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Mechanical Properties of Glass Fiber Polyester Hybrid Composite Filled with Rice Husk

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DEDICATION

To my dear father, mother, siblings, and friends, who have always been there for me spiritually and emotionally.

Ts. Dr. Khairum Bin Hamzah, my supervisor, for mentoring, instructing, and assisting me in finishing my thesis.

ABSTRACT

Nowadays recycle of natural waste-based materials have been widely used in engineering and technology due to their considerable properties, and one of the waste-based material is rice husk. The mechanical properties of glass fiber polyester hybrid composite filled with rice husk are a very important and interesting area to discuss in detail. The objectives of this research are to fabricate a glass fiber polyester hybrid composite filled with rice husk, perform the fabricated materials into the testing specimen, and investigate the mechanical properties of the fabricated materials using tensile, flexural, and impact tests. This research will divide into four stages. The first stage is the fabrication of the materials by using the hand lay-up technique. The second stage is cutting the fabricated material into the testing specimen using the CNC router machine. The third stage is the testing of the mechanical properties of the specimen using tensile, flexural, impact and water absorption tests. The final stage is the analysis of the results using statistical analysis. Based on the analyzed results of the mechanical properties, we will be achieved the convenient ratio that suits the best result of glass fiber polyester hybrid composite filled with rice husk.

ABSTRAK

Pada masa kini kitar semula bahan berasaskan sisa semula jadi telah digunakan secara meluas dalam kejuruteraan dan teknologi kerana sifatnya yang besar, dan salah satu bahan berasaskan sisa ialah sekam padi. Ciri-ciri mekanikal komposit hibrid poliester gentian kaca yang diisi dengan sekam padi adalah kawasan yang sangat penting dan menarik untuk dibincangkan secara terperinci. Objektif penyelidikan ini adalah untuk menghasilkan komposit hibrid poliester gentian kaca yang diisi dengan sekam padi, melakukan bahan yang difabrikasi ke dalam spesimen ujian, dan menyiasat sifat mekanikal bahan yang direka menggunakan ujian tegangan, lentur dan hentaman. Penyelidikan ini akan dibahagikan kepada empat peringkat. Peringkat pertama ialah fabrikasi bahan dengan menggunakan teknik letak tangan. Peringkat kedua ialah memotong bahan fabrikasi ke dalam spesimen ujian menggunakan mesin penghala CNC. Peringkat ketiga ialah ujian sifat mekanikal spesimen menggunakan ujian tegangan, lentur, hentaman dan penyerapan air. Peringkat terakhir ialah analisis keputusan menggunakan analisis statistik. Berdasarkan hasil analisis sifat mekanikal, kita akan mencapai nisbah mudah yang sesuai dengan hasil terbaik komposit gentian kaca poliester hibrid yang diisi dengan sekam padi.

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My utmost appreciation goes to my main supervisor, Ts Dr. Khairum Bin Hamzah, who constantly supported my journey. My special thanks for all the help and support I received from him.

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LIST OF SYMBOLS AND ABBREVIATIONS

20RH80P	-	20% Rice Husk 80% Polyester
40RH60P	-	40% Rice Husk 60% Polyester
50RH50P	-	50% Rice Husk 50% Polyester
60RH40P	-	60% Rice Husk 40% Polyester
80RH20P	-	80% Rice Husk 20% Polyester
ANOVA	-	Analysis of Variance
ASTM	-	American Society for Testing and Materials
CAD	-	Computer Aided Design
CNC	-	Computer Numerical Control
NC	-	Numerical Control
P	-	Polyester
RH	-	Rice Husk
RHP	-	Rice Husk Polyester

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CHAPTER 1

INTRODUCTION

1.1 Research Background

In this day and age, usage of natural wastes material has been globally used in engineering and technology due to their worthwhile properties. In the direction of breaking through and reducing costs,the volume and number usability of application have propagated. The natural fibre waste element such rice husk, rice straw, wood dust, pineapple leaf, coconut leaf, sugarcane bagasse, eggshell, coconut pulp, coconut coir and banana peel are the elements that can be applied. The natural waste material were used in this analysis is rice husk. The existance of the mechanical properties of glass fiber polyester hybrid composites with rice husk are very significant and appealing component to deliberate. The natural fiber-based composite materials' sustainability has increased their use in a variety of manufacturing industries.

Composite materials have seized the absorption over the years because of their good candidate materials for modern industrial applications. Composite materials are very excellent in terms of mechanical properties such as good specific strength, low density, biodegradability and renewability. The composite materials involve a combination of two materials with different physical and chemical properties to enhance the strongness and durability of the materials. With addition of natural fiber in the component, it will build non-toxicity, high performance, easy processing at low cost and versatility. Moreover, the implementation of natural fiber composite can reduce abrasiveness and makes processing and recycle easier. Due to their thermoplastic characteristics, some plant proteins are attractive renewable materials.

An agricultural substance called rice husk can be employed in hybrid composites as a natural fibre. A good source of cellulose and lignin, the two components that make up plant fibres and are important for the mechanical properties of composites, may be found in rice husk. Because of its availability, affordability, and ability to be recycled, it is a material that holds promise for composite applications. Rice husk fibres can lower the weight of hybrid composites while also enhancing their strength and stiffness when employed as reinforcement. Other benefits of using rice husk as a filler material in composites include improved wear resistance, improved heat and flame resistance, and improved dimensional stability. It is a potential field of research to use rice husk as a natural fiber in hybrid composites since it has a number of benefits. Rice husk-based composites may replace conventional synthetic composites in a variety of industrial applications with additional development and optimisation.

The analysis's goal is to find out what kind of reinforcement rice husk fibres have as compared to glass fibres and polyester resin in a hybrid composite material. Moreover, the objective of the analysis is to look forward at the influence of changing the proportion of rice husk fibres in composite material and the impact of surface treatment on the bonding of rice husk fibres to the polymer structure. Other than that, in order to provide an environmentally friendly and economically viable substitute for conventional synthetic composite materials, the investigation also sought to ascertain the ideal circumstances for using rice husk as a natural fibre reinforcement in hybrid composites.

1.2 Problem Statement

The use of conventional synthetic composites in a variety of applications has raised environmental concerns due to their non-biodegradable nature, the use of conventional synthetic composites in a variety of applications has raised environmental concerns. Natural composites are being developed as an alternative, eco-friendly material as a result of this increased interest. However, compared to synthetic composites, natural composites frequently have lower mechanical properties, which restricts the range of uses for which they can be used. In order to increase the usage of natural composites in industrial applications, it is necessary to research and improve their mechanical qualities.

