buatan dengan menggunakan mesin penghala CNC mengikut piawaian ASTM. Setelah menyelesaikan proses pemotongan sepenuhnya, ia akan menguji ujian tegangan, lenturan, dan hentaman untuk menentukan sifat mekanikal sampel. Data yang dikumpulkan dianalisis menggunakan analisis statistik. Berdasarkan ujian tegangan, lenturan, hentaman dan penyerapan air komposit hibrid poliester jut yang diperkuat dengan sekam padi mengikut standard ujian ASTM D3039, ASTM D790, ASTM D6110 dan ASTM D570 masing-masing. Kemudian, analisis varians sehala (ANOVA) diterapkan untuk menganalisis kekuatan dan keanjalan tegangan, beban lenturan daya maksimum dan tekanan maksimum, kekuatan hentaman dan penyerapan komposit hibrid poliester jut yang diperkuat dengan sekam padi

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In the Name of Allah, the Most Gracious, the Most Merciful for providing permission and blessing, my Creator, my Sustainer, for everything I received since the beginning of my life and I have undergone my Bachelor Degree Project 1. Thank you, appreciation, to the Universiti Teknikal Malaysia (UTeM) for providing the research platform.

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## TABLE OF CONTENTS

| | | PAGE |
|---|---|---|
| **DECLARATION** | | |
| **APPROVAL** | | |
| **DEDICATION** | | |
| **ABSTRACT** | | **i** |
| **ABSTRAK** | | **ii** |
| **ACKNOWLEDGEMENTS** | | **iii** |
| **TABLE OF CONTENTS** | | **iv** |
| **LIST OF TABLES** | | **vi** |
| **LIST OF FIGURES** | | **viii** |
| **LIST OF SYMBOLS AND ABBREVIATIONS** | | **x** |
| **LIST OF APPENDICES** | | **xi** |
| **CHAPTER 1** | **INTRODUCTION** | **1** |
| 1.1 | Background | 1 |
| 1.2 | Problem Statement | 2 |
| 1.3 | Research Objective | 3 |
| 1.4 | Scope of Research | 4 |
| **CHAPTER 2** | **LITERATURE REVIEW** | **5** |
| 2.1 | Introduction | 5 |
| 2.2 | Natural Fiber Composite | 5 |
| 2.3 | Jute | 7 |
| 2.4 | Matrix of Composite | 8 |
| 2.5 | Polymer Matrix Composites | 9 |
| | 2.5.1 Thermoplastic | 10 |
| | 2.5.2 Thermosets | 11 |
| 2.6 | Polyester Resin | 12 |
| 2.7 | Rice Husk | 13 |
| | 2.7.1 Rice Husk Application | 15 |
| 2.8 | CNC Router Machine | 16 |
| 2.9 | Mechanical Testing | 18 |
| | 2.9.1 Tensile Test | 18 |
| | 2.9.2 Flexural Test | 20 |
| | 2.9.3 Impact Test | 21 |
| | 2.9.4 Water Absorption Test | 22 |

| | | |
|---|---|---|
| **CHAPTER 3** | **METHODOLOGY** | **24** |
| 3.1 | Introduction | 24 |
| 3.2 | Material Preparation | 25 |
| 3.3 | Hand Lay-up Method | 26 |
| 3.4 | Cutting Process (CNC machine) | 27 |
| 3.5 | Mechanical Testing | 29 |
| | 3.5.1 Tensile Strength Testing | 29 |
| | 3.5.2 Flexural Strength Testing | 31 |
| | 3.5.3 Impact Strength Testing | 32 |
| | 3.5.4 Water Absorption Testing | 35 |
| 3.6 | The Statistical Analysis (ANOVA) | 37 |
| 3.7 | Summary | 37 |
| 3.8 | Gantt Chart | 37 |
| | 3.8.1 Gantt Chart PSM I | 37 |
| | 3.8.2 Gantt Chart PSM II | 37 |
| **CHAPTER 4** | **RESULT** | **38** |
| 4.1 | Introduction | 38 |
| 4.2 | Tensile Test | 38 |
| | 4.2.1 Tensile Strength | 38 |
| | 4.2.2 Maximum Tensile Strain | 42 |
| 4.3 | Flexural Test | 45 |
| 4.4 | Impact Test | 49 |
| 4.5 | Water Absorption Test | 53 |
| | 4.5.1 Water Absorption For 20P80RH | 54 |
| | 4.5.2 Water Absorption For 40P60RH | 56 |
| | 4.5.3 Water Absorption For 50P50RH | 58 |
| | 4.5.4 Water Absorption For 60P40RH | 59 |
| | 4.5.5 Water Absorption For 80P20RH | 61 |
| **CHAPTER 5** | **RESULT** | **63** |
| 5.1 | Conclusion | 63 |
| 5.2 | Recommendation | 65 |
| 5.3 | Potential of Project | 65 |
| **APPENDICES** | | **66** |
| **REFERENCE** | | **69** |

## LIST OF TABLES


| TABLE | TITLE | PAGE |
|---|---|---|
| Table 2.1 | Mechanical Properties of Natural Fiber (Ilyas et al., 2019) | 7 |
| Table 2.2 | Advantage and Disadvantage of Thermoplastic Resin (Abtec, 2019) | 10 |
| Table 2.3 | Mechanical and Chemical Properties of Rice Husk (Santhosh et al., 2020) | 15 |
| Table 3.1 | Procedure of Hand-Lay Up Method | 27 |
| Table 3.2 | Procedure of Tensile Test | 31 |
| Table 3.3 | Procedure of Flexural Test | 32 |
| Table 3.4 | Procedure of Charpy Impact Test | 34 |
| Table 3.5 | Procedure of Water Absorption Testing (Mishra, 2017) | 36 |
| Table 4.1 | Method of ANOVA for Tensile Strength | 40 |
| Table 4.2 | ANOVA for Tensile Strength | 40 |
| Table 4.3 | Mean for Tensile Strength | 40 |
| Table 4.4 | Tukey Simultaneous Test for Diffrences of Means for Tensile Strength | 41 |
| Table 4.5 | Method of ANOVA for Maximum Tensile Strain | 43 |
| Table 4.6 | ANOVA for Maximum Tensile Strain | 43 |
| Table 4.7 | Mean for Maximum Tensile Strain | 44 |
| Table 4.8 | Tukey Simultaneous Test for Maximum Tensile Strain | 44 |
| Table 4.9 | Method of ANOVA for Flexural Strength | 47 |
| Table 4.10 | ANOVA for Flexural Strength | 47 |
| Table 4.11 | Mean of Specimen for Flexural Strength | 47 |
| Table 4.12 | Tukey Test for Flexural Strength | 48 |
| Table 4.13 | Method of ANOVA for Impact Strength | 51 |
| Table 4.14 | ANOVA for Impact Strength | 51 |
| Table 4.15 | Average Mean for Impact Strength | 51 |
| Table 4.16 | Tukey Test for Impact Strength Strength | 52 |
| Table 4.17 | Method of ANOVA | 55 |
| Table 4.18 | ANOVA for Rate of Water Absorption for 20P80RH | 56 |
| Table 4.19 | Method of ANOVA for Percentage Rate of Water Absorption | 57 |
| Table 4.20 | ANOVA for Percentage Rate of Water Absorption of 40P60RH | 57 |
| Table 4.21 | Method of ANOVA for Water Absorption | 59 |

Table 4.22 ANOVA of Rate of Water Absorption of 50P50RH 59
Table 4.23 Analysis of Variance for Water Absorption 60
Table 4.24 ANOVA of Rate of Water Absorption of 60P40RH 61
Table 4.25 Method of ANOVA for Rate of Water Absorption 62
Table 4.26 ANOVA for Rate of Water Absorption of 80P20RH 62

## LIST OF FIGURES


| FIGURE | TITLE | PAGE |
|---|---|---|
| Figure 2.1 | Example of Natural and Synthetic Fiber (Ray, 2015) | 6 |
| Figure 2.2 | Example of Natural Fiber (Nurazzi et al., 2021) | 6 |
| Figure 2.3 | Polyester Resin Used in This Project | 12 |
| Figure 2.4 | Packet of Unsorted Rice Husk | 14 |
| Figure 2.5 | Example of CNC Router machine | 17 |
| Figure 2.6 | The workflow of the G-code for CNC router machine | 17 |
| Figure 2.7 | Specimen Size for Tensile Strength Based on ASTM D3039 | 19 |
| Figure 2.8 | Equipment Used of Tensile Strength Testing | 20 |
| Figure 2.9 | Equipment Used for Flexural Strength Testing | 21 |
| Figure 2.10 | Flexural Strength Testing of 3 Point Bending | 21 |
| Figure 2.11 | Comparison of Charpy Impact Test and Izod Impact Test | 22 |
| Figure 3.1 | General Flow Chart of the Project | 24 |
| Figure 3.2 | Rice Husk After Grinding Process | 25 |
| Figure 3.3 | Usage of Testing Sieve | 25 |
| Figure 3.4 | Mixing material | 26 |
| Figure 3.5 | Hand lay-up process | 26 |
| Figure 3.6 | Cutting Process using MODELA PRO2 (MDX-540) | 28 |
| Figure 3.7 | Cutting Template A for Tensile, Impact and Water Absorption Test | 28 |
| Figure 3.8 | Cutting Template B for Flexural Test | 29 |
| Figure 3.9 | Tensile Testing using Universal Testing Machine | 30 |
| Figure 3.10 | Specimen after Reaching Failure Stage | 30 |
| Figure 3.11 | Specimen during Flexural Test | 32 |
| Figure 3.12 | Example of V-Notch of Specimen | 33 |
| Figure 3.13 | Impact Testing using INSTRON CEAST 9050 | 33 |
| Figure 3.14 | Specimen after Impact Testing | 34 |
| Figure 3.15 | Weighting the Specimen | 35 |
| Figure 3.16 | Specimen During Water Absorption Test | 36 |
| Figure 4.1 | Tensile Strength Vs Ratio of Sample | 39 |
| Figure 4.2 | Tukey Simulation for Tensile Strength of Each Ratio Sample | 41 |

| | | |
|---|---|---|
| Figure 4.3 | Maximum Tensile Strain Vs Ratio of Sample | 43 |
| Figure 4.4 | Tukey Simultaneous 95% C1s for Tensile Strain | 45 |
| Figure 4.5 | Maximum Flexural Strength Vs Ratio of Sample | 46 |
| Figure 4.6 | Tukey Simultaneous 95% C1s for Flexural Strength | 49 |
| Figure 4.7 | Impact Strength vs Ratio of Sample | 50 |
| Figure 4.8 | Tukey Simultaneous 95% C1s for Impact Strength | 53 |
| Figure 4.9 | Graph of Rate of Water Absorption for Each Ratio | 54 |
| Figure 4.10 | Graph of Rate of Water Absorption for 20P80RH | 55 |
| Figure 4.11 | Rate of Water Absorption for 20P80RH vs Days | 57 |
| Figure 4.12 | Graph of Percentage Rate of Water Absorption for 50P50RH | 58 |
| Figure 4.13 | Graph of Percentage Rate of Water Absorption for 60P40RH | 60 |
| Figure 4.14 | Rate of Water Absorption for 80P20RH vs Days | 62 |

## LIST OF SYMBOLS AND ABBREVIATIONS

| | | |
|---|---|---|
| UP | - | Unsaturated Polymers |
| l | - | Length of the Specimen |
| L | - | Length of Span between Support |
| b | - | Width of Specimen |
| 20P80RH | - | 20% Polyester to 80% Rice Husk |
| 40P60RH | - | 40% Polyester to 60% Rice Husk |
| 50P50RH | - | 50% Polyester to 50% Rice Husk |
| 60P40RH | - | 60% Polyester to 40% Rice Husk |
| 80P20RH | - | 80% Polyester to 20% Rice Husk |

# LIST OF APPENDICES


| APPENDIX | TITLE | PAGE |
| --- | --- | --- |
| APPENDIX A | Specific Flow Chart of the Project | 66 |
| APPENDIX B | Gantt Chart of PSM I | 67 |
| APPENDIX C | Gantt Chart of PSM II | 67 |
| APPENDIX D | Turnitin Index | 68 |

# CHAPTER 1
# INTRODUCTION

## 1.1 Background

Natural fibers nowadays received lot of attention due to their ability to sustain and renewable sources. Most of the usage for the natural fiber reinforced polymer composite were contributed at automotive, packaging, aerospace and industrial usage. The research on the usage of natural fiber reinforced polymer composite also abundant and attract the industry to provide development due to the lot advantages such as low in density (Sapuan et al., 2016), cost-effective, highly renewability where about $22.6 \times 10^6$ tonnes were produced yearly (Madueke et al., 2022), highly biodegrability where it is environmental friendly and high in strength due to the enhancement toward the jute fiber with composite material(Preethi et al., 2022). One of the mainly natural fibers that used is jute fiber. Jute is one of the lignocellulosic fibrous crops that primarily filled with cellulose and lignin.



Rice husk is an agriculture waste material were removed from the rice grain during milling process. It also complexes fiber that consist of cellulose, hemicellulose and lignin. Plus, the significant amount of silica allow the rice husk to be used in lot of way especially inform of rice husk powder (Chen et al., 2018). The rice husk also grabs the attention most of the researcher to be developed and used in industrial as the mechanical properties of the rice husk is suitable to be used as reinforced material in polymer composite.

The jute fiber reinforced with rice husk will be combined with help of polyester resin that act as a matrix that bind the material. Polyester resin is one of the most used in industries as it offered lot of benefit such as magnificent chemical and physical properties. It commonly called as unsaturated polyester unless it been specified toward it. The polyester resin already been developed since 1847 by Berzelius and still being used until for today's usage.

## 1.2 Problem Statement

Nowadays, there have been high awareness around the world that required people to do the research that able provide protection toward the environment and the biodiversity by producing high quality eco-friendly product and improve the sustainability. However, due to its natural hydrophilic cellulosic fiber, jute fiber was highly capable to absorb moisture, poor compatibility toward hydrophobic polymer matrix which will lead to poor mechanical properties of the composite. As a result, the natural fiber reinforced composite become highly interested by developer to develop the product in recent year.



The potential for the jute fiber composite to become most used composite material was highly promising to be used in industrial working area. Plus, some of the downside of using the natural fiber such as hydrophilic and biocompatibility able to be solve by variety of ways such as chemical treatment process and hydrophilic surface modification treatment to control the interaction of the jute fiber composite.

Problem statement for this investigation stated that the problem to determine the optimal volume ratio for rice husk and polyester resin on jute fiber. Furthermore, we need to understand the exact value parameter of the composite can handle by running few tests such as tensile strength test, flexural strength test, impact test and water absorption test toward the jute fiber polyester hybrid composite reinforced with rice husk according to the standard for each testing.

## 1.3 Research Objective

The main aim of this research is to estimate best ratio for the jute fiber polyester hybrid composite reinforced with rice husk based on the mechanical properties obtained from the test. Specifically, the objectives are as follows: -

i. To fabricate the jute fiber polyester hybrid composite reinforced with rice husk
ii. To conduct mechanical testing and identify the mechanical properties of the speciment according to their ratio using tensile test, flexural test, impact test and water absorption test
iii. To analyse the best ratio of jute fiber polyester hybrid composite reinforced with rice husk using statistical method

## 1.4 Scope of Research

The scope of this research is based on the objective of the project which are sample preparation, specimen testing and data analyzation. For sample preparation, the average length of rice husk will be identified to determine either it need to be grinded or not and prepare the mold and polyester resin.

Then, the rice husk and the polyester resin will be fabricated into five ratio using hand lay-up method which are 20:80, 40:60, 50:50, 60:40 and 80:20. Next it will be fabricated using the router CNC machine according to the testing standard size with thickness of 10 mm for all testing.

For specimen testing, mechanical testing was conducted toward each of the ratio according to the testing standard which are tensile test using ASTM D3039, flexural test using ASTM D790, impact test using ASTM D6110 and absorption test using ASTM D570. For data analyzation, the best ratio of jute fiber polyester hybrid composite filled with rice will be determine using the ANOVA analysis.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Introduction

In this chapter will discuss about the literature review that related to the mechanical properties of jute fiber polyester hybrid composite reinforced with rice husk. The purpose of this research is to optimize the mechanical properties of jute fiber in term of tensile strength, flexural strength and impact strength.

## 2.2 Natural Fiber Composite

There are are two type of fiber that can be can be classified as natural and synthetic as shown in Figure 2.1. Natural fiber are any hairlike raw material that capable of being gathered from vegetable, animal or mineral sources and processed into non woven fabric like-paper or being spun into yarn and woven into clothing as shown in Figure 2.2. Most of the small-scale businesses are typically fabricated the basic good such as mats, carpet, ropes and bag using fiber-based material.



Nowdays, the natural fiber composites are one of the most profoundly materials that meet the industrial demands due to the numerous amount of benefit such as the capabilities sequestration the carbon dioxide, water-proof, high stress failure, light weighted, made from biodegradable material and cost effective. Based on Table 2.1, it shows that the mechanical properties of different type of fiber including the jute. It states that the tensile strength of jute is between 400 Mpa to 800 Mpa and the tensile modulus is between 10 Gpa to 30 Gpa. Jute only elongates about 1.8 percent during break which is suitable as material.

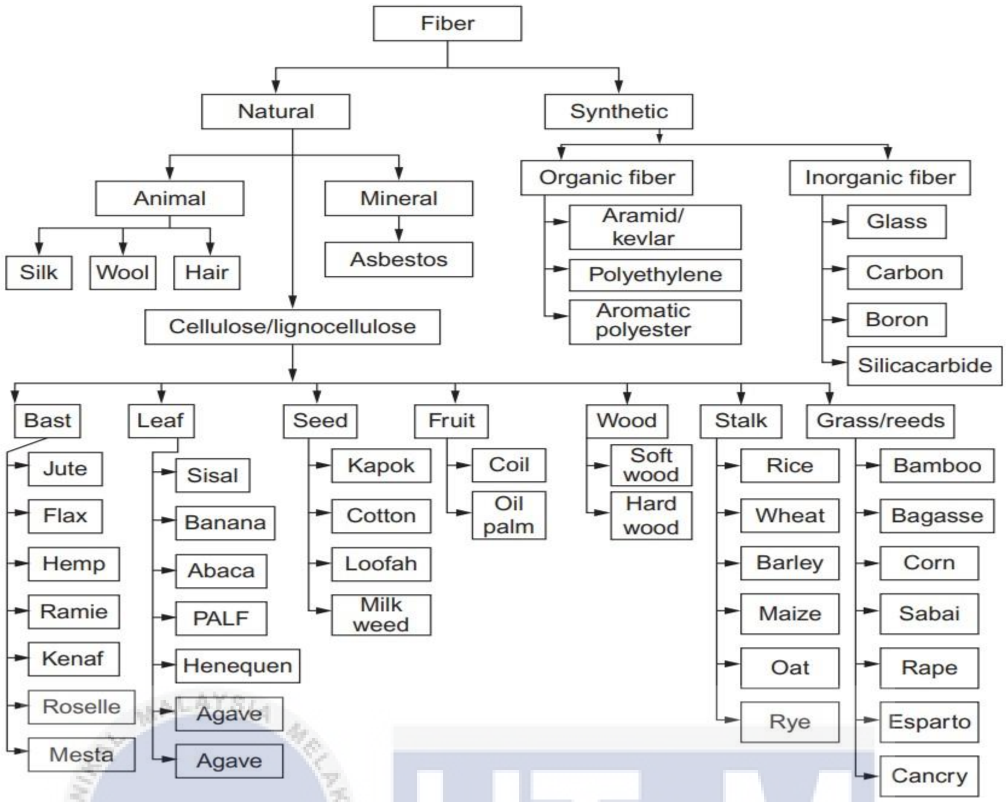



Figure 2.1 Example of Natural and Synthetic Fiber (Ray, 2015)


Figure 2.2 Example of Natural Fiber (Nurazzi et al., 2021)

Table 2.1 Mechanical Properties of Natural Fiber (Ilyas et al., 2019)

| Type of Fiber | Tensile Strength (Mpa) | Tensile Modulus (Gpa) | Elongation at Break (%) |
|---|---|---|---|
| Jute | 400.0-800.0 | 10.0-30.0 | 1.8 |
| Oil Palm | 248.0 | 3.2 | 2.5 |
| Kenaf (bast) | 295.0 | - | 2.7-6.9 |
| Flax | 800.0-1500.0 | 60.0-80.0 | 1.2-1.6 |
| Sugar Palm (frond) | 421.4 | 10.4 | 9.8 |
| Pineapple | 170.0-1627.0 | 82.0 | 1.0-3.0 |
| Hemp | 550.0-900.0 | 70.0 | 1.6 |
| Coir | 220.0 | 6.0 | 15.0-25.0 |

## 2.3 Jute



Jute is very beneficial in term of economic and environmental. There are lot of components from the jute that can be used as raw material in bio-degradable and bio-composite product. Jute is consisting of nutrients such as proteins, carbs, fiber, vital amino acid, vitamins and minerals (Nyadanu and Lowor, 2015). The jute leaves can be utilizing as purgative and demulcent in providing important antioxidant that necessary for the optimal health. The jute leaves, seeds and roots can be used as natural remedies meanwhile the jute mallow is mostly used by the local population as a treatment for illness including tumors, gonorrhea and lot of other medical condition around the world.

Other than that, the cellulosic stem or can be called as the stem bark are extracted from the jute plant and it is totally biodegradable. It mostly been used to make various kind of important commercial items including twine, rope, binding and particularly in agriculture. Jute fiber is one of the natural fibers that being used mainly in furnishing and decorative product. Due to the agro-renewable, biodegradable and widely available at great rates prices, it become the main attention to be implement as reinforcement in polymeric composite in addition to its technical benefits including high tensile strength, sound insulation, heat insulation and good dye acceptance.

The main component of jute chemically made of up to 54% to 60% of cellulose, 20% to 24% of hemicellulose and 12%-14% of lignin. The cellulose and hemicellulose will provide the network together meanwhile the lignin will act as a quality adhesive that responsible for the rigidity and strength of the cellulosic fiber. As the level of cellulose content is high and the microfibrillar angle is low, it will provide better strength properties for the fiber (Samanta et al., 2020). As for the density for the jute fiber is 1.30 g/cm$^3$ where it is suitable for commercial uses (Jeyapragash et al., 2020).



## 2.4 Matrix of Composite

Composite materials are formed of two or more constituent material that when combined it will result in the difference of material physical or chemical properties compared to its original properties (Krauklis et al., 2021). The earliest application of composite material was known by the ancient Egyptian where their wall was reinforced with the natural fiber straw 3000 years ago. Over time, lot of resilient material were created and nowadays fiber reinforced composite can be made on big scale for industrial use (Amaechi et al., 2020).

Since 1932, fiber reinforced plastic has been developed into material with wide range of application such as automotive, aerospace, offshore, structural, transportation and marine. Due to its resistance toward corrosion and high strength-to-weight ratio, it offers considerable advantages in mechanical performance as it is light weighted and highly durable. Everything that able to be held by the matrix or resin system will use the fiber to transfer the mechanical stress into the entire structure. The resin systems come in several chemical families where each of it was developed to serve a particular industry with benefit including the low price, high resistance toward different properties and regulatory compliance. There are four primary categories of composites which are polymer matrix composites, metal matrix composites, ceramic matrix composite and carbon matrix composite. For this project, we will be using the polymer matrix composite as the matrix for the jute fiber composite (Zweben, 2015).

## 2.5 Polymer Matrix Composites

Generaly, the polymer matrix are viscoelastic and low-stiffness material that are rather to be considered as weak. The reinforcing fiber are principally responsible for it strength and stiffness of polymers matrix composite. There are two main catogories of polymer that can be utilise as matrix material which are thermoset and thermo plastic. Eventhough the thermoset steadily gaining ground, the thermosets are now by far the often utilised matrix reinforcement for the structural purposes. For this project, thermosetting polymer is used as the matrix for the jute composite matrix.

### 2.5.1 Thermoplastic

Thermoplastic is kind of polymer that able to be soften by heating before being processed by extrusion, injection moulding, blow molding and thermoforming. Thermoplastic are easily recyclable since there are no changes in chemical properties even after being heated and cooled for several time. The process of polymerization is used to connect the monomers or tiny molecule and create long chain to create thermoplastic. There are lot of monomers that can be used to create a single polymer chain. The atom of the polymers chain are connected by strong covalent bond which make the force between the chain relatively weak. The advantages and disadvantage of using the thermoplastic shown in Table 2.2.

Table 2.2 Advantage and Disadvantage of Thermoplastic Resin (Abtec, 2019)

| Thermoplastic Resin | |
|---|---|
| Advantage | Disadvantage |
| Readily recyclable | Inappropriate for high temperature uses as it can easily melt |
| Consist wide range of mechanical properties | |
| Light weighted | |
| Aesthethic surface finish | |
| Highly resist toward chemical | |

### 2.5.2 Thermosets

Thermosetting polymers or commonly known as thermosets are the class of distinguished plastic where they are created from the form of liquid solution and become permanently set when being exposed to the heat. The irreversible liquid-to-solid transition also can be created by other technique such as ultra violet ray or electron beam radiation. The procss used as polymer going through the original liquid state to soli is referred as material cure (Pavlacky et al., 2013).There are lot of advantage when using the thermosetting polymers such as resistance toward heat, rigid form and consist of high mehcanical properties.

Most of the thermoset such as phenol-formaldehyde resin, unsaturated polyester resin and epoxy resin are made from the compound based on the petroleum. However, there has been a rise of interest in producing an environmental friendly thermosetting resit that made from the renewable raw material called bio-based polymers. The fact that bio-based polymers are not always biodegradable is an essential feature where the misperception from the assumption when chemical contact with the bio-degradable polymer, it will undergo polymerization. However, a thermosetting polymers is created when a crosslinked polymer network is produced and likely to exhibit decrease in biodegradability regardless the monomers origin. For this project, polyester resin was choosen due to the low cost material production (Quirino et al., 2021).

## 2.6 Polyester Resin

There are two type of polyester resin which are saturated polyester resin and unsaturated polyester resin (UP). Saturated polyester resin is a polymer with fundamental that has no double or bond main carbon chain of the polymer). Saturated polyester resin mostly used the making of coil coating, primer and backing paint for coil painting. Meanwhile, UP is a polymer with fundamental that has double bonds at its carbon chain. It also known as linear polymer with ester bond and double bond. UP mostly used in creating the molding sheet compound, toner for printer and bulk molding compound. Therefore, UP is a suitable polymer to be used as the matrix of the fiber composite as the characteristic of UP are heat resistance, high tensile strength, and resistance to the chemical corrosion. UP able to be produced by condensation process reaction between unsaturated dicarboxylic acids (Madhu, 2018). The density of the polyester Resin is 1.15g/cm$^3$ when in liquid stage and 1.22g/cm$^3$ when it is in solid stage (Paul, 2020).




Figure 2.3 Polyester Resin Used in This Project

## 2.7 Rice Husk

Rice husk is one of the fibers that commercially used in agriculture that able to act as fertilizer. Rice Husk is also one of the abundant resources globally that obtained from the paddy field mainly where over 130 million tons of rice husk produced annually around the world. Due to the huge amount of resource, there is surge of interest of using the rice husk as composite reinforcement in engineering field (Danso, 2020). Rice husk also known as raw lignocellulosic material and mainly consist of hemicellulose, α cellulose, silica and lignin.

The Cellulose will apply strength toward the rice husk and help rice husk to absorb moisture from the environment. Meanwhile, hemicellulose is a branched polysaccharide with huge amount of polar hydroxyl group. However, we need to acknowledge that the rice husk also one of the main agro-industrial products that abundantly accumulated. It provides 20% of paddy weight and fill up most of the spaces. The rice husk is mostly being disposed to the landfill or often being burnt which have significant effect toward the environment. A systematic gathering of the waste product of the paddy which is rice husk would contribute the boost of the agricultural activity sustainability and encourage to minimize the overall environmental impact. Plus, there were numerous investigation that utilize the rice husk as a material especially as composite material and insulation material.

Rice husk has been recycled for its value in application as it cost efficient material. It also important to keep in mind that rice husk was a life-cycle assessment product that need to be considered as a possible environmental performance type of material based on few article by author previously (António et al., 2018). The rice husk that going to be used is as shown in Figure 2.4. Based on Table 2.3, it shows that the chemical and mechanical properties of the rice husk. For chemical properties it consists of 35% of α cellulose, 21% of hemicellulose and 31% of lignin. For the mechanical properties, it detailed that the density of rice husk is 0.3 $g/cm^3$, the ultimate tensile strength is 135 MPa and elastic modulus is 130 Gpa.

Figure 2.4 Packet of Unsorted Rice Husk

Table 2.3 Mechanical and Chemical Properties of Rice Husk (Santhosh et al., 2020)

| Type of Fiber | Rice Husk |
|---|---|
| Density (g/$cm^3$) | 0.3 |
| α cellulose (wt%) | 35.0 |
| Hemicellulose (wt%) | 21.0 |
| Lignin (wt%) | 31.0 |
| Ultimate tensile strength (MPa) | 135.0 |
| Elastic Modulus (Gpa) | 130.0 |

### 2.7.1 Rice Husk Application

Rice husk is one of the waste products that able to use for multipurpose especially in industrial usage. Rice husk is suitable to be used in various application based on the chemical and physical properties such as rice husk ashes and the silica content in rice husk. Rice husk ashes can be used in the ceramic and refractory industry because of its insulation properties. The rice husk ashes consist of silica that have higher yields cordierites which will replace the kaolinite in the mixture composition due to the cordierite crystallise at lower temperature and require lower activation energy (Bhargava, 2017). Rice husk can be processed to become rice husk biochar.

The rice husk are occasionally being used to generate energy through variety of process including gasification, pyrolysis and combustion (Shaheen et al., 2022). This is because of the high yield in the creation of the liquid fuel which known as bio-oil. The pyrolysis is one of the methods that shows lot of promise in utilizing the usage of rice husk. Due to the potential of being use as a subsequence generation of bio-fuel and a raw material for chemical compound, it attracts lot of developer to conduct a great deal of research. It also capable for environmental rehabilitation since the consist of high carbon content that able to promote soil fertility (Herrera et al., 2022).

## 2.8 CNC Router Machine

A CNC router is a router that use the computer numerical control capabilities for tool path control as shown in Figure 2.5. It uses a computer-controlled device to cut a variety of hard materials including steel, wood, aluminum and also composite. The principle of a CNC router and a CNC milling machine are extremely similar. Compared to the CNC mills, CNC routers are less costly and have smaller body. The main component of the CNC router is a table, an AC inverter, one or more spindle motor and a specialized CNC controller desktop. The most common CNC router format are 3-axis and 5-axis CNC formats. The CNC router will regularly use CAD to make the design of the specimen and CAM to translate the design into the instruction for the machine as shown in Figure 2.6. The CNC router also can be controlled manually to speed up the programming process but it is considered as impractical action (Samaneh and Masoud, 2013).