The use of rice husk fibres as a natural reinforcement in hybrid composites offers the potential to lessen the reliance on synthetic composites and offer a practical, cost-effective alternative. Although the rice husks have some benefits that give goods to environmental and industries, there are still difficulties to be resolved with regards to enhancing the composite material's composition, treating the fibres' surfaces, and comprehending the mechanical performance of the resulting hybrid composites. The goal of this study is to determine whether it is feasible to use rice husk as a natural reinforcement in hybrid composites and to improve the composition and processing methods to achieve improved mechanical performance while preserving affordability and environmental friendliness.

1.3 Research Objective

The main objective of the research is to investigate the mechanical properties of a glass fibre polyester composite filled with rice husk. The following are the specific objectives :

a) To fabricate a glass fiber polyester hybrid composite filled with rice husk.

b) To testing whether adding rice husk fibres could improve the mechanical properties of the composite material, especially in terms of tensile strength, flexural strength, impact resistance and water absorption test.

c) To analyse the effect of improving the composite material which is rice husk fibre component and the effectiveness of surface enhancement on the fibres' attachment to the matrix of polymers.

1.4 Scope of Research

The scopes of this research are to inspect the mechanical properties of glass fiber polyester hybrid composite filled with rice husk. This research will be divided into four phases. First phase of the process is applying the hand lay-up technique. The process will proceed to the second step which is cutting the fabricated material into desired testing specimen size using CNC router machine. Thirdly, the process is continued by testing the mechanical properties of the specimen using tensile test that follow standard ASTM D3039, flexural test that follow standard ASTM D790, impact test that follow standard ASTM D 6110, and water absorption test that follow standard ASTM D570. This third process is very important to accomplish the best result and could make comparisons with previous research. Last but not least,the last step is analyse the results obtained using statistical analysis. After all the processes is done, we will obtain the splendid ratio of glass fiber hybrid composite filled with rice husk based on the analysis mechanical properties result.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will go into detail on a review that indicate the theory or fundamentals behind a number of challenges, as well as known or modern research on rice husks. Furthermore, the process and specifications of a composite material based on rice husk will be given out. This study investigated the effects of flaws on natural wastes produced by various procedures. Aside from that, this chapter will determine mechanical properties and traditional American Society for tests and Materials (ASTM) tests.

2.2 Agriculture Waste

Balance wastage from huge scorch enterprises are receiving consideration in alternating nations for their potential application in the development of continual materials. Natural fibers are economically significant as agricultural residual wastes since they are used in building materials all over the world. Natural fibres' capability to reduce the amount of basic ingredients in various composite materials is now recognised as a sustainable step towards ecologically friendly products (Ahmed and Ali, 2020). Agricultural wastes are made from a variety of materials, including grape pomace, tomato pomace, pineapple, orange, and lemon peels, sugarcane bagasse, rice husks, wheat straw, and palm oil fibres, among others. Environmentalists have advocated for the adoption of a new manufacturing model that assures that today's useful goods generate assets and materials for the advancement of tomorrow's goods (Maraveas, 2020).

In terms of processing and utilising agricultural waste, developed countries are normally ahead of underdeveloped countries . At the same time, developing nations are focusing heavily on the proper disposal of agricultural waste (He, Kawasaki, and Achal, 2020). Moreover, agronomic is one of the main organic districts, producing the most biomass, which can be used in the bioeconomy (Koul, Yakoob, and Shah, 2022). Agriculture produces a large quantity of biomass waste, including animal manure, leftover plant materials from crops, unsold products that are not suitable for sale, waste from crop fields, waste from fruit and vegetable processing industries, and waste from olive, grape, and milk processing industries (De Corato, 2020).

2.2.1 Properties of biocomposites

Biocomposites have been used in a variety of ways nowadays. Biocomposites are materials made up of two or more separate ingredient materials, one of which is organically produced. This combination leads to the development of a new material that is more efficient than using each individual material separately (Ilyas et al., 2022). Natural fibres have been widely used in the production of biocomposite materials for use in building and construction, as well as diversions, vehicle, along with airship elementals. The principal impure materials used in particleboard manufacturing include manufactory excess acting as sawdust, planer shavings and chips, and a variety of agricultural leftovers such as wheat straw, rice husks, jute, and cotton stalk (Amiandamhen, Meincken, and Tyhoda, 2020). The physical and mechanical complexion of these natural fibers, such as economical, low density, high precise hardiness and firmness, purification tractability, ecological, and non-toxicity, make them an easy substitute for counterfeit fibers (Tavares et al., 2020).

2.3 Work Material

Work materials are the materials, tools, equipment, parts, machinery, apparatus, supplies, and utilities needed to complete the work. In this project, we presented many materials and procedures in order to achieve the best results.

2.4 Rice husk

The rice husk, a milling by-product, is the exterior coat of the rice, accounting for 20% of the total paddy produced. By reason of its ampleness, divisional connection, fragment framework, cheap, insolubility in water, high chemical stability, and mechanical strength, RH was chosen as a suitable biosorbent (Shamsollahi and Partovinia, 2019). Due to its large silica content, RH is recognised as an penny-pinching advantageous impure physical for the prolongation of silicates and silica products (Azat et al., 2019). RH is composed of 70-80% anatomic chemicals alike dextrin, botany, and others, with the remaining 20-30% consisting of miner-alogical components such as silica, alkalis, and trace elements (Hossain, Mathur, and Roy, 2018).

In Malaysia, RH is a natural fiber that have the most production rate by product of rice production. It is because according to data gathered by the Malaysian Ministry of Agriculture, manufactory and accumulation procedures produced around 0.48 million tonnes of RH in Malaysia (Low et al., 2021). With the usage of RH in many applications such as engineering and other because of the charateristics itself, the inclusion of RH to the eco-composite structure reduced the flammability heat release rates by roughly 39%, which can be attributed to the presence of silica in RH. Furthermore, the breakdown rate values for RH reinforced polymer were relocated to a higher temperature, demonstrating that the biocomposite had better thermal stability than recovered polymer (Haziatul et al., 2021).

2.4.1 Rice husk properties

The use of RH as a natural fiber developing substantial in natural fibre reinforced polymer composites has been proposed.. Researchers have conducted numerous tests and attempts to get the optimal distribution of RH in bio epoxy resin for the production of RH and straw fiber-reinforced hybrid composites with improved mechanical properties. As a broad understanding of RH's functions, it should be noted that it is causting in nature, low density, hard, and weather resistant. It is employed in the production of bricks, panels, decks, window and door frames, as a fuel, and as a filler in building and insulation materials (Ghalme, 2021). The usage of RH as a filler natural fiber in hybrid composite plays a role which comes to optimization in tensile strength. It is prove by tensile strength of 0.05-0.5 MPa was recorded in PLA composites, and the addition of 4 wt.% and 6 wt.% raw RH fibre boosted tensile strength by 95% and 43%, respectively (Yiga et al., 2021).

2.5 Rice husk ash

Rice husk ash (RHA) is an excellent ancillary cementitious material for concrete production since it takes less vitality, produces little greenhouse gas throughout processing and service life, and has a strong pozzolanic reactivity. By cause all of these elements are related to the dissolution of silica from RHA, the pozzolanic reactivity of RHA is affected by its nebulous silica concentration, high quality, mix percentage, accessible alkaline media, and temperature. RHA in concrete gives increased strength and durability features, lower material costs as a result of cement savings, and concomitant gains connected to waste management (Siddika et al., 2021). Many countries, particularly developing countries such as Vietnam, China, Indonesia, and India, have an abundance of RHA.

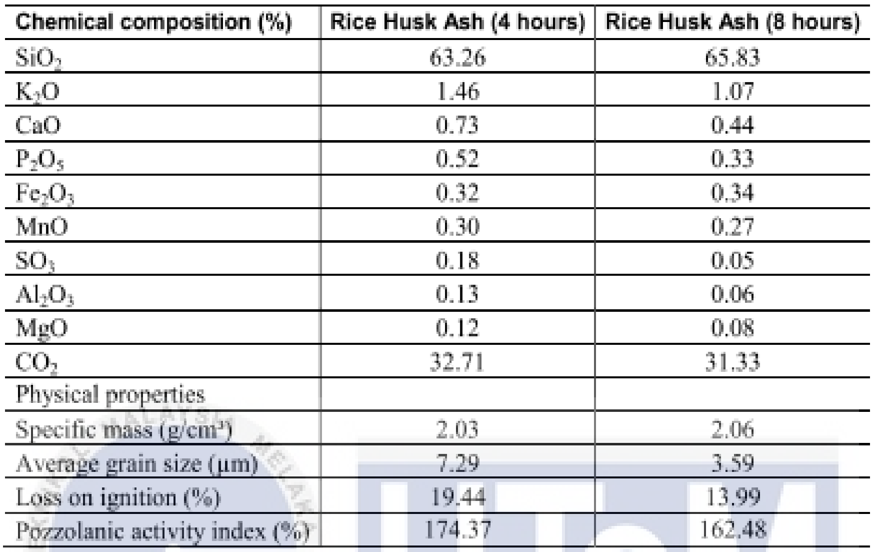
RHA is an outgrowth generated by burning RH, which are the outer shells of rice grains. With global rice production expected to reach approximately 500 million tonnes annually, more than 100 million tonnes of RH are generated each year as a consequence (Nguyen et al., 2020). Furthermore, instead of being discarded, RHs are often burned directly for heating purposes. In the past two decades, RH has gained importance as a significant biomass resource due to global energy concerns, climate change, and environmental deterioration. These husks are compacted into blocks and then converted into clean energy, such as electricity or heat, through methods like combustion, pyrolysis, gasification, and other similar processes (Chen et al., 2021). Figure 1 shows the production of RHA and waste disposal and stacking of RHA.

Figure 2.1 shows the production of RHA and waste disposal and stacking of RHA (Chen et al., 2021)

2.5.1 Rice husk properties

During the agitate of rice grains, raw RHA is commonly employed as a heat source. When RH is charred in heating system, it rapidly generates ash that is essentially black or dark grey in color. In this study, the ash was crushed for a duration of four to eight hours using a ball mill with dimensions of 310 mm in length and 275 mm in diameter. This process resulted in the production of 75 mm balls with a diameter of 38 mm. Table 2.1 provides information on the chemical composition and physical characteristics of the RHAs utilized in this research (Righi et al., 2017).

Table 2.1 shows the chemical and physical properties of RHA (Righi et al., 2017)



Chemical composition (%)	Rice Husk Ash (4 hours)	Rice Husk Ash (8 hours)
SiO_2	63.26	65.83
K_2O	1.46	1.07
CaO	0.73	0.44
P_2O_5	0.52	0.33
Fe_2O_3	0.32	0.34
MnO	0.30	0.27
SO_3	0.18	0.05
Al_2O_3	0.13	0.06
MgO	0.12	0.08
CO_2	32.71	31.33
Physical properties		
Specific mass (g/cm^3)	2.03	2.06
Average grain size (μm)	7.29	3.59
Loss on ignition (%)	19.44	13.99
Pozzolanic activity index (%)	174.37	162.48

When RHA is burned in an open fire, the outer layer of the ash mound undergoes open burning in the atmosphere, resulting in the formation of black carbonized ash known as Black RHA. On the other hand, the inner layer of the mound experiences higher temperatures, leading to the oxidation of the carbonized ash and the formation of white ash primarily composed of silica, referred to as White RHA (Moayedi et al., 2019). RHA is a unique type of ash with high silicon content that offers significant potential in various applications. RHA consists mainly of amorphous SiO2, and its non-compact agglomeration, aided by SiO2 gel particles, results in the formation of numerous nanoscale pores. This characteristic gives RHA a large specific surface area and exceptional pozzolanic activity. Consequently, RHA has the capability to enhance self-compactness, reduce shrinkage and permeability, and improve the resistance of concrete against chloride penetration and carbonation (Zhu et al., 2019). Using RHA in the concrete industry will not only provide a chance to reduce nS consumption, but will also assist reduce the pollution concerns caused by RHA disposal in landfill, particularly in rice-producing countries like Thailand, India, and other Asian countries (Nuaklong et al., 2020).

2.6 Hand lay-up method

Composite structure manufacturers have traditionally used prepreg to build structural components. The fibrous sheets are coated or soaked in partially dry resin. Figure 2.2 demonstrates the use of a controlled prepreg technique that involves coating technology and a roller to apply a consistent amount of uncured resin onto the substrate (Mahmoud Zaghloul, Yousry Zaghloul, and Yousry Zaghloul, 2021).