Figure 2.5 Example of CNC Router machine

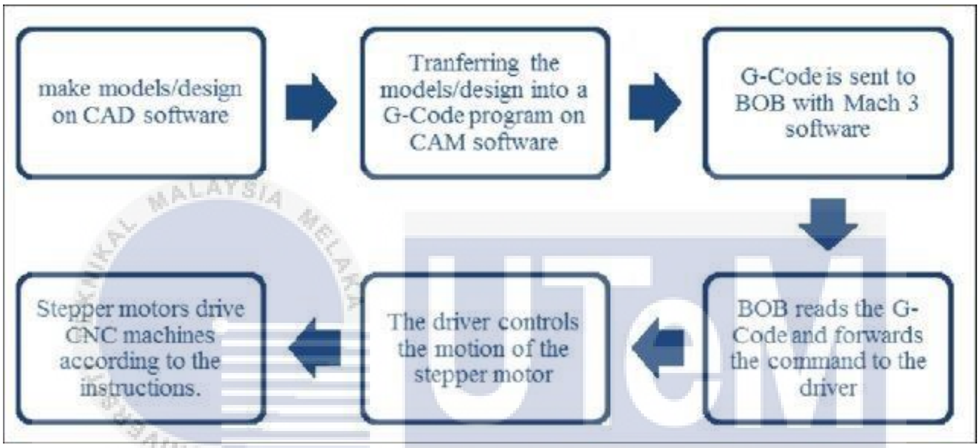



Figure 2.6 The workflow of the G-code for CNC router machine (Bangse et al., 2020)



#### 2.8.1.1 Cutting Parameter

There are few parameters during using the CNC router machine. For the chip load, it can be known as the theoretical length of material that theoretically fed into each of the cutting edge as it passes through the specimen. It can be calculated using the Equation (2.1). For the depth of cut, it describes on how far the cutting tool cable to remove material in one pass. The maximum depth of the cut is equal to the tool diameter which make it impossible to have a deeper cut than the diameter tool. The process of deeper incision can be speed up however it will affect the instrument or reduce its lifespan. For the spindle speed, it can be described as the speed of the spindle where it is measured in Revolution Per Minute.

The speed of the spindle speed will be decided by the material and the quantity of flutes. The variation of speed might reduce the tool path and potentially to initiate catastrophic fire. For the feed rate, it is described as the pace where the cutting tool travel laterally over the specimen. In order to get a great cut and have a longer lifespan of the machine, make sure to use it at optimal speed as excessively high speed can causes the machine to break.

Chip Load = Feed Rate (inches per minute) / (RPM x number of flutes) (2.1)

## 2.9 Mechanical Testing

For every design or product that being manufactured need to be included in mechanical testing. This is due to identify the mechanical properties of the product or design for safety usage. For this project, it will be carried out by testing the mechanical properties of the jute fiber polyester hybrid composite reinforced with rice husk specimen using the tensile, flexural, impact and water absorption testing. The specimen thickness for each testing will be standardized to 10 mm.



### 2.9.1 Tensile Test

A material tensile strength is the ability of the material to withstand the maximum amount of tensile stress before it starts to fail or break (Michelle et al., 2023). This processes also able to provide the information about the yield strength, ductility of metallic material, tensile strength, tensile modulus, tensile strain, percentage elongation at yield and percentage of elongation at break (Saba et al., 2018). The machine that going to be used was ASTM D3039.

The size of the specimen that will be used for this testing based on the requirement of the ASTM D3039 model which is 250 mm x 25 mm. A digitalized UTM with maximum capacity of 50 kN as stated in universal testing will be used to evaluate the tensile strength of the specimen at 5 mm/min crosshead speed. The UTM sensor able to capture the changing parameter that happen toward the specimen. For this case, the tensile strength of the jute fiber polyester hybrid composite reinforced with rice husk and the behavior of the specimen during the testing will be identified (Hemnath et al., 2020). The tensile strength of jute fiber polyester hybrid composite reinforced with rice husk able to be calculated by using the Equation (2.1).

$$\sigma = \frac{F}{A} \qquad (2.2)$$

where $\sigma$ = tensile strength (Pa), F = force (N) and A = cross-section of the area ($m^2$).



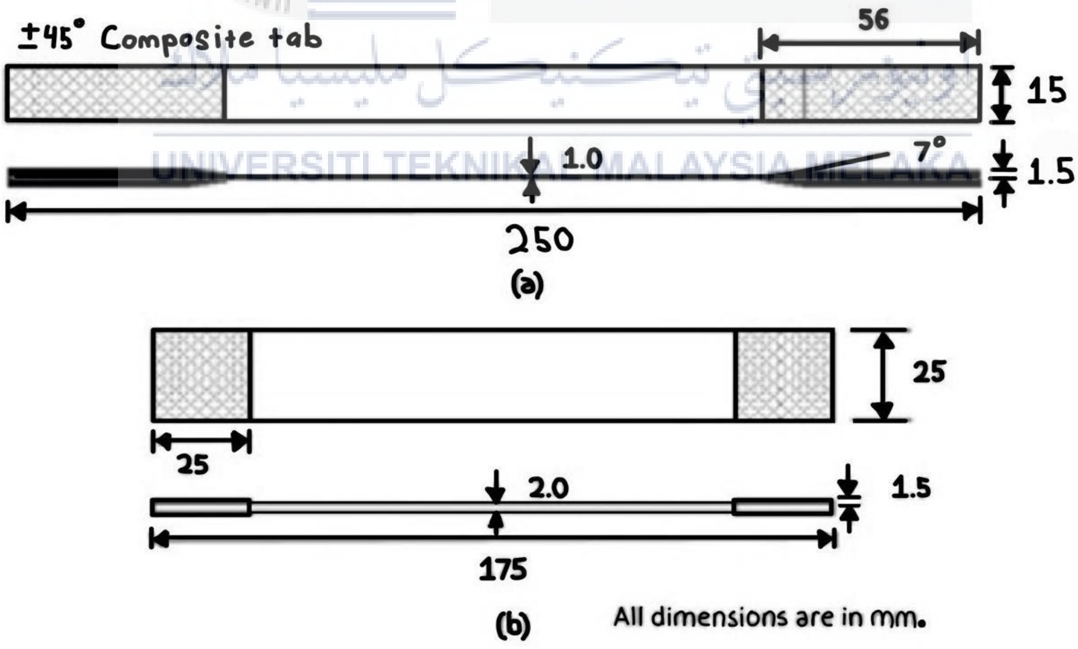



Figure 2.7 Specimen Size for Tensile Strength Based on ASTM D3039 (F. Hassan and Abdullah, 2015)

Figure 2.8 Equipment Used of Tensile Strength Testing

### 2.9.2 Flexural Test

A material flexural strength is the ability to withstand deformation under load. The machine that going to be used is the 3-point bending machine as shown in Figure 2.9. During the flexural testing, the specimen will be placed horizontally at 3-point bending to identify the stress applied toward the material which can be called as flexural strength.



The size of the specimen to run the test is based on the specimen requirement of the ASTM D790 model which is 250 mm x 25mm. The highest shear stress that occurs between layer of laminated material is known as the inter-laminar shear strength (ILSS). The crosshead speed during the flexural test on a specimen is 5mm/min (Sundarababu et al., 2020). To conduct the testing, the specimen will be placed at the 3-point bending machine according to ASTM D790 as shown in Figure 2.10. To find the value of flexural strength, the Equation (2.2) and the flexural modulus, it will be determined by using Equation (2.3).

$$\delta = \frac{3FL}{2bt^2} \qquad (2.2)$$

where $\sigma$ = Flexural Strength (Pa), F = Max load, L = Distance between the support (mm), b = Width of the specimen (mm) and t = Thickness of the specimen.

$$E = \frac{ð}{s} = \frac{FL^3}{4bt^3d} \qquad (2.3)$$

where E = Flexural Modulus and d = length of deflection (mm)

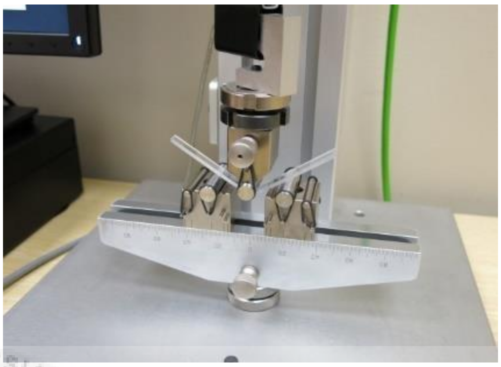


Figure 2.9 Equipment Used for Flexural Strength Testing

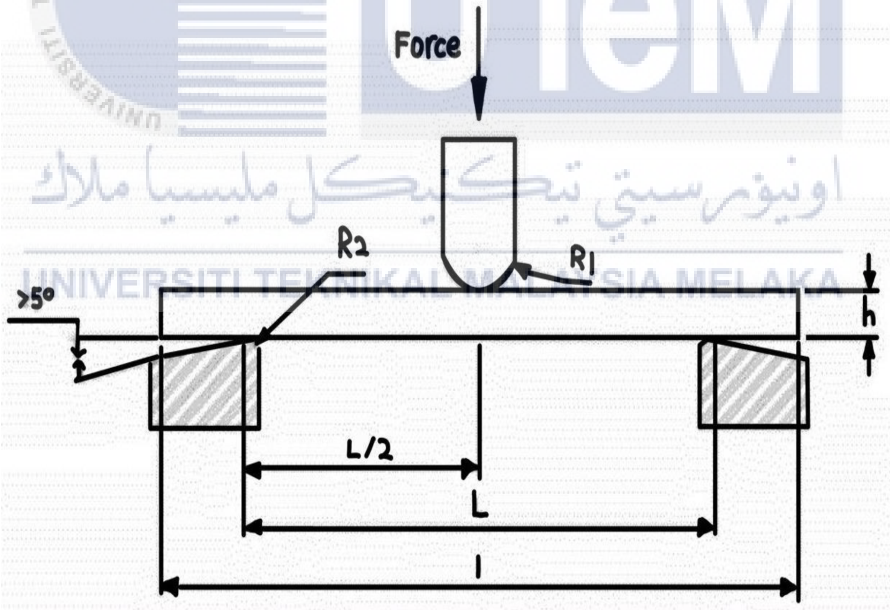



Figure 2.10 Flexural Strength Testing of 3 Point Bending (Preethi et al., 2022)

### 2.9.3 Impact Test

A material impact strength is the ability of an object to withstand the maximum impact before it starts to crack or fail. The impact blow toward the There are two types of testing for the impact test which are Charpy impact test and Izod impact test. The Charpy test is considered as a cost-effective quality control technique to assess the impact toughness and notch sensitivity of a material which make it of the favorable testing. Meanwhile, Izod impact test is mostly used in the medical, plastic industries and also automotive industries to evaluate the impact toughness of material and its relative toughness (Abidin et al., 2019). The Charpy impact test hold the specimen horizontally with notch facing away the pendulum meanwhile Izod impact test hold the specimen vertically with notch facing the pendulum. For this project, the specimen will be tested using the Charpy impact test. The machine that going to be used is INSTRON CEAST 9050. The size of specimen to run the test was according to the requirement of the ASTM D6110 model which is 60 mm x 10 mm x 10 mm.

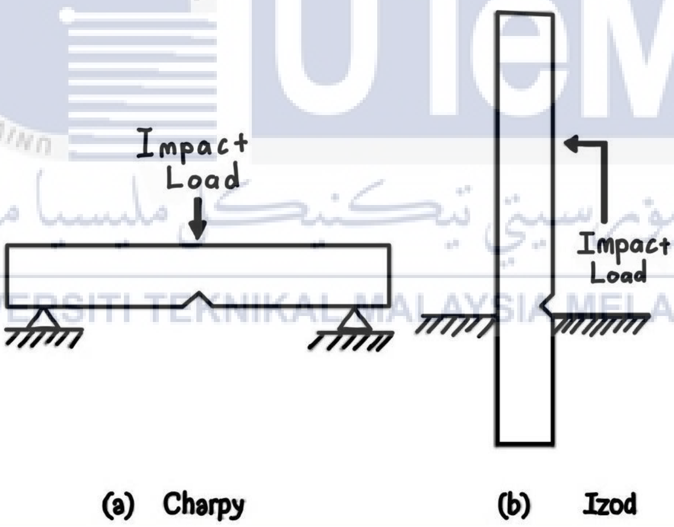



Figure 2.11 Comparison of Charpy Impact Test and Izod Impact Test (Haque et al., 2021)

### 2.9.4 Water Absorption Test

The water absorption test is to identified the rate of absorption of water by let the specimen to be immerse for a specific period of time. There are few condition for the water absorption testing which are water absorption for 24 hours at 23˚C,  water absorption for 24 hours at 100˚C, water absorption at saturation and water absorption at equilibrium. There few factors that can affect the water absorption which are length of specimen exposed, the relative humidity and temperature of surrounding and type of filler and reinforcement used on the specimen. The machine going to be used for water absorption testing is ASTM D570. The size of specimen size was choosen based on the standard of ASTM D570 which is 60 mm x 60 mm x 10mm. For this project the specimen will be immersed in distilled water to examine the rate of water absoption and the change in thickness of the specimen. To calculate the percentange of water absorption by mass after immersed in water can be calculated using Equation (2.3)

$$W(\%) = \frac{M2-M1}{M1} \times 100 \qquad (2.3)$$

where W = percentage weight, M2 = Mass of Specimen after Immerse in Water and
M1 = Mass of Specimen before Immerse in Water

# CHAPTER 3
# METHODOLOGY

## 3.1 Introduction

In this chapter will discuss about the methodology on how to produce jute fiber polyester hybrid composite reinforced with rice husk. There are several steps to make sure that this research successful which are material preparation, hand lay-up method, cutting process, and material mechanical testing which are tensile strength, flexural strength, impact strength and water absorption test. This research will be rounded up by data analysis of all the testing. The project conducted based objective as shown at general flow chart in Figure 3.1.

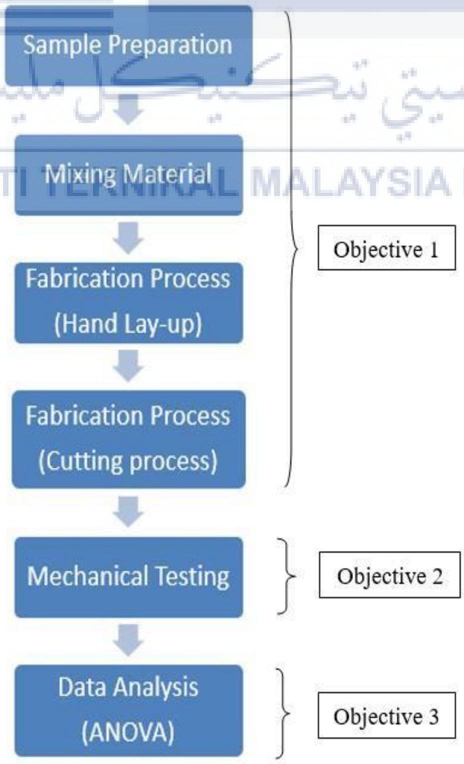



Figure 3.1 General Flow Chart of the Project

## 3.2 Material Preparation

Before proceeding with the hand lay-up method, the jute will be cut into the size of the mold which is 31.2 cm x 21.2 cm x 1 cm and the size of the rice husk needs to be grinded to make sure that most of the rice husk share the similar mass and density by using the grinder machine as shown in Figure 3.2. To measure the size of the rice husk, the testing sieve will be used to identify the size of the rice husk as shown in Figure 3.3. By using this apparatus, the sizing of the rice husk will be identified which is 500 microns.



Figure 3.2 Rice Husk After Grinding Process

Figure 3.3 Usage of Testing Sieve

## 3.3 Hand Lay-up Method

For this project, the size of mold is 31.2 cm x 21.2 cm x 1 cm. To get the ratio of rice husk to polyester resin, volume of the mold needs to be identified which is 661.44 $cm^3$. Then, the hand lay-up method process will be done as shown in Figure 3.5, Figure 3.6 and Table 3.1.

Figure 3.4 Mixing material



Figure 3.5 Hand lay-up process

Table 3.1 Procedure of Hand-Lay Up Method

| Step | Description |
| --- | --- |
| 1 | The mold was prepared according to the shape and size which are a x b x c. Make sure that there was no dust or residue on the mold. |
| 2 | Weight the amount of polyester resin and rice husk needed according to the ratio of rice husk to polyester resin which are 20:80, 40:60, 50:50, 60:40, 80:20 |
| 3 | Fill the mixture of natural fiber with polyester the first layer which is jute into the mold |
| 4 | Mix the mixture ratio of rice husk and polyester and spread it on the mold as second layer. The mixture was spread by using roller |
| 5 | Let the product rest for curing process for 1 day before removing from the mold |



## 3.4 Cutting Process (CNC machine)

After removing the jute fiber polyester hybrid composite reinforced with rice husk from the mold, it will be divided into four different sizes according to the requirement size of specimen of each ASTM standard using the CNC router machine. The CNC router machine model used is MODELA PRO2 (MDX-540) at Project Laboratory. The specimen was placed on top of the vice and the coordinate axis was set to zero at the computer control. The speed of the spindle was set between 100 rpm to 200 rpm and the cutting procedure was proceeded by pressing the button at the control panel.

The mold size specimen will be cut into three different type of ASTM standard based on the mechanical testing needed. For tensile and flexural testing, the dimension used is 250 mm x 25 mm x 5 mm based on the requirement of ASTM D3039 and ASTM D790 model standard. Meanwhile for the impact testing, the dimension is 60 mm x 15 mm x 5 mm based on the requirement of the ASTM D6110 model standard as shown in Figure 3.8 and Figure 3.9. For water absorption test, the dimension is 60 mm x 60 mm x 10 mm based on ASTM D570 model standard. The machine condition will be check and updated before using it and make sure that the cutting tool was placed at correct position to ensure the cutting process going steadily.



Figure 3.6 Cutting Process using MODELA PRO2 (MDX-540)

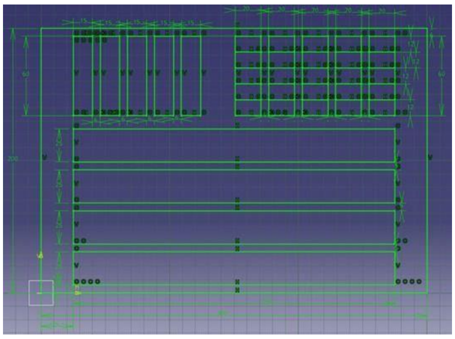


Figure 3.7 Cutting Template A for Tensile, Impact and Water Absorption Test

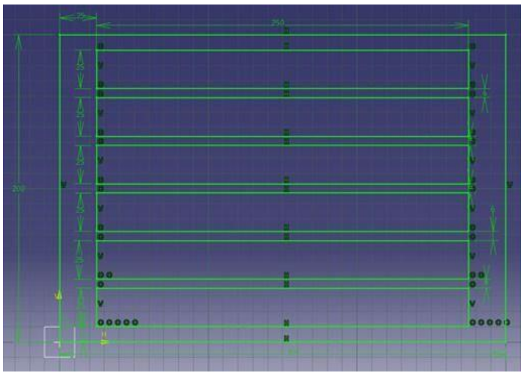


Figure 3.8 Cutting Template B for Flexural Test

## 3.5 Mechanical Testing

After cutting prosses using the CNC router machine, the specimen will undergo curing process where the polyester resin will become solid before tested for its mechanical properties. The test that conducted toward the specimen are tensile strength test using ASTM D3039, flexural strength test using ASTM D790, impact strength test using ASTM D6110 and water absorption test using ASTM D70.

### 3.5.1 Tensile Strength Testing

The tensile testing was accomplished by using the universal testing machine at Material Testing Technology Laboratory. From this test, the mechanical properties needed for the jute fiber polyester hybrid composite reinforced with rice husk were obtained which are the maximum stress and maximum strain elongation as shown in figure. The load will be increase till the specimen meet the failure state. At the end of the test, the sample with “dog bone shape” was obtained. There are few steps to conduct the testing as shown in Table 3.2.

Figure 3.9 Tensile Testing using Universal Testing Machine

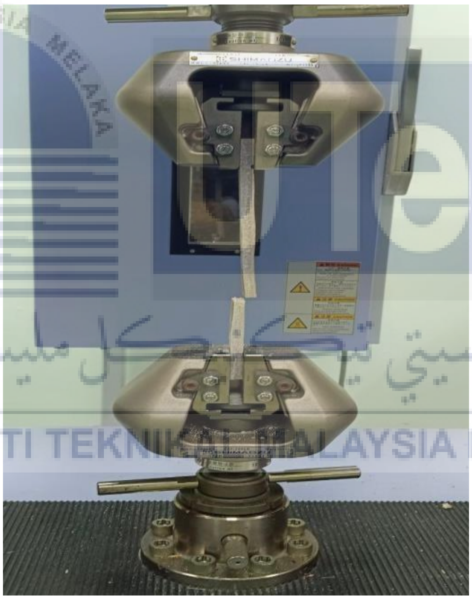




Figure 3.10 Specimen after Reaching Failure Stage

Table 3.2 Procedure of Tensile Test

| Step | Description |
|---|---|
| 1 | The specimen was placed at the grid of the testing machine |
| 2 | The testing machine was set to it specific rate |
| 3 | The testing started till the specimen at failure state |

### 3.5.2 Flexural Strength Testing

Flexural strength is the capacity of a composite material to endure bending forces applied perpendicular to its longitudinal axis. The flexural testing was performed to evaluate the construction of stiffness and flexural strength of the specimen. The highest shear stress that occurs between layer of laminated material is known as the inter-laminar shear strength (ILSS). The jute fiber polyester hybrid composite reinforced with rice husk is placed horizontally on the three-point loading of SHIMADZU Universal Testing Machine as shown in Figure 3.10.



Failure will happen when the strain or elongation surpasses the material limitation. The loading nose will apply the force at center of the specimen to test the maximum deflection it. The test is completed when the specimen almost reaches the break point. After the test completed, the result data that consist of flexural strain at yield, flexural strain at break, flexural stress at break and flexural stress at yield. The Stress-strain curve with raw data information also will be provided and shown at the computer. There are few procedures to conduct the flexural test as shown in Table 3.3: -


Figure 3.11 Specimen during Flexural Test

Table 3.3 Procedure of Flexural Test

| Step | Description |
|---|---|
| 1 | The support span length was adjusted based on the size of the specimen |
| 2 | The Specimen was placed on the 3-point bend fixture |
| 3 | The flexural testing machine was set according to the ASTM D790 standard |
| 4 | The Test was started till it bending to 5% of it strain or till the specimen breaks |

### 3.5.3 Impact Strength Testing

For the impact test, we able to identified the amount of energy absorbed by the specimen. This testing was conducted using the impact tester machine which are INSTRON CEAST 9050. This testing uses the Charpy method where the specimen will be tested using a V-notch in order to obtain the data needed as shown in figure 3.13. This test will be conducted based on the procedure of Charpy Impact test as shown in Figure 3.14 and Table 3.4: -

Figure 3.12 Example of V-Notch of Specimen




Figure 3.13 Impact Testing using INSTRON CEAST 9050

Figure 3.14 Specimen after Impact Testing



Table 3.4 Procedure of Charpy Impact Test

| Step | Description |
|---|---|
| 1 | The Charpy V-notch specimen was placed across the parallel jaws of the impact-testing machine |
| 2 | The value of the pointer was set to it maximum value |
| 3 | The hammer was released from the initial height downward to it sample |
| 4 | The specimen was observed and the value of energy absorbed was recorded and tabulated |
| 5 | Step 1 to 4 was repeated with different ratio of specimen |

### 3.5.4 Water Absorption Testing

The maximum level of water absorption that developed by the hybrid composites based on the ASTM D570 standard. The objective of this test is to identify the rate of absorption of water by let the specimen to be immerse for a specific period of time. The initial weight of each specimen will be recorded using the weighting scale as shown in figure 3.15

.

The water absorption test of the specimen will be conducted by submerged it into container filled with clean water with interval of 5 days at room temperature at Malaysia as shown in figure 3.15. There will be five data which for 5 days, 10 days, 15 days, 20 days and 25 days. Five specimens from each ratio will be weighted when reaching the duration needed. There are few steps on how to conduct the test as shown in Table 3.5: -




Figure 3.15 Weighting the Specimen

Figure 3.16 Specimen During Water Absorption Test

Table 3.5 Procedure of Water Absorption Testing (Mishra, 2017)

| Step | Description |
|---|---|
| 1 | Dry the specimen under hot temperature till it attains the substantially mass constant |
| 2 | The specimen was cooled under the room temperature and the initial weight of the specimen was recorded |
| 3 | The Specimen was completely immerse in clean water at standard room temperature around 26˚C for 5 days |
| 4 | The specimen was removed from the water and traces of water on the specimen was wiped with damp cloth |
| 5 | The Specimen was weighted for M2 and record the result |
| 6 | Step 1 to step 5 was repeated with different period which are 10 days, 15 days, 20 days and 25 days |

### 3.6 The Statistical Analysis (ANOVA)

After completed all testing, the statistical analysis is used to analyses the result that obtained from the mechanical testing. We able to determine the best ratio of the jute fiber polyester hybrid composite reinforced with rice husk based on the mechanical properties of it on every ratio. The ANOVA is a statistical method to approach on determining the average data value of the sample from the same population. A one-way analysis of variance (ANOVA) is used to evaluate the energy of the composite. To analyze all five ratios for environmentally friendly option, the P-value need to be below the significant threshold level which is 0.05. If the P- value is lower than the significant level, then $h_o$ is rejected where $h_o$ is null hypothesis meanwhile if P-Value is higher than significant level, then $h_1$ is rejected where $h_1$is alternate hypothesis

### 3.7 Summary

Briefly, sample preparation and procedure for every testing need to be carried out carefully to meet the project objective. At the end of the chapter 3, each of the planning, preparation and method are critically significant that affect in obtaining accurate outcome and result.

### 3.8 Gantt Chart

#### 3.8.1 Gantt Chart PSM 1

As shown in Appendix B

#### 3.8.2 Gantt Chart PSM 2

As shown in Appendix C

# CHAPTER 4
# RESULT

## 4.1 Introduction

After completing each of the testing which are tensile test, flexural test, impact test and water absorption test, the data will be represented in form of graph and ANOVA one-waytest.

## 4.2 Tensile Test

For tensile test, the tensile strength and the maximum strain is the result that needed for this project. This testing was conducted at Material Testing Technology Laboratory using universal testing machine.

### 4.2.1 Tensile Strength



Figure 4.1 illustrate the tensile strength of each specimen of jute fiber polyester hybrid composite reinforced with rice husk with difference ratio of 20P80RH,40P60RH, 50P50RH, 60P40RH, 80P20RH. The tensile strength upon reaching failure of the composite with ratio of 80P20RH has the highest average value which is 20.71 Mpa meanwhile composite ratio of 20P80RH has the lowest average value of tensile strength which is 4.913 MPa. Based onthe observation toward the tensile strength data, we able to identify that as the percentage of polyester resin increase, the tensile strength of the composite will increase.

The one-way analysis of variance (ANOVA) was used to analyze the tensile strength of composite using minitab application with condition as shown in Table 4.1 and Table 4.2. The result from the ANOVA testing of tensile test is significant since the P-Value is lower than the significant level where α = 0.05. It show that all of JFPHCRRH have different average. As a result, the ratio of 80% of polyester to 20% of rice husk has the best tensile properties. By using the Tukey test, two means are different if the sample difference absolute is greater. By using the Minitab application, the Tukey test was conducted according to $\alpha$ = 0.05 and $f$ = 20 degrees of freedom for error. According to Table 4.4, $h_0$ is rejected since that all of the data were significantly different where the adjusted P-value is lower than the significant level which is 0.05.

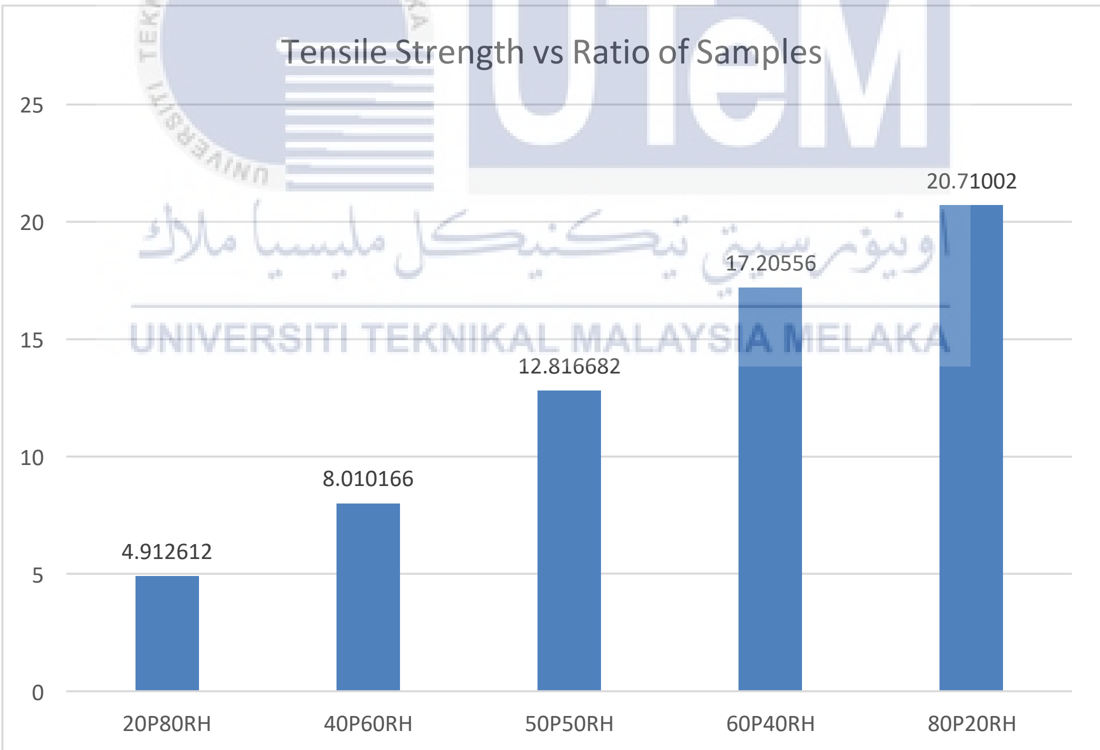



Figure 4.1 Tensile Strength Vs Ratio of Sample

Table 4.1 Method of ANOVA for Tensile Strength

| | |
|---|---|
| **Null Hypothesis** | All means are equal |
| **Alternative Hypothesis** | Not all means are equal |
| **Significance Level** | $\alpha = 0.05$ |

Table 4.2 ANOVA for Tensile Strength

| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
|---|---|---|---|---|---|
| C1 | 4 | 835.536 | 208.884 | 928.03 | 0.000 |
| Error | 20 | 4.502 | 0.225 | | |
| Total | 24 | 840.038 | | | |

Table 4.3 Mean for Tensile Strength

| C1 | N | Mean | StDev | 95% CI |
|---|---|---|---|---|
| 20P80RH | 5 | 1.2692 | 0.0595 | (1.2045, 1.3339) |
| 40P60RH | 5 | 1.9693 | 0.0299 | (1.9046, 2.0340) |
| 50P50RH | 5 | 2.2818 | 0.0457 | (2.2171, 2.3465) |
| 60P40RH | 5 | 2.9638 | 0.1225 | (2.8991, 3.0285) |
| 80P20RH | 5 | 3.7371 | 0.0502 | (3.6724, 3.8018) |