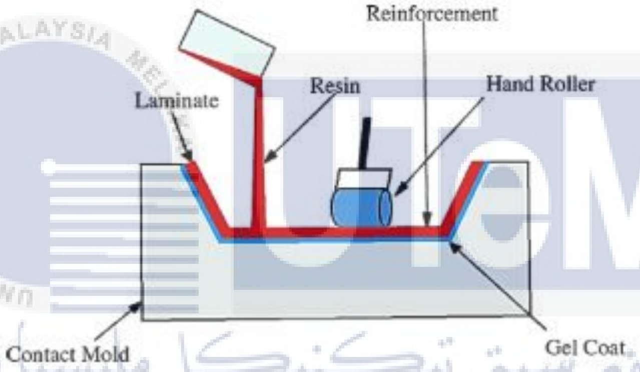


Figure 2.2 shows the schematic diagram of hand lay-up (Mahmoud Zaghloul, Yousry Zaghloul, and Yousry Zaghloul, 2021)

Hand-bringing fibres onto a mould and brushing the resin (Epoxy is one of the most prevalent) is conceivable. Beachcombers improve the density of the gathered layers, and accelerators and catalysts are frequently used (Karthik et al., 2020). Composite structure manufacturers have traditionally used prepreg to build structural components. The coarse foils are concealed or saturated in semi-dry adhesive. A contained prepreg is used with laminating machinery and a roller to utilize a constant quantity the application of uncured resin to the substrate. The resin contains the hardener and the basic matrix. Using film backing paper, the two remarks of the sheets are coated to avoid cross-linking and adhering. The sheets must be stored at moderate temperatures to prevent the resin matrix from becoming hard or cross-linked at relatively high temperatures (Mahmoud Zaghloul, Yousry Zaghloul, and Yousry Zaghloul, 2021).

2.7 Cutting Process Machine

A CNC router machine will be used as a cutting procedure in this project. Specimens must be sliced within a specific size range, with specific characteristics, and at the right tool vision speed. The measurement of each specimens that want to cut must have a precise measurement to ensure the samples are enough by each processes that will be tested for this project.

2.7.1 CNC Router Machine

Numerical control (NC), also referred to as computer numerical control (CNC), is the process of automatically controlling machining gears like drills, boring tools, and lathes using a computer. A NC machine is capable of transforming raw materials such as metal, plastic, wood, ceramic, or composite into precise shapes according to programmed instructions, without the need for manual operation. NC machines utilize a computer-controlled system to operate a movable tool, and sometimes a movable platform as well. These machines respond to specific input instructions given by a computer core. The instructions are typically in the form of graphical computer-aided design CAD files, which are translated into a step-by-step program of machine control instructions and then carried out (Prashil et al., 2019).

2.8 Mechanical Testing

Mechanical behaviour refers to the physical characteristics that a material exhibits when forces are applied to it. Mechanical qualities include modulus of elasticity, tensile strength, elongation, hardness, and exhaustion bound. Traditional mechanical testing arrangements, developed and utilised first for non-organic materials, necessitate the preparation of specimens of a specific geometry optimized to allow for uniform malformation states throughout testing. This is plainly not conceivable until the substance is removed from its native habitat and its biological functionality is destroyed (Budday et al., 2020).

2.8.1 Tensile Testing

In the tensile test process, loads are applied either manually using a screwdriver or hydraulically using pressurized oil in Universal Testing Machines. Using a Universal Tensile testing equipment offers the advantage of gradually deforming the material over time in response to the applied force. Because of their larger load capacity and lower cost, hydraulic systems are often preferred. Tensile, compressive, flexural, and banding tests can all be performed on the Universal tensile machine. Specimens were created in accordance with the ASTM D638 standards for testing in both techniques (Ram, Kumar, and Kumar, 2020). The tensile characteristics of composites can help us understand the deformation behaviour as well as the mechanisms of strengthening and load transfer in composites (Jagannatham et al., 2020). A static tensile test was performed on the samples to assess the elastic properties of the material (Stanciu, Drăghicescu, and Roșca, 2021).

2.8.2 Flexural Testing

The flexural test is performed to measure the strength of the composite material when subjected to bending. For this test, a simple supported 330 Material Engineering and Application II loading test was conducted using the ASTM D790 standard and Universal

Tensile Testing equipment. The stress was gradually applied over a period of time, and the outcomes were documented (Ram, Kumar, and Kumar, 2020). Four-point flexural tests were conducted to evaluate various aspects including strength, load-deflection curve, peak deflection, flexural toughness, and residual strength (Liu et al., 2020). T0 is the time it takes for the stress wave to travel from the impact location through half the beam and return to the loading point. If the duration of the flexural test (Tb) is longer than T0, the loading stress can fully reach the supports of the beam. In this case, each support response is equal to half of the loading tension (Feng et al., 2019). Flexural tests were carried out using an MTS Insight 5 electromechanical loading frame. The crosshead moved at a rate of 1.5 mm/min (Yu et al., 2019). The composite specimens were subjected to a flexural test using a universal testing machine (Shimadzu Corp, Kyoto, Japan) equipped with a 5 KN load cell and a crosshead speed of 0.5 mm/min (Eweis, Yap, and Yahya, 2020).

2.8.3 Impact Testing

The impact strength test is a practical approach that provides an accurate estimate of the material's strength and resistance to breaking under high-speed stress (Karim et al., 2019). It is critical to emphasize that the drop weight impact test is overly simple, as there is no need for vibration, displacement data, or time history. The drop weight impact test simply requires the first crack and failure impact figures to be recorded (Murali et al., 2021). The intention of the impact test is to increase load carrying capacity, structural rigidity, and impact resistance (Zhang et al., 2021). Impact tests are regarded quasi-static qualities, whereas creep, fatigue, and fracture formation are considered dynamic (Kabir, Mathur, and Seyam, 2020).

2.8.4 Water Absorption Testing

The movement of water and fluidify chloride ions through unimmersed concrete depends on the water content in the concrete pores. This is closely linked to the deportation response seen during water absorption tests, and that occurs due to the apparent rigidity of artery outlets (Bao et al., 2020). The humidity penetration process involves three mechanisms: firstly, water molecules enter the mini chasms within the chains; secondly, the water continues to spread further inside the chains through capillary transport; and finally, the fibers swell as a result of micro cracks. The domination of humidity penetration qualities on natural fibre reinforced composites has frequently become an unsettling signal to the majority of natural fibre consumers. Actually, this absorption greatly reduces the adhesion force between the fibre and matrix. As a result, depending on the absorption duration or type, it weakens the durability of the composite in an acceptable manner. It also leads to inadequate stress transfer, which eventually results in specimen fracture over time. The majority of the investigations are entirely focused on the moisture absorption characteristics of composites at various temperatures and fibre surface treatments (Srinivasan et al., 2021).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter comes up with detailed information or detains that were used to locate, choose, and evaluate the information in this subject. In this chapter,which is methodology part, the reader is given an opportunity to analyse the entire procedure and solidity used by researchers to accomplish the work objective. There will be provide three stages in this research. First stage that we will include for this research is to fabricate of experiment material by using hand lay-up process, which will divided into five different ratios based on volume. The ratios are 10% of rice husk and 90% polyester (10RH90P), 40% of rice husk and 60% of polyester (40RH60P), 50% of rice husk and 50% of polyester (50RH50P), 70% of rice husk and 30% of polyester (70RH30P) and 80% of rice husk and 20% of polyester (80RH20P). Next, the second stage is cutting the finished material into experiment specimen using a CNC router machine. The standard size of the specimen will conferring with ASTM D3039 for tensile testing, ASTM D6110 for impact testing, ASTM D790 for flexural testing and ASTM D570 for water absorption testing. The last stage of this research is the analysis of the experiment material using statistical analysis. This chapter will provide a general summary of the experiment and technique to obtain an optimal outcomes.

3.2 Process Flowchart

The flowchart figure narrate a procedure where the process has been accomplished stage by stage. Flowcharts are illustrations or diagrams that describe the sequence of actions or activities in a process where it uses any kind of symbol to illustrate the information. Figure 3.1 shows the flow of the process from the beginning until the end of the process.

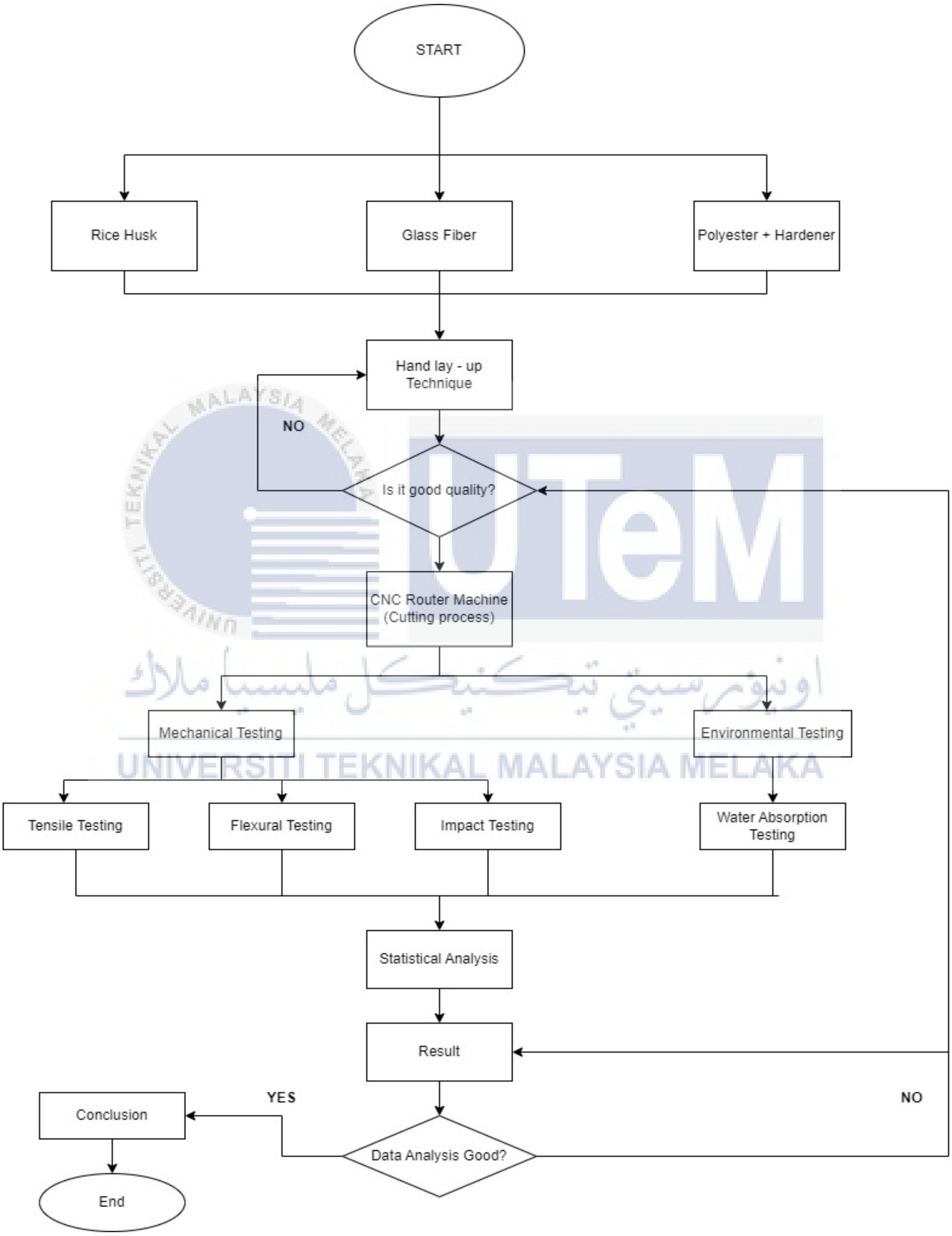


Figure 3.1 shows the flowchart starting from the combination of three elements, processes for obtaining mold and two types of testing to achieve data results.

3.3 Fabrication process

In this project,unblended RH will be blended into powder using blender to achieve the particular size of the material. Figure 3.2 shows the blending process of RH.

Figure 3.2 shows the raw rice husk was blended using blending machine to obtain rice husk ashes.

The second step for fabrication process is a roll of woven fiberglass will cut based on measurement that have been measured follow by the size of the mold. The size of mold is 31.2 cm x 21.2 cm x 2 cm, and each of woven fiberglass pieces have excess measurement in length and width which is 32 cm x 22 cm to maximize the base of mold. Figure 3.3 shows the measuring and cutting process of woven fiberglass.