Table 4.4 Tukey Simultaneous Test for Differences of Means for Tensile Strength

| Difference of Levels | Difference of Means | SE of Difference | 95% CI | T-Value | Adjusted P-Value |
|---|---|---|---|---|---|
| 40P60RH - 20P80RH | 3.098 | 0.300 | (2.200, 3.995) | 10.32 | 0.000 |
| 50P50RH - 20P80RH | 7.904 | 0.300 | (7.007, 8.802) | 26.34 | 0.000 |
| 60P40RH - 20P80RH | 12.293 | 0.300 | (11.395, 13.190) | 40.97 | 0.000 |
| 80P20RH - 20P80RH | 15.797 | 0.300 | (14.900, 16.695) | 52.65 | 0.000 |
| 50P50RH - 40P60RH | 4.807 | 0.300 | (3.909, 5.704) | 16.02 | 0.000 |
| 60P40RH - 40P60RH | 9.195 | 0.300 | (8.298, 10.093) | 30.65 | 0.000 |
| 80P20RH - 40P60RH | 12.700 | 0.300 | (11.802, 13.597) | 42.33 | 0.000 |
| 60P40RH - 50P50RH | 4.389 | 0.300 | (3.491, 5.286) | 14.63 | 0.000 |
| 80P20RH - 50P50RH | 7.893 | 0.300 | (6.996, 8.791) | 26.31 | 0.000 |
| 80P20RH - 60P40RH | 3.504 | 0.300 | (2.607, 4.402) | 11.68 | 0.000 |



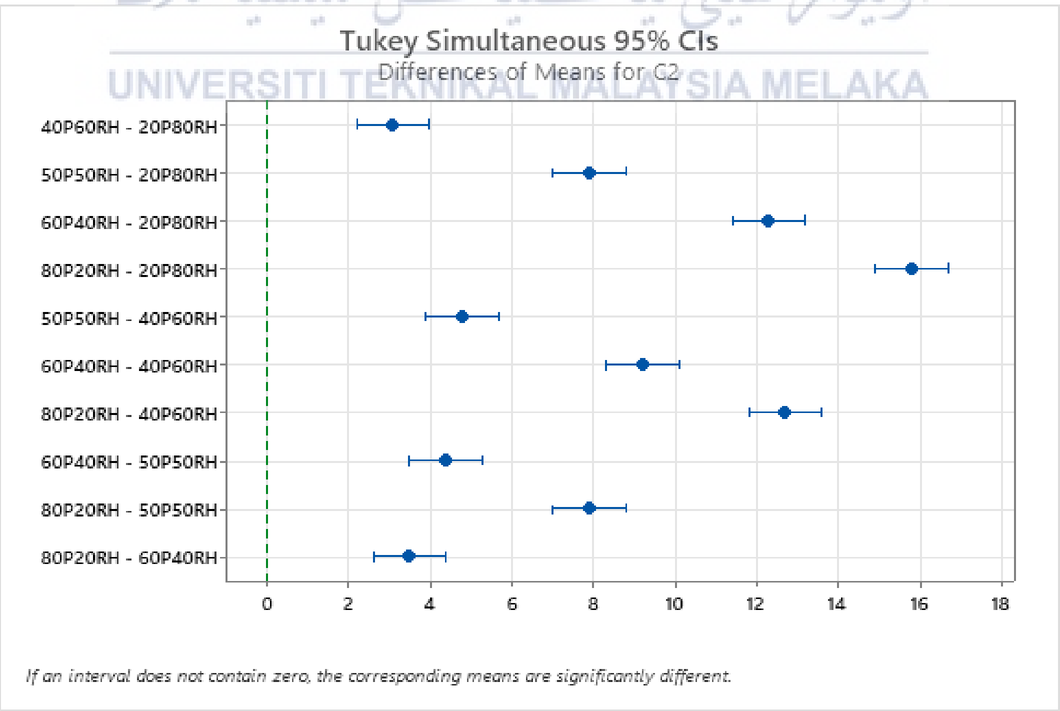



Figure 4.2 Tukey Simulation for Tensile Strength of Each Ratio Sample

### 4.2.2 Maximum Tensile Strain

Figure 4.3 illustrate the maximum tensile strain of each specimen of jute fiber polyester hybrid composite reinforced with rice husk with difference ratio of 20P80RH,40P60RH, 50P50RH, 60P40RH, 80P20RH during tensile test. The maximum tensile strain upon failure of the composite with ratio of 80P20RH has the highest average value which is 3.737 % meanwhile composite ratio of 20P80RH has the lowest average value of maximum strain upon reaching failure which is 1.271 %. Based on the observation toward the maximum strain of data as shown in Figure 4.3, we able to identify that as the percentage of polyester resin increase, the maximum tensile strain of the composite will increase.

The one-way analysis of variance (ANOVA) was used to analyze the maximum tensile strain of composite using Minitab application with condition as shown in Table 4.5 and Table 4.6. The result from the ANOVA testing of tensile test is significant since the P-Value is lower than the significant level where $\alpha = 0.05$. It show that all of JFPHCRRH have different average. As a result, the ratio of 80% of polyester to 20% of rice husk has the best tensile properties. By using the Turkey test, two means are different if the sample difference absolute is greater. By using the Minitab application, the Turkey test was conducted according to $\alpha = 0.05$ and $f = 20$ degrees of freedom for error. According to Table 4.8, $h_0$ is rejected since that all of the data were significantly different since the adjusted P-value is lower than the significant level which is 0.05.

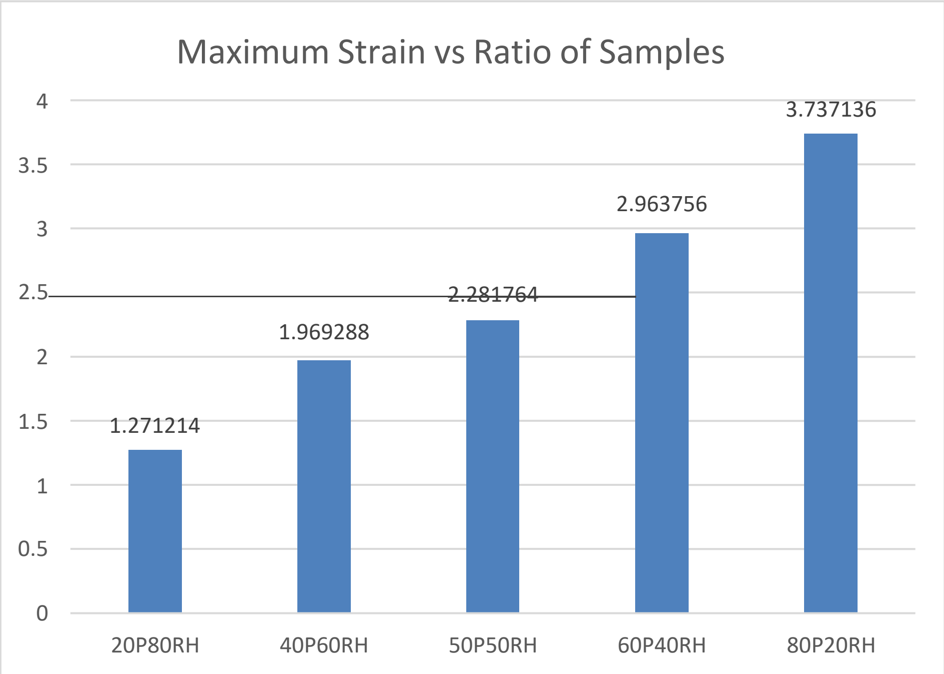



Figure 4.3 Maximum Tensile Strain Vs Ratio of Sample

Table 4.5 Method of ANOVA for Maximum Tensile Strain

| | |
|---|---|
| **Null Hypothesis** | All means are equal |
| **Alternative Hypothesis** | Not all means are equal |
| **Significance Level** | α = 0.05 |



Table 4.6 ANOVA for Maximum Tensile Strain

| **Source** | **DF** | **Adj SS** | **Adj MS** | **F-Value** | **P-Value** |
|---|---|---|---|---|---|
| C1 | 4 | 17.8707 | 4.46768 | 928.72 | 0.000 |
| Error | 20 | 0.0962 | 0.00481 | | |
| Total | 24 | 17.9669 | | | |

Table 4.7 Mean for Maximum Tensile Strain

| C1 | N | Mean | StDev | 95% CI |
|---|---|---|---|---|
| 20P80RH | 5 | 1.2692 | 0.0595 | (1.2045, 1.3339) |
| 40P60RH | 5 | 1.9693 | 0.0299 | (1.9046, 2.0340) |
| 50P50RH | 5 | 2.2818 | 0.0457 | (2.2171, 2.3465) |
| 60P40RH | 5 | 2.9638 | 0.1225 | (2.8991, 3.0285) |
| 80P20RH | 5 | 3.7371 | 0.0502 | (3.6724, 3.8018) |

Table 4.8 Tukey Simultaneous Test for Maximum Tensile Strain

| Difference of Levels | Difference of Means | SE of Difference | 95% CI | T-Value | Adjusted P-Value |
|---|---|---|---|---|---|
| 40P60RH - 20P80RH | 0.7001 | 0.0439 | (0.5689, 0.8313) | 15.96 | 0.000 |
| 50P50RH - 20P80RH | 1.0126 | 0.0439 | (0.8813, 1.1438) | 23.08 | 0.000 |
| 60P40RH - 20P80RH | 1.6945 | 0.0439 | (1.5633, 1.8257) | 38.63 | 0.000 |
| 80P20RH - 20P80RH | 2.4679 | 0.0439 | (2.3367, 2.5991) | 56.26 | 0.000 |
| 50P50RH - 40P60RH | 0.3125 | 0.0439 | (0.1813, 0.4437) | 7.12 | 0.000 |
| 60P40RH - 40P60RH | 0.9945 | 0.0439 | (0.8633, 1.1257) | 22.67 | 0.000 |
| 80P20RH - 40P60RH | 1.7678 | 0.0439 | (1.6366, 1.8991) | 40.30 | 0.000 |
| 60P40RH - 50P50RH | 0.6820 | 0.0439 | (0.5508, 0.8132) | 15.55 | 0.000 |
| 80P20RH - 50P50RH | 1.4554 | 0.0439 | (1.3242, 1.5866) | 33.18 | 0.000 |
| 80P20RH - 60P40RH | 0.7734 | 0.0439 | (0.6422, 0.9046) | 17.63 | 0.000 |

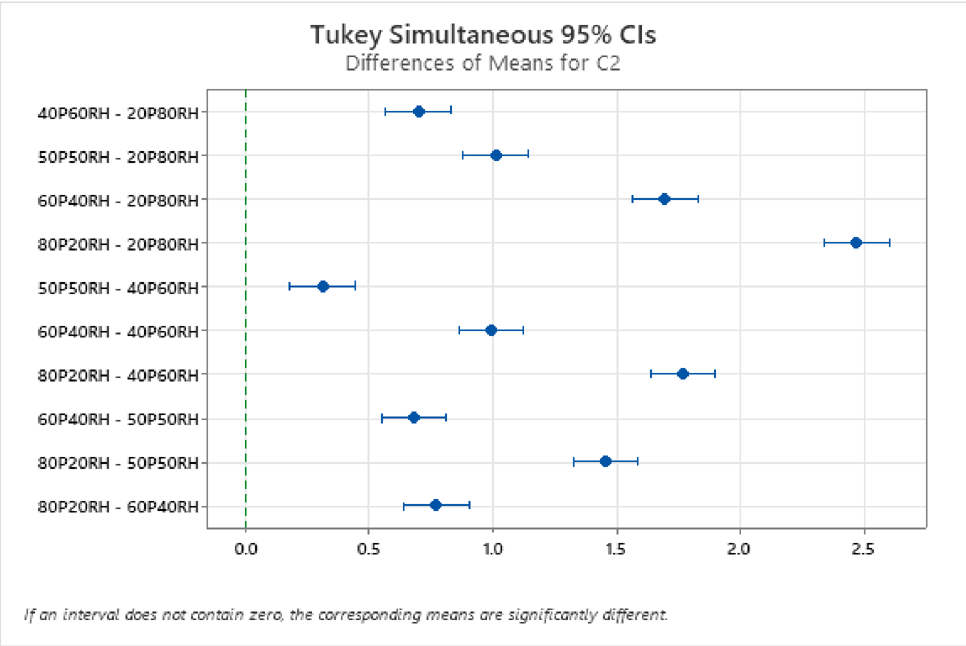



Figure 4.4 Tukey Simultaneous 95% C1s for Tensile Strain

## 4.3 Flexural Test

For flexural test, the flexural strength is the result that needed for this project. This testing was conducted at Material Testing Technology Laboratory using universal testing machine.

Figure 4.5 illustrate the flexural strength of each specimen of jute fiber polyester hybrid composite reinforced with rice husk with difference ratio of 20P80RH,40P60RH, 50P50RH, 60P40RH, 80P20RH. The flexural strength of the composite with ratio of 80P20RH has the highest average value in term of flexural strength which is 73.157 MPa meanwhile composite ratio of 20P80RH has the lowest average value of flexural strength which is 21.353 MPa. Based on the observation toward the flexural strength data, we able to identify that as the percentage of polyester resin increase, the flexural strength of the composite will increase.

The one-way analysis of variance (ANOVA) was used to analyze the flexural strength of composite using Minitab application with condition as shown in Table 4.9 and Table 4.10. The result from the ANOVA testing of tensile test is significant since the P-Value is lower than the significant level where α = 0.05. It show that all of JFPHCRRH have different average. As a result, the ratio of 80% of polyester to 20% of rice husk has the best flexural properties. By using the Tukey test, two means are different if the sample difference absolute is greater. By using the Minitab application, the Turkey test was conducted according to $\alpha$ = 0.05 and $f$ = 20 degrees of freedom for error. According to Table 4.12, $h_0$ is rejected since that all of the data were significantly different since the adjusted P-value is lower than the significant level which is 0.05.