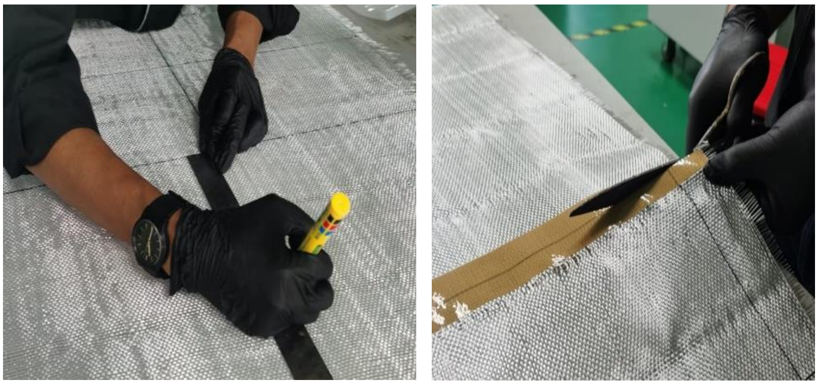


Figure 3.3 describes the fibreglass was measured and cut based on mold size before proceed to the next process.

Next, the second process is blended RH will be mixed with polyester resin with hardener based on ratio that we have set which is 20RH80P using manual process which is mixing and pouring process. Before mixing process, the polyester and blended RH will be weight on digital scaler to obtain precise weight. Figure 3.4 shows the weighing process.

Figure 3.4 displays the polyester was weighed using digital scaler based on measurement that being calculated before fabricating process.

The fourth process which is hand lay-up process will be proceed with layering the base into the rubber mold with woven fiberglass and the mix of polyester and blended RH will pour into rubber mold. Figure 3.5 shows the mixing process being held. Then,we should let the mixing dry for 24 hours for drying process based on result shown in Figure 3.6.

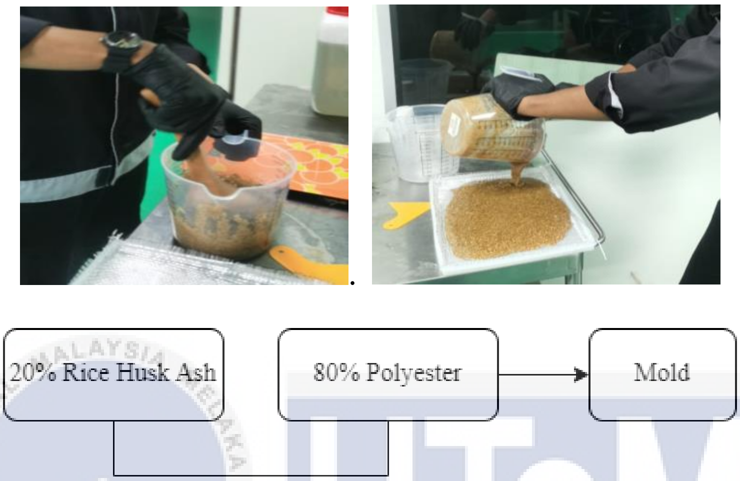


Figure 3.5 describes the mixing of polyester and rice husk ash was poured to the plastic mould based on ratio to obtain mold.

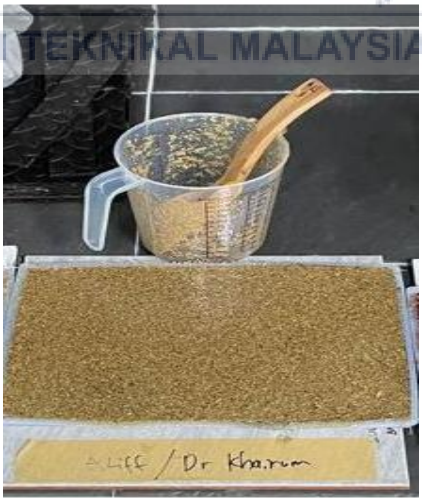


Figure 3.6 shows the mold was allowed to dry for 24 hours to achieve solid mixed mold.

The fabricated composite for tensile, flexural, impact and water absorption testing will fabricate in only one size of mold for 10 samples per ratio. The fabricated composite for tensile and flexural samples will be made in a single mould with dimensions of 312 mm width x 212 mm length x 10 mm thick for a total of 10 samples per ratio. This is done to cut down on production time and waste. The impact sample will be performed in a mould with dimensions of 312 mm width, 212 mm length, and 10 mm thickness for 5 samples per ratio. This is because to reduce cost and waste.

3.4 CNC Router Machine Process

For mechanical testing samples, a CNC router machine will be used to cut the specimen to a precise size. I need to provide 5 samples per ratio for each mechanical test, for a total of 75 samples. The sample size for the tensile and flexural testing is 250mm x 25 mm per sample, whereas the sample size for the impact test is 60 mm x 15 mm. The CNC router machine's spindle speeds will be set at 100rpm, 200rpm, and 300rpm, and the cutting tool diameter will be 3mm. The material test should then be placed over the vice to secure it. The computer control panel must be properly positioned, and the coordinate axis must be set to zero. Once the coordinates are in the proper place, start the machine by clicking the "output" button on the control panel.

3.5 Tensile Testing

The produced composite samples with dimensions of 250 mmx 25 mm will be tensile tested utilising an ASTM D3039 universal testing equipment with a load cell range of 100 kN. Insert all sample data, such as material thickness, length, and material kinds into a software programme for tensile testing. Place the samples in the lower and upper clamps in their proper positions to avoid material fracture in the grasped area. Run the programme, and the results will be displayed in stress-strain curves.

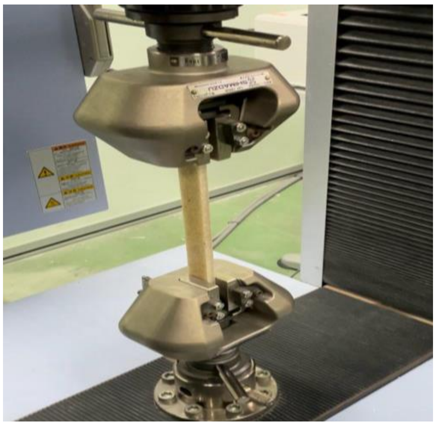


Figure 3.7 shows the specimen was being tested in tensile testing using universal testing machine and followed by all ratios to obtain results.

3.6 Flexural Testing

The produced composite samples of size 250 mm x 25 mm will also be subjected to flexural testing utilising an ASTM D790 universal testing equipment. The programme under flexural test (three-point bending) will be chosen and all of the sample data was required. The crosshead speed was set to 50 mm and 1.25 mm/min for the support span, respectively. The flexural property of the samples was measured by taking the average of five samples.