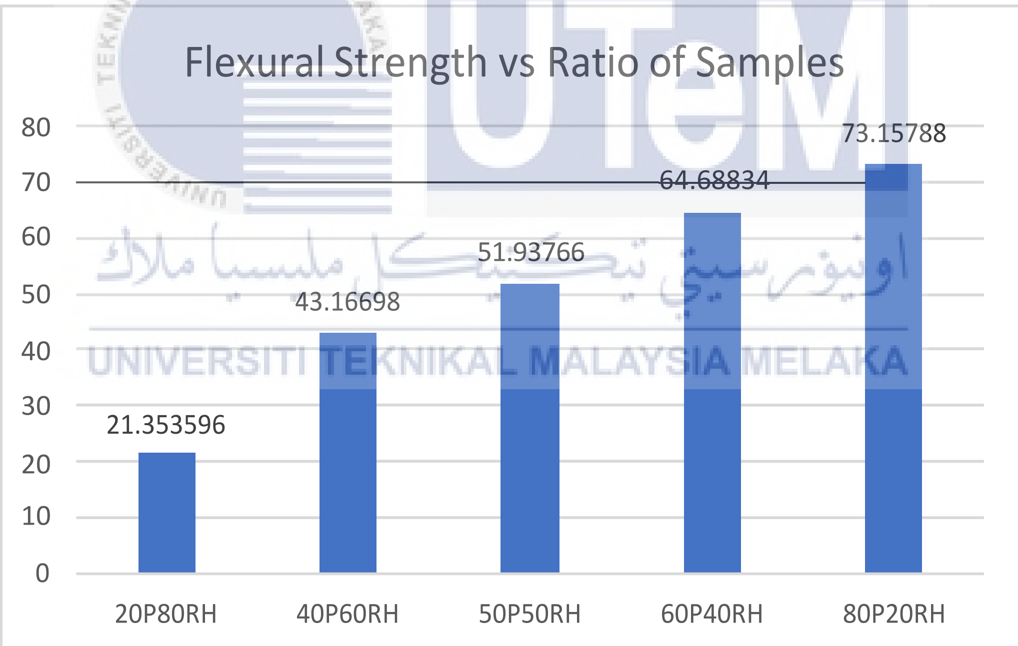



Figure 4.5 Maximum Flexural Strength Vs Ratio of Sample

Table 4.9 Method of ANOVA for Flexural Strength

| | |
|---|---|
| **Null Hypothesis, $h_1$** | All means are equal |
| **Alternative Hypothesis, $h_0$** | Not all means are equal |
| **Significance Level** | α = 0.05 |

Table 4.10 ANOVA for Flexural Strength

| **Source** | **DF** | **Adj SS** | **Adj MS** | **F-Value** | **P-Value** |
|---|---|---|---|---|---|
| C1 | 4 | 8156.13 | 2039.03 | 6617.76 | 0.000 |
| Error | 20 | 6.16 | 0.31 | | |
| Total | 24 | 8162.29 | | | |

Table 4.11 Mean of Specimen for Flexural Strength

| **C1** | **N** | **Mean** | **StDev** | **95% CI** |
|---|---|---|---|---|
| 20P80RH | 5 | 21.154 | 0.336 | (20.636, 21.671) |
| 40P60RH | 5 | 43.167 | 0.730 | (42.649, 43.685) |
| 50P50RH | 5 | 51.938 | 0.464 | (51.420, 52.455) |
| 60P40RH | 5 | 64.688 | 0.430 | (64.171, 65.206) |
| 80P20RH | 5 | 73.158 | 0.703 | (72.640, 73.676) |

Table 4.12 Tukey Test for Flexural Strength

| Difference of Levels | Difference of Means | SE of Difference | 95% CI | T-Value | Adjusted P-Value |
|---|---|---|---|---|---|
| 40P60RH - 20P80RH | 22.013 | 0.351 | (20.963, 23.063) | 62.70 | 0.000 |
| 50P50RH - 20P80RH | 30.784 | 0.351 | (29.734, 31.834) | 87.69 | 0.000 |
| 60P40RH - 20P80RH | 43.535 | 0.351 | (42.485, 44.585) | 124.01 | 0.000 |
| 80P20RH - 20P80RH | 52.004 | 0.351 | (50.954, 53.054) | 148.13 | 0.000 |
| 50P50RH - 40P60RH | 8.771 | 0.351 | (7.721, 9.821) | 24.98 | 0.000 |
| 60P40RH - 40P60RH | 21.521 | 0.351 | (20.471, 22.571) | 61.30 | 0.000 |
| 80P20RH - 40P60RH | 29.991 | 0.351 | (28.941, 31.041) | 85.43 | 0.000 |
| 60P40RH - 50P50RH | 12.751 | 0.351 | (11.701, 13.801) | 36.32 | 0.000 |
| 80P20RH - 50P50RH | 21.220 | 0.351 | (20.170, 22.270) | 60.45 | 0.000 |
| 80P20RH - 60P40RH | 8.470 | 0.351 | (7.419, 9.520) | 24.13 | 0.000 |

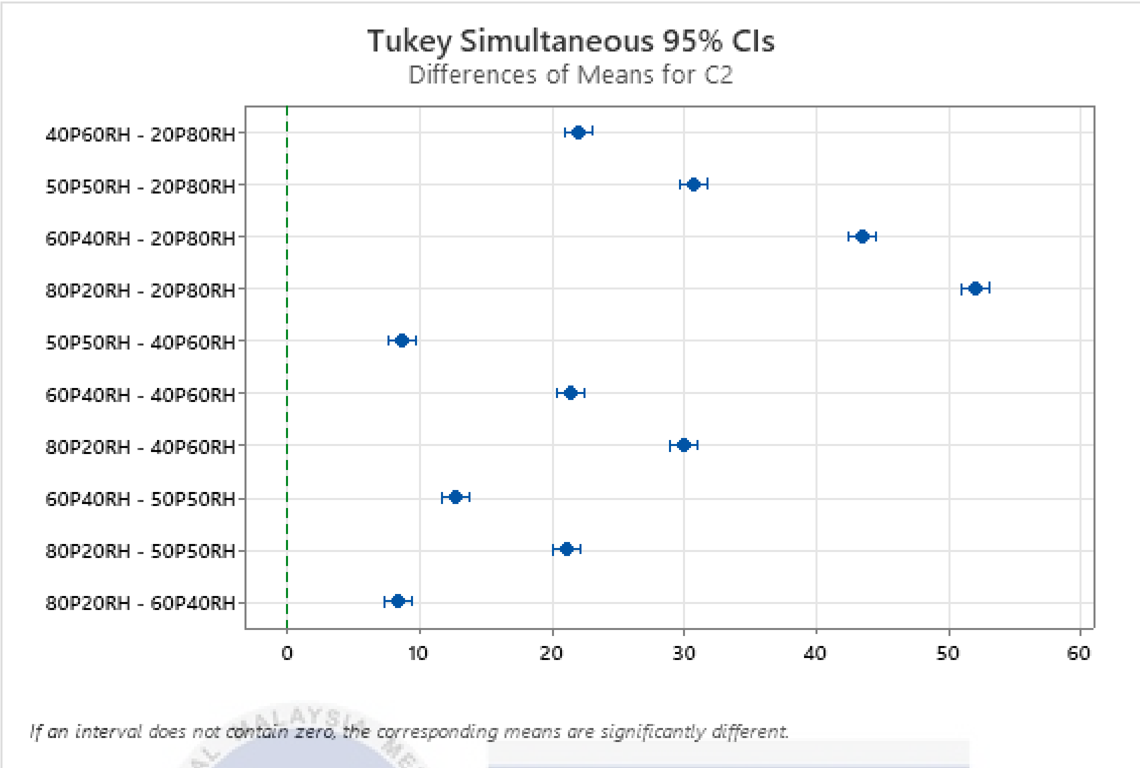



Figure 4.6 Tukey Simultaneous 95% C1s for Flexural Strength

## 4.4 Impact Test

For Impact test, the Impact strength is the result that needed for this project. This testing was conducted at Material Testing Technology Laboratory using INSTRON CEAST 9050.

Figure 4.7 illustrate the impact strength of each specimen of jute fiber polyester hybrid composite reinforced with rice husk with difference ratio of 20P80RH,40P60RH, 50P50RH, 60P40RH, 80P20RH. The impact strength of the composite with ratio of 80P20RH has the highest average value in term of impact strength which is 0.8658 J meanwhile composite ratio of 20P80RH has the lowest average value of impact strength which is 0.2184 J as shownin Figure 4.7.

The one-way analysis of variance (ANOVA) was used to analyze the impact strength of composite using Minitab application with condition as shown in Table 4.13 and Table
4.14. The result from the ANOVA testing of tensile test is significant since the P-Value is lower than the significant level where $\alpha = 0.05$. It show that all of JFPHCRRH have different average. As a result, the ratio of 80% of polyester to 20% of rice husk has the best tensile properties as shown in Figure 4.7. By using the Tukey test, two means are different if the sample difference absolute is greater., the Tukey test was conducted according to $\alpha = 0.05$ and $f = 20$ degrees of freedom for error. According to Table 4.16, $h_1$ is rejected for level 40P60RH - 20P80RH, 50P50RH - 40P60RH, 60P40RH - 40P60RH and 60P40RH - 50P50RH since that all of the data were significantly different since the adjusted P-value is lower than the significant level which is 0.05 where the P-value were 0.206, 0.552, 0.066 and 0.684. Meanwhile, for the other level were significantly different since the P-value were lower than significant level which is 0.05.



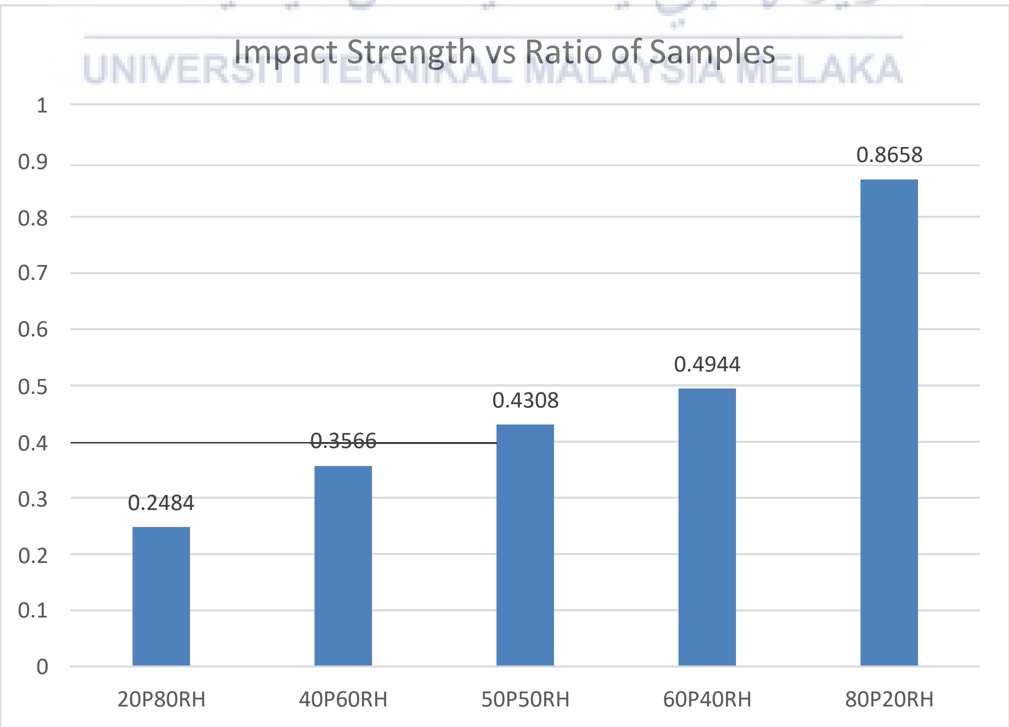



Figure 4.7 Impact Strength vs Ratio of Sample

Table 4.13 Method of ANOVA for Impact Strength

| | |
|---|---|
| **Null Hypothesis** | All means are equal |
| **Alternative Hypothesis** | Not all means are equal |
| **Significance Level** | $\alpha = 0.05$ |

Table 4.14 ANOVA for Impact Strength

| **Source** | **DF** | **Adj SS** | **Adj MS** | **F-Value** | **P-Value** |
|---|---|---|---|---|---|
| C1 | 4 | 1.1017 | 0.275416 | 47.21 | 0.000 |
| Error | 20 | 0.1167 | 0.005834 | | |
| Total | 24 | 1.2183 | | | |

Table 4.15 Average Mean for Impact Strength

| **C1** | **N** | **Mean** | **StDev** | **95% CI** |
|---|---|---|---|---|
| 20P80RH | 5 | 0.2484 | 0.0460 | (0.1771, 0.3197) |
| 40P60RH | 5 | 0.3566 | 0.0758 | (0.2853, 0.4279) |
| 50P50RH | 5 | 0.4308 | 0.0468 | (0.3595, 0.5021) |
| 60P40RH | 5 | 0.4944 | 0.1176 | (0.4231, 0.5657) |
| 80P20RH | 5 | 0.8658 | 0.0727 | (0.7945, 0.9371) |

Table 4.16 Tukey Test for Impact Strength Strength

| Difference of Levels | Difference of Means | SE of Difference | 95% CI | T-Value | Adjusted P-Value |
|---|---|---|---|---|---|
| 40P60RH - 20P80RH | 0.1082 | 0.0483 | (-0.0363, 0.2527) | 2.24 | 0.206 |
| 50P50RH - 20P80RH | 0.1824 | 0.0483 | (0.0379, 0.3269) | 3.78 | 0.009 |
| 60P40RH - 20P80RH | 0.2460 | 0.0483 | (0.1015, 0.3905) | 5.09 | 0.000 |
| 80P20RH - 20P80RH | 0.6174 | 0.0483 | (0.4729, 0.7619) | 12.78 | 0.000 |
| 50P50RH - 40P60RH | 0.0742 | 0.0483 | (-0.0703, 0.2187) | 1.54 | 0.552 |
| 60P40RH - 40P60RH | 0.1378 | 0.0483 | (-0.0067, 0.2823) | 2.85 | 0.066 |
| 80P20RH - 40P60RH | 0.5092 | 0.0483 | (0.3647, 0.6537) | 10.54 | 0.000 |
| 60P40RH - 50P50RH | 0.0636 | 0.0483 | (-0.0809, 0.2081) | 1.32 | 0.684 |
| 80P20RH - 50P50RH | 0.4350 | 0.0483 | (0.2905, 0.5795) | 9.01 | 0.000 |
| 80P20RH - 60P40RH | 0.3714 | 0.0483 | (0.2269, 0.5159) | 7.69 | 0.000 |

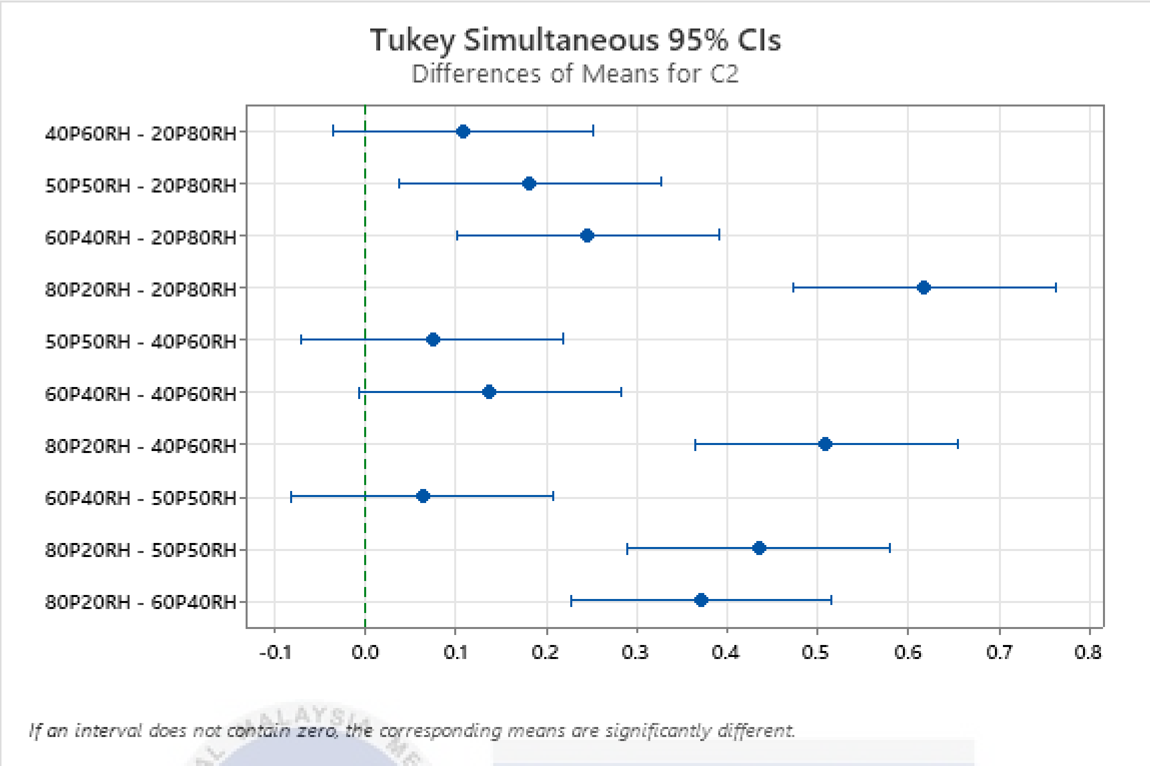



Figure 4.8 Tukey Simultaneous 95% C1s for Impact Strength

## 4.5 Water Absorption Test

For water absorption test, the percentage rate of water absorption is the result that needed for this project. This testing was conducted at standard Malaysia room temperature surrounding using multi-space container. For every 5 days, data weight of the specimen will be weighted till it reach day 25.