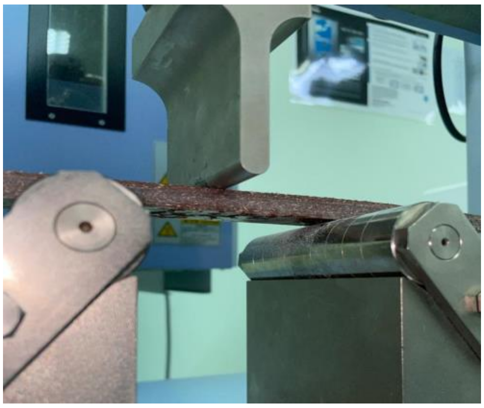


Figure 3.8 shows the specimen was tested using universal testing machine and followed by all ratios to obtain results.

3.7 Impact testing

The Charpy impact test will be used in line with the ASTM D6110 standard to analyse the toughness of the materials and strength at the yield point. To determine the notch toughness of the test material, a V notch will be made to the body of the samples. The average values will then be calculated using data from all fifteen samples.

Figure 3.9 shows the specimen was tested using Instron Impact Machine to obtain results and followed by all ratios.

3.8 Water Absorption Testing

The water absorption testing will be used in line with the ASTM D570 which is the impact of moisture absorption properties on natural fibre reinforced composites has frequently been an alarming signal for the majority of natural fibre customers.

Figure 3.10 shows the immersion of specimens followed by ratios and weight the soaked specimens using digital scale.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter will go over all of the results obtained from producing the sample, as well as the outcomes for each test run in the hopes of obtaining a positive result. The findings of several tests that were conducted, as well as the computation that was used, will be analysed and explained in this chapter. To assess the RHP composite, three separate testing methods will be implemented which are impact, tensile, and flexural testing. In all testing processes, the specimen size is typically determined by following the ASTM standard.

4.2 Tensile Test Result

In this study, RH and polyester were combined to create composites. All marketplaces have commercially available polyester and RH. The specimen will undergo a tensile test to determine its tensile strength and elasticity in order to evaluate the mechanical qualities of the experiment. The tensile strength and elasticity values for each RHP ratio are shown in Figures 4.1 and 4.2. It was found that the tensile strength and elasticity of the 20RH80P composite ratio were higher than those of the other RHP composite ratios. On the other hand, 80RH20P had the lowest values for elasticity and tensile strength. Based on this finding, it was concluded that the tensile strength and elasticity values of RHP composites rise when the percentage of RH increases to 20%. The specimen's final results following tensile testing are displayed in Figure 4.3 which is the specimens followed by ratios are broken. Table 4.1

shows the settings for the mechanical and physical tests that were performed based on the literature review.

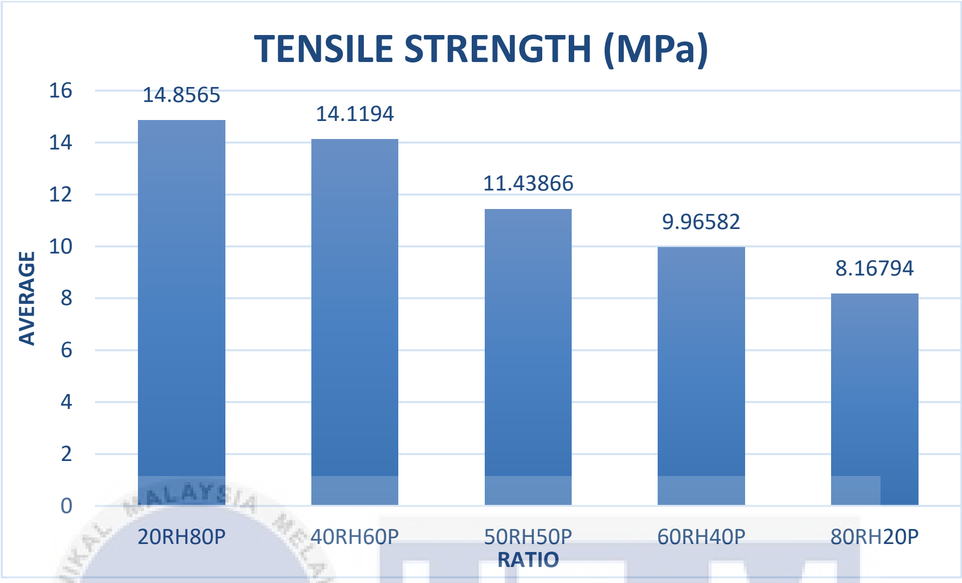


Figure 4.1 describes the tensile strength for five ratios of RHP composites from the highest to the lowest values of average.

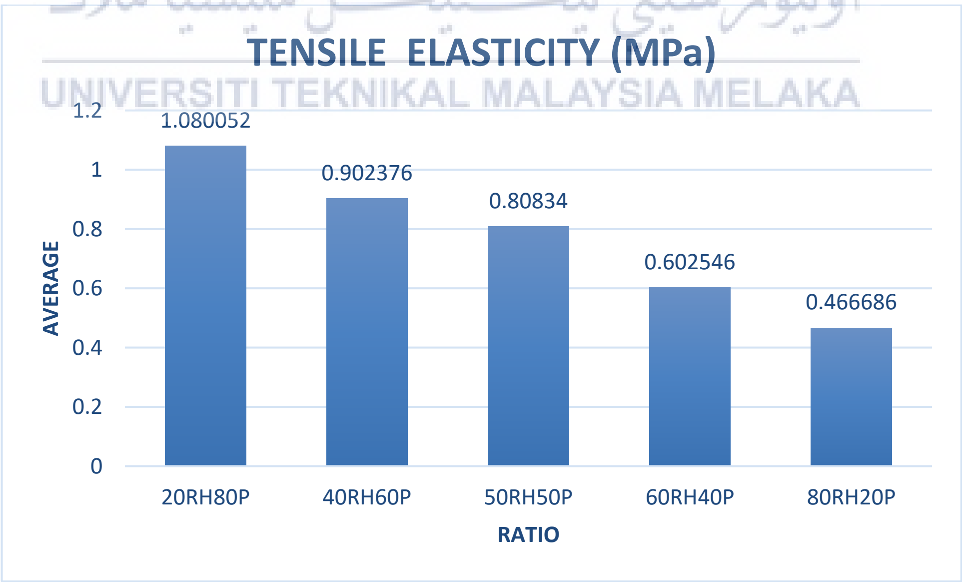


Figure 4.2 describes the tensile elasticity for five ratios of RHP composites from the highest to the lowest values of average.

Figure 4.3 displays the specimen results after tensile testing that shows as the specimens are broken in half.

The tensile strength and elasticity of the RHP composites were next examined using a one-way ANOVA, as indicated in Tables 4.1 and 4.2, respectively. The findings demonstrated that the tensile strength and elasticity of the RHP composites for each of the five ratios remained significant as the P-value was less than the significant cut-off threshold, which is $\alpha = 0.05$. As a result, it showed that the tensile strength and elasticity averages for the five RHP composite ratios varied. Thus, the optimum tensile performance is obtained by mixing polyester resin with rice husk in amounts of 20% and 80%, respectively.

Table 4.1 shows the summary of tensile strength for five ratios of RHP composites that contain sum, average and variance.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
20RH80P	5	74.2827	14.85654	0.441781
40RH60P	5	70.5971	14.11942	0.105661
50RH50P	5	57.1933	11.43866	0.171031
60RH40P	5	49.8291	9.96582	0.376732
80RH20P	5	40.8397	8.16794	0.129514

Table 4.2 describes ANOVA of tensile strength for five ratios of RHP composites to obtain *MS* value in row of within groups to show if it is significant or insignificant.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Ratios	156.84	4	39.21	160.0776	6.95E-15	2.866081
Within Groups	4.898875	20	0.244944			
Total	161.7389	24				

To identify means that are significantly distinct from one another, Tukey's test must be run because the P-value was less than the significant cut-off level of α = 0.05. The Tukey's test formula is shown below.

$$T\alpha = q\alpha\ (a, f)\sqrt{\frac{MS\varepsilon}{n}}$$

With α = 0.05 and f =20 degrees of freedom for error, table of percentage points of the studentized range statistic gives q0.05(5,20) = 4.24. Therefore,

$$T_{0.05} = q_{0.05}(5{,}20)\sqrt{\frac{0.2449}{5}} = 4.24\sqrt{\frac{0.2449}{5}} = 0.9384$$

Thus, any pairs of ratio averages that differ in absolute value by more than 0.9384 would imply that the corresponding pair of population means are significantly different. The five ratio averages are;

$$\bar{y}_1 = 14.8565$$

$$\bar{y}_2 = 14.1194$$

$$\bar{y}_3 = 11.4387$$

$$\bar{y}_4 = 9.9658$$

$$\bar{y}_5 = 8.1679$$

and the differences in averages are;

$$\bar{y}1 - \bar{y}2 = 14.8565 – 14.1194 = 0.7371$$

$$\bar{y}1 - \bar{y}3 = 14.8565 – 11.4387 = 3.4178^*$$

$$\bar{y}1 - \bar{y}4 = 14.8565 – 9.9658 = 4.8907^*$$

$$\bar{y}1 - \bar{y}5 = 14.8565 – 8.1679 = 6.6886^*$$

$$\bar{y}2 - \bar{y}3 = 14.1194 – 11.4387 = 2.6807^*$$

$$\bar{y}2 - \bar{y}4 = 14.1194 – 9.9658 = 4.1536^*$$

$$\bar{y}2 - \bar{y}5 = 14.1194 – 8.1679 = 5.9515^*$$

$$\bar{y}3 - \bar{y}4 = 11.4387 – 9.9658 = 1.4729^*$$

$$\bar{y}3 - \bar{y}5 = 11.4387 – 8.1679 = 3.2708^*$$

$$\bar{y}4 - \bar{y}5 = 9.9658 – 8.1679 = 1.7979^*$$

The starred values signify the pairings of means that deviate significantly from one another. Remember the Tukey procedure's claim that each pair of means has a difference. The mean etch rate for any power level differs from the mean etch rate for each other power setting as a consequence.

Table 4.3 displays the summary of elasticity for five ratios of RHP composites that contain sum, average and variance.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
20RH80P	5	5.40026	1.080052	0.005674
40RH60P	5	4.51188	0.902376	0.001913
50RH50P	5	4.0417	0.80834	0.002094
60RH40P	5	3.01273	0.602546	0.00295
80RH20P	5	2.33343	0.466686	0.002967

Table 4.4 displays ANOVA of tensile elasticity for five ratios of RHP composites to obtain *MS* value in row of within groups to show if it is significant or insignificant.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Ratios	1.175729	4	0.293932	94.21869	1.11E-12	2.866081
Within Groups	0.062394	20	0.00312			
Total	1.238123	24				

Similar to Table 4.3, Tukey's test must be run in order to identify means that differ substantially from one another because the P-value was less than the significant cut-off level of = 0.05. The Tukey's test formula is shown below.

$$T\alpha = q\alpha\ (a, f)\sqrt{\frac{MS\varepsilon}{n}}$$

With α = 0.05 and f =20 degrees of freedom for error, table of percentage points of the studentized range statistic gives q0.05(5,20) = 4.24. Therefore,

$$T_{0.05} = q_{0.05}(5,20)\sqrt{\frac{0.00312}{5}} = 4.24\sqrt{\frac{0.00312}{5}} = 0.1059$$

Thus, any pairs of ratio averages that differ in absolute value by more than 0.1059 would imply that the corresponding pair of population means are significantly different. The five ratio averages are;

$\bar{y}_1 = 1.0801$

$\bar{y}_2 = 0.9024$

$\bar{y}_3 = 0.8083$

$\bar{y}_4 = 0.6025$

$\bar{y}_5 = 0.4667$

and the differences in averages are;

$\bar{y}1 - \bar{y}2 = 1.0801 – 0.9024 = 0.1777^*$

$\bar{y}1 - \bar{y}3 = 1.0801 – 0.8083 = 0.2718^*$

$\bar{y}1 - \bar{y}4 = 1.0801 – 0.6025 = 0.4776^*$

$\bar{y}1 - \bar{y}5 = 1.0801 – 0.4667 = 0.6134^*$

$\bar{y}2 - \bar{y}3 = 0.9024 – 0.8083 = 0.0941^*$

$\bar{y}2 - \bar{y}4 = 0.9024 – 0.6025= 0.2999^*$

$\bar{y}2 - \bar{y}5 = 0.9024 – 0.4667 = 0.4357^*$

$\bar{y}3 - \bar{y}4 = 0.8083 – 0.6025= 0.2058^*$

$\bar{y}3 - \bar{y}5 = 0.8083 – 0.4667 = 0.3416^*$

$\bar{y}4 - \bar{y}5 = 0.6025 – 0.4667 = 0.1358^*$

Starred values indicate pairs of means that differ significantly from one another. Remember that the Tukey procedure demonstrates that there are differences between every pair of means. As a result, the average etch rate at each power level is different from the average etch rate at all other power settings.

4.3 Flexural Test Result

The specimen has undergone flexural testing throughout this experiment