Figure 4.9 illustrate the percentage rate of water absorption of each specimen of jute fiber polyester hybrid composite reinforced with rice husk with difference ratio of 20P80RH,40P60RH, 50P50RH, 60P40RH, 80P20RH. The rate of water absorption of the composite with ratio of 20P80RH has the highest percentage rate of water absorption which is 9.421% meanwhile composite ratio of 20P80RH has the lowest average percentage rate of water absorption which is 3.161%.

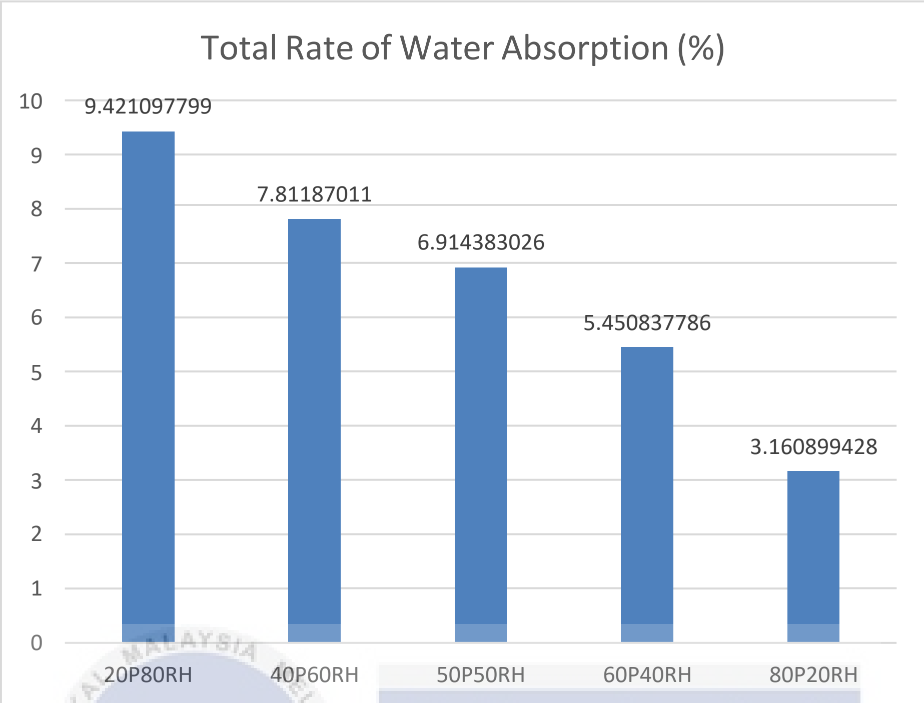



Figure 4.9 Graph of Rate of Water Absorption for Each Ratio

### 4.5.1 Water Absorption For 20P80RH

Figure 4.10 illustrate the percentage rate of water absorption of each specimen of jute fiber polyester hybrid composite reinforced with rice husk with ratio of 20P80RH for 5 days, 10 days, 15 days, 20 days, 25 days . The rate of water absorption of the composite during day 20 has the highest average value in term of percentage of water absorption which is 11.624% meanwhile day 5 has the lowest value rate of water absorption which is 2.224%.

The one-way analysis of variance (ANOVA) was used to analyze the percentage rate of water absorption of composite using Minitab application with condition as shown in Table

4.17 and Table 4.18. The result from the ANOVA of percentage rate of water absorption test is significant since the P-Value is lower than the significant level where α = 0.05. It shows that all of JFPHCRRH have different average. As a result, day 20 has the highest percentage rate of water absorption shown in Figure 4.10.

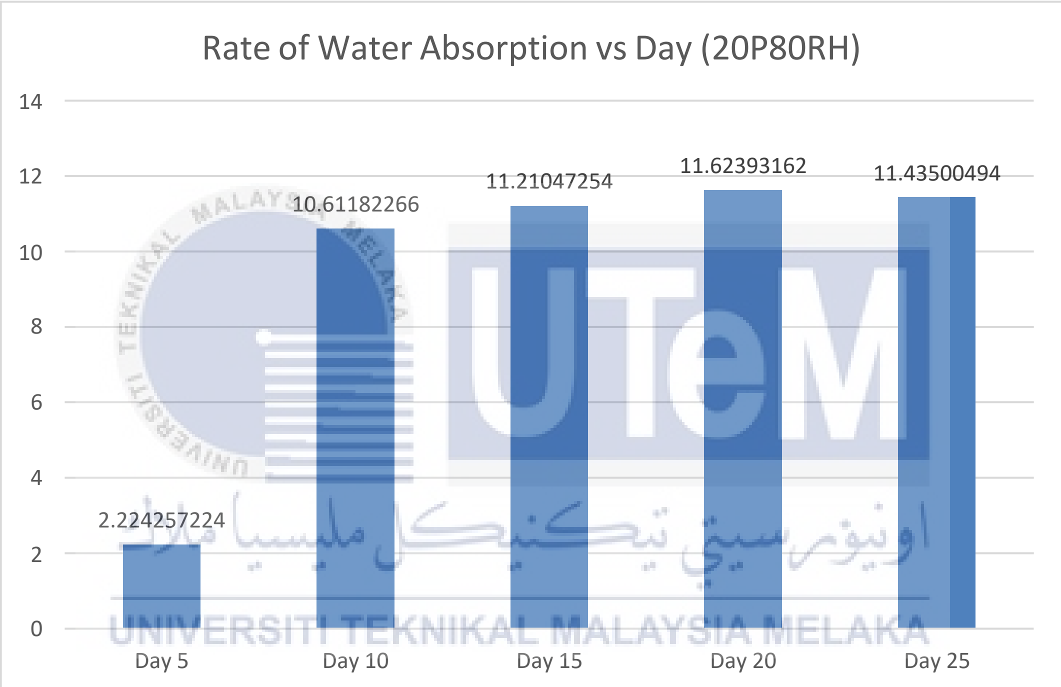



Figure 4.10 Graph of Rate of Water Absorption for 20P80RH

Table 4.17 Method of ANOVA

| | |
|---|---|
| **Null Hypothesis** | All means are equal |
| **Alternative Hypothesis** | Not all means are equal |
| **Significance Level** | α = 0.05 |

Table 4.18 ANOVA for Rate of Water Absorption for 20P80RH

| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
|---|---|---|---|---|---|
| C1 | 4 | 282.8 | 70.71 | 5.57 | 0.004 |
| Error | 20 | 253.7 | 12.68 | | |
| Total | 24 | 536.5 | | | |

### 4.5.2 Water Absorption For 40P60RH

Figure 4.11 illustrate the average percentage rate of water absorption of each specimen of jute fiber polyester hybrid composite reinforced with rice husk with ratio of 40P60RH for 5 days, 10 days, 15 days, 20 days, 25 days. The average rate of water absorption of the composite during day 20 has the highest average percentage rate of water absorption which is 10.8512% meanwhile day 5 has the lowest rate of water absorption which is 1.428%.

The one-way analysis of variance (ANOVA) was used to analyze the percentage rate of water absorption of composite using Minitab application with condition as shown in Table

4.19 and Table 4.20. The result from the ANOVA of percentage rate of water absorption test is significant since the P-Value is lower than the significant level where $\alpha = 0.05$. It show that all of JFPHCRRH have different average. As a result, day 20 has the highest percentage rate of water absorption shown in Figure 4.11.

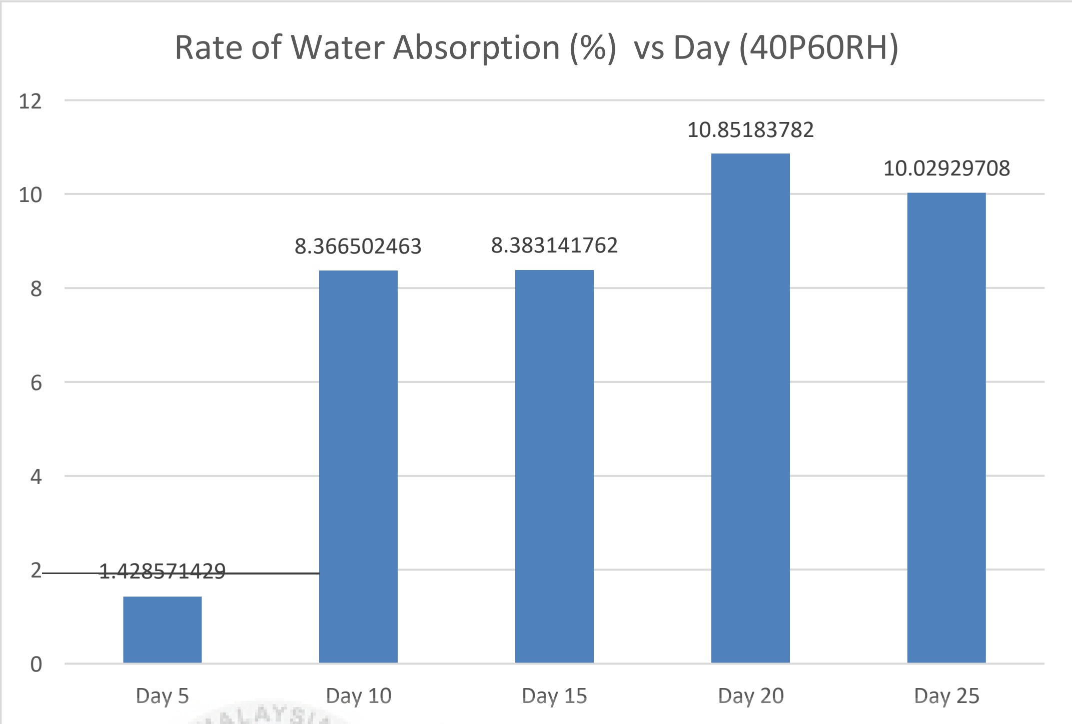



Figure 4.11 Rate of Water Absorption for 40P60RH vs Days

Table 4.19 Method of ANOVA for Percentage Rate of Water Absorption

| | |
|---|---|
| **Null Hypothesis** | All means are equal |
| **Alternative Hypothesis** | Not all means are equal |
| **Significance Level** | $\alpha = 0.05$ |

Table 4.20 ANOVA for Percentage Rate of Water Absorption of 40P60RH

| **Source** | **DF** | **Adj SS** | **Adj MS** | **F-Value** | **P-Value** |
|---|---|---|---|---|---|
| C1 | 4 | 277.7 | 69.42 | 5.01 | 0.006 |
| Error | 20 | 277.0 | 13.85 | | |
| Total | 24 | 554.7 | | | |

### 4.5.3 Water Absorption For 50P50RH

Figure 4.12 illustrate the percentage rate of water absorption of each specimen of jute fiber polyester hybrid composite reinforced with rice husk with ratio of 50P50RH for 5 days, 10 days, 15 days, 20 days, 25 days . The average rate of water absorption of the composite during day 20 has the highest percentage water absorption which is 8.789% meanwhile day 5 has the lowest percentage rate of water absorption which is 2.288%.

The one-way analysis of variance (ANOVA) was used to analyze the percentage rate of water absorption of composite using Minitab application with condition as shown in Table

4.21 and Table 4.22. The result from the ANOVA water absorption test is significant since the P-Value is lower than the significant level where α = 0.05. It show that all of JFPHCRRH have different average. As a result, day 20 has the highest percentage rate of water absorption shown in figure 4.12

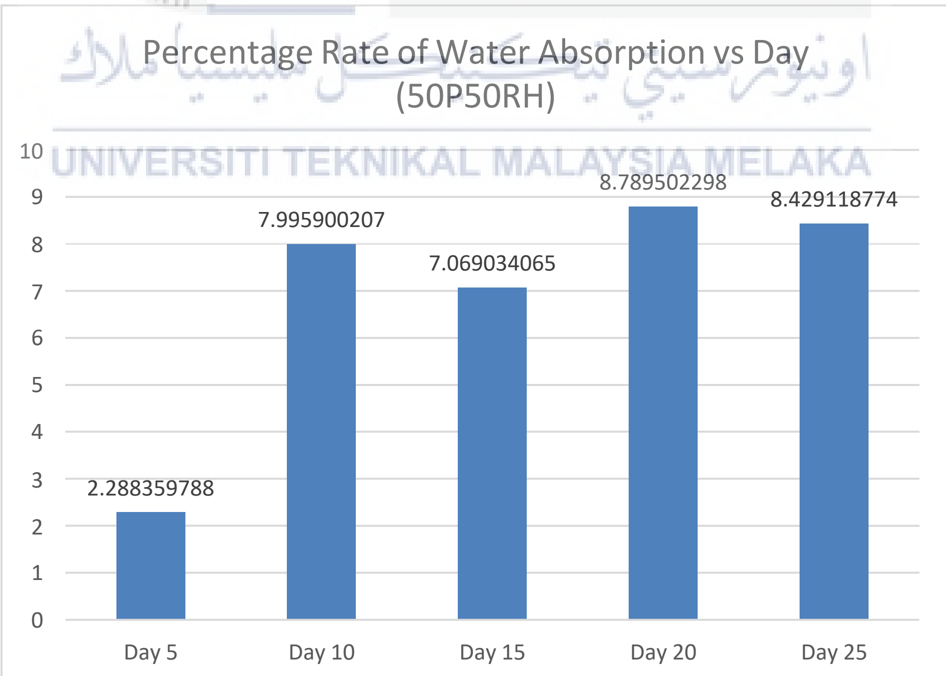



Figure 4.12 Graph of Percentage Rate of Water Absorption for 50P50RH

Table 4.21 Method of ANOVA for Water Absorption

| | |
|---|---|
| Null Hypothesis | All means are equal |
| Alternative Hypothesis | Not all means are equal |
| Significance Level | α = 0.05 |

Table 4.22 ANOVA of Rate of Water Absorption of 50P50RH

| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
|---|---|---|---|---|---|
| C1 | 4 | 142.0 | 35.51 | 2.79 | 0.054 |
| Error | 20 | 254.3 | 12.71 | | |
| Total | 24 | 396.3 | | | |

### 4.5.4 Water Absorption For 60P40RH

Figure 4.13 illustrate the average percentage rate of water absorption of each specimen of jute fiber polyester hybrid composite reinforced with rice husk with ratio of 60P40RH for 5 days, 10 days, 15 days, 20 days, 25 days . The average rate of water absorption of the composite during day 20 has the highest average value in term of water absorption which is 6.989% meanwhile day 5 has the lowest average percentage rate of water absorption which is 0.645%.

The one-way analysis of variance (ANOVA) was used to analyze the percentage rate of water absorption for ratio 60P40RH using Minitab application with condition as shown in Table 4.23 and Table 4.24 . The result from the ANOVA testing of water absorption test is significant since the P-Value is lower than the significant level where α = 0.05. It show that all of JFPHCRRH have different average. As a result, day 20 has the highest percentage water absorption properties as shown in Figure 4.13.

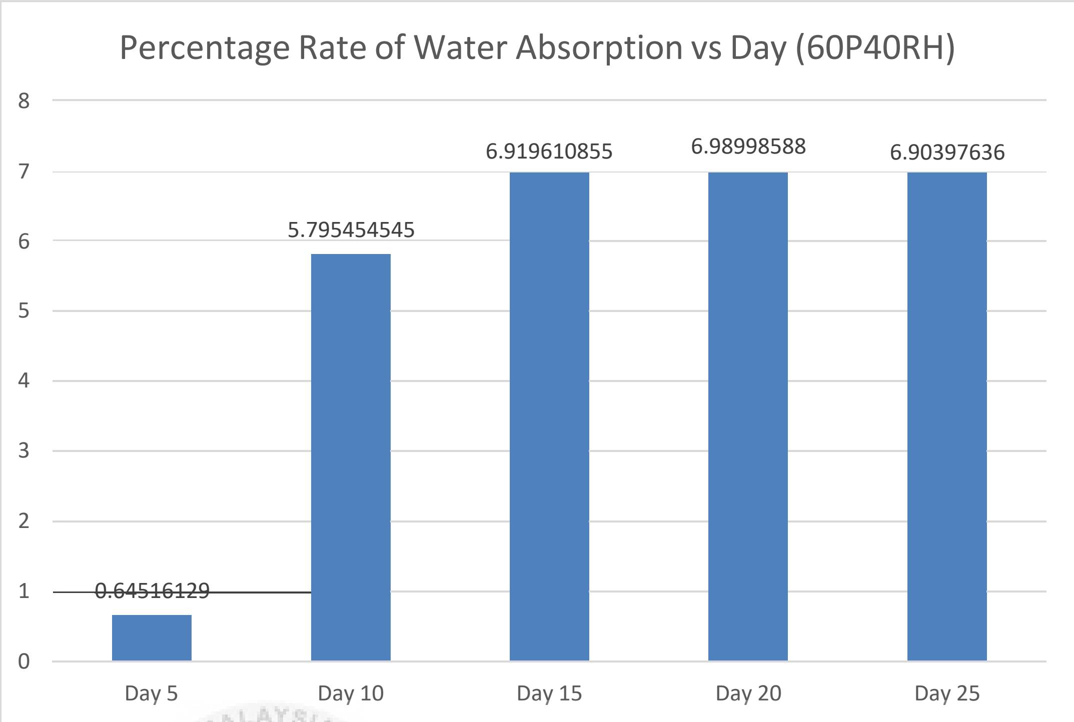



Figure 4.13 Graph of Percentage Rate of Water Absorption for 60P40RH

Table 4.23 Method of ANOVA for Water Absorption

| | |
|---|---|
| Null Hypothesis | All means are equal |
| Alternative Hypothesis | Not all means are equal |
| Significance Level | $\alpha = 0.05$ |

Table 4.24 ANOVA of Rate of Water Absorption of 60P40RH

| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
|---|---|---|---|---|---|
| C1 | 4 | 149.26 | 37.314 | 9.08 | 0.000 |
| Error | 20 | 82.21 | 4.110 | | |
| Total | 24 | 231.46 | | | |

### 4.5.5 Water Absorption For 80P20RH

Figure 4.14 illustrate the average percentage rate of water absorption of each specimen of jute fiber polyester hybrid composite reinforced with rice husk with ratio of 80P20RH for 5 days, 10 days, 15 days, 20 days, 25 days . The average rate of water absorption of the composite during day 25 has the highest average value in term of water absorption which is 4.143% meanwhile day 5 has the lowest average value of rate of water absorption which is 0.541%.

The one-way analysis of variance (ANOVA) was used to analyze the rate of water absorption of composite using Minitab application with condition as shown in Table 4.25 and Table 4.26. The result from the ANOVA testing of water absorption test is significant since the P-Value is lower than the significant level where $\alpha = 0.05$. It show that all of JFPHCRRH have different average. As a result, day 25 has the best rate of water absorption properties as shown in Figure 4.14.

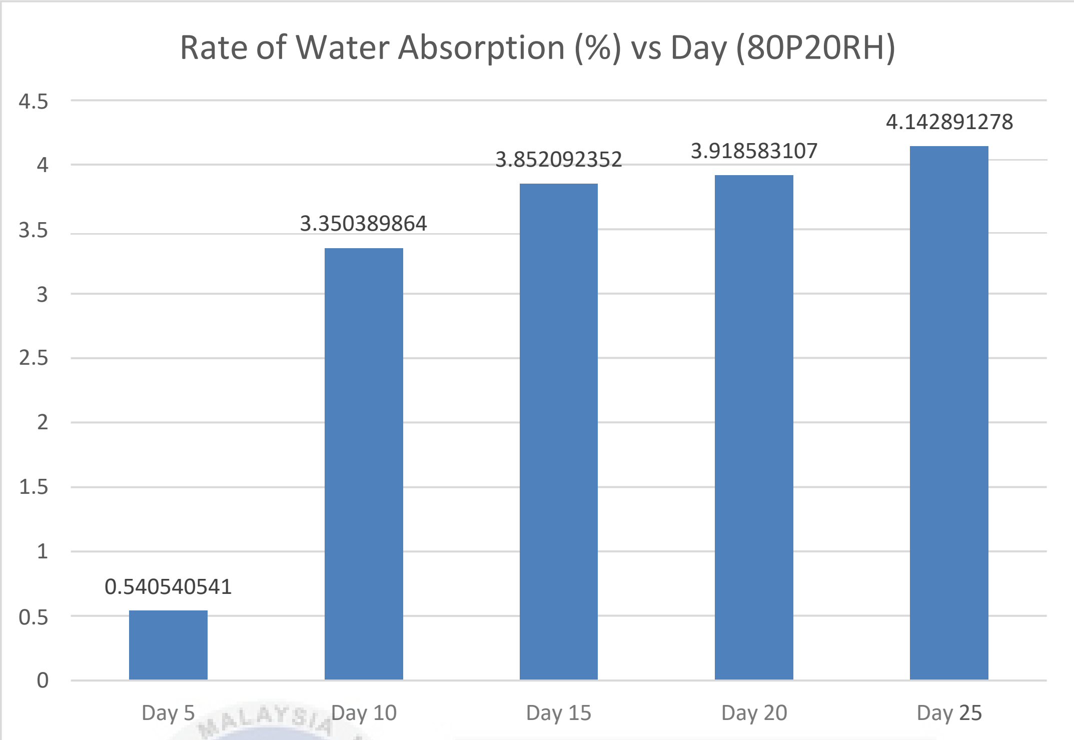



Figure 4.14 Rate of Water Absorption for 80P20RH vs Days

Table 4.25 Method of ANOVA for Rate of Water Absorption

| | |
|---|---|
| Null Hypothesis | All means are equal |
| Alternative Hypothesis | Not all means are equal |
| Significance Level | $\alpha = 0.05$ |

Table 4.26 ANOVA for Rate of Water Absorption of 80P20RH

| **Source** | **DF** | **Adj SS** | **Adj MS** | **F-Value** | **P-Value** |
|---|---|---|---|---|---|
| C1 | 4 | 44.59 | 11.148 | 8.65 | 0.000 |
| Error | 20 | 25.77 | 1.289 | | |
| Total | 24 | 70.37 | | | |

# CHAPTER 5
# RESULT

## 5.1 Conclusion

This project is successful if three objectives are achieved which are to fabricate the jute fiber polyester hybrid composite reinforced with rice husk conduct mechanical testing to identify mechanical properties of specimen by tensile test, flexural test impact test and water absorption test. There are five different ratios of polyester to rice husk which are 20% polyester to 80% rice husk, 40% polyester to 60% rice husk, 50% polyester to 50% rice husk, 60% polyester to 40% rice husk and 80% polyester to 20% rice husk. The specimen was fabricated using hand lay-up method. Every preparation to complete the fabrication process such as purchasing equipment, material and grinding of rice husk was prepared before proceed the fabrication process. Each of the mechanical testing of the JFPHCRRH are successful and the data achieved are recorded. The mechanical testing toward the specimen was conducted according to ASTM standard.



According to the result, it shows that the maximum tensile strength and strain of 80P20RH was the highest compared to other composite ratios which is maximum tensile strength upon reaching failure (20.71 MPa) and maximum strain upon reaching failure (3.737 % ). Comparatively, 20P80RH had the lowest value of maximum tensile strength upon reaching failure (9.983778 MPa) and maximum strain upon reaching failure (1.271 %). Based on the observation suggested that the tensile strength of the JFPHCRRH becomes stronger as the percentage of polyester increase proportionally to rice husk. Then, a one-wayanalysis of variance (ANOVA) was used using Minitab to analyze the tensile strength and maximum strain of the JFPHCRRH.

For the flexural testing, it shows that the maximum flexural strength of 80P20RH was the highest compared to other composite ratios which is maximum flexural strength upon reaching failure (73.158 MPa). Meanwhile, 20P80RH had the lowest value of maximum tensile strength (21.354 MPa) upon reaching failure. Based on the observation suggested that the flexural strength of the JFPHCRRH becomes stronger as the percentage ratio of polyester increase proportionally to rice husk. Then, a one-way analysis of variance (ANOVA) was used using Minitab to analyze the maximum flexural strength.

For the impact testing, it shows that the impact strength of 80P20RH was the highest compared to other composite ratios which is maximum impact strength upon reaching failure (0.866 J). Meanwhile, 20P80RH had the lowest value of maximum tensile strength (0.248 J) upon reaching failure. Based on the observation suggested that the flexural strength of the JFPHCRRH becomes stronger as the percentage ratio of polyester increase proportionally to rice husk. Then, a one-way analysis of variance (ANOVA) was used using Minitab to analyzethe maximum flexural strength.



For the water absorption testing, it shows 20P80RH ratio has the highest percentage rate of water absorption compared to other composite ratios where the percentage rate of water absorption is (9.421 %). Meanwhile, 80P20RH had the lowest percentage rate of water absorption (3.161 %). Based on the observation suggested that the percentage rate of water absorption of the JFPHCRRH becomes stronger as the percentage ratio of rice husk increase proportionally to polyester. Then, a one-way analysis of variance (ANOVA) was used Minitab to analyze the maximum flexural strength.

## 5.2 Recommendation

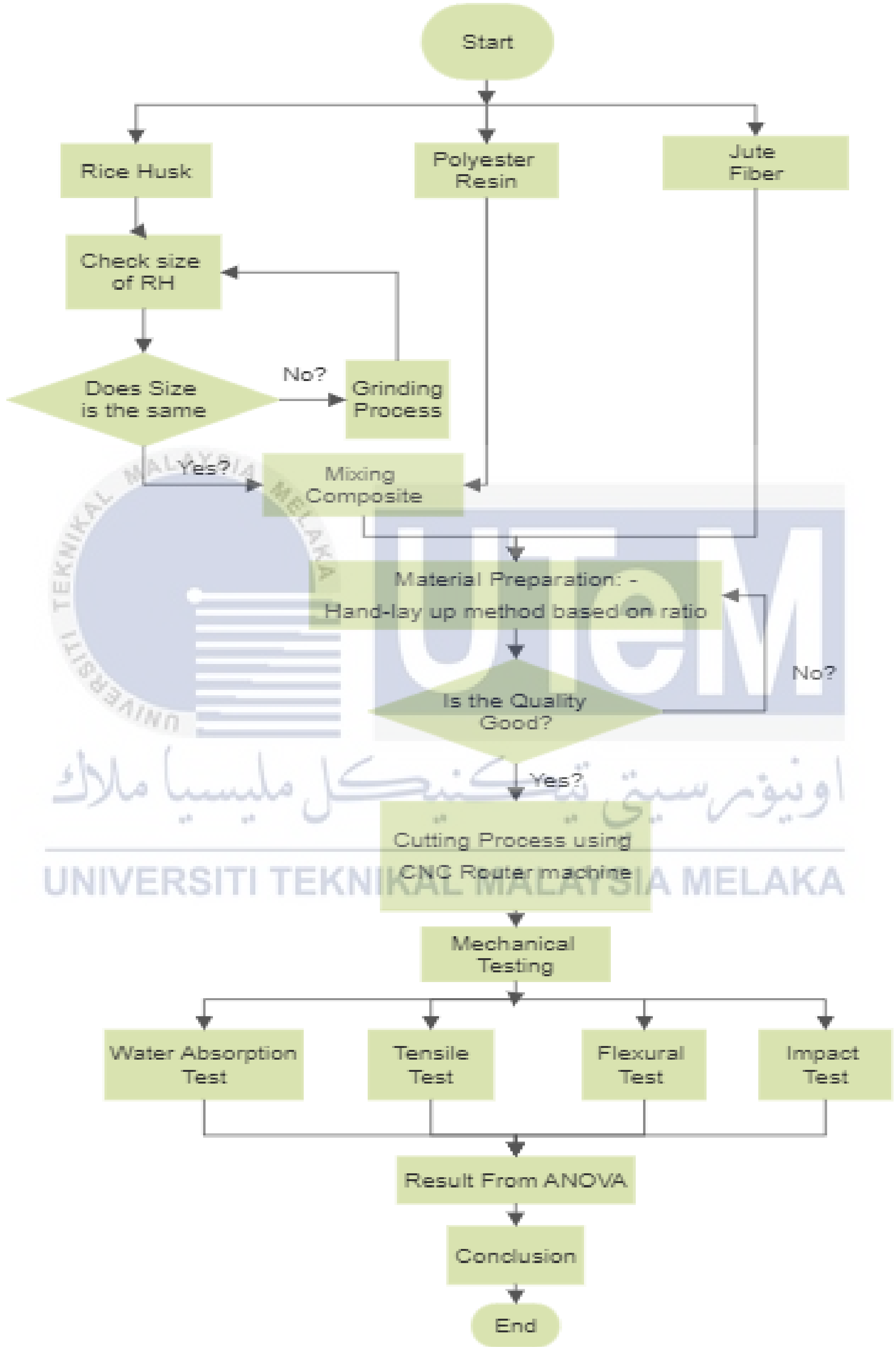
For upcoming research, it is a recommended for the specimen to had other mechanical testing such as compression test in order to investigate the mechanical properties of JFPHCRRH. To make sure the future outcome be more accurate, the water absorption testing need to be conducted in an incubator that able to set the temperature of surrounding so that the result received does not manipulated by the various value of temperature during the testing.

## 5.3 Potential of Project

The composite that produced able to be identify as a multipurpose material that can be used at different sector and environment such as building structural, panel, storage tank, interior tank and many more. Plus, the usage of natural composite can be used in variety part of industrial especially in automotive industries where the manufacturing of door panel, engine compartment and dashboard can be made with this material as an alternative. It due to the non-corrosion properties at damp or high humidity place with high impact strength test to withstand repeatable usage. Therefore, it can be concluded that the obtained result of JFHCRRH composite result may be a potential added value toward the industrial sector and make the usage of natural composite able to become beneficial toward the economy of the country.

# APPENDICES

APPENDIX A Specific Flow Chart of the Project



APPENDIX B Gantt Chart of PSM I

| Activities | Status | Week | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Supervisor and Title Registration | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Project Explanation and Briefing by Supervisor | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Defining Problem Statement, Objective and Project Scope | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Drafting and Writing Chapter 1 | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Material Preparation | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Defining and Finding Source for Literature Review | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Drafting and Writing Chapter 2 | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Defining Methodology on How to Conduct the Project | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Drafting and Writing Chapter 3 | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Revising Report Chapter 1,2 and 3 before Submission | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |

APPENDIX C Gantt Chart of PSM II

| Activities | Status | Week | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Grinding Process of Natural Fiber | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Fabrication Process Hand Lay-up method | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Cutting Specimen | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Water Absorption Testing | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Tensile and Flexural Testing | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Impact Testing | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Result Discussion with the Supervisor | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Report Writing and Submission | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |
| Poster Preparation and Presentation | Plan | | | | | | | | | | | | | | |
| | Actual | | | | | | | | | | | | | | |

APPENDIX D Turnitin Index

ORIGINALITY REPORT

| 19% | 14% | 8% | 9% |
|---|---|---|---|
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

PRIMARY SOURCES

| | | |
|---|---|---|
| 1 | Submitted to Universiti Teknikal Malaysia Melaka<br>Student Paper | 3% |
| 2 | umpir.ump.edu.my<br>Internet Source | 1% |
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| 4 | Submitted to iParadigms<br>Student Paper | 1% |
| 5 | www.researchgate.net<br>Internet Source | 1% |
| 6 | Submitted to Heriot-Watt University<br>Student Paper | 1% |
| 7 | garuda.kemdikbud.go.id<br>Internet Source | <1% |
| 8 | "Green Composites", Springer Science and Business Media LLC, 2019<br>Publication | <1% |
| 9 | link.springer.com | |

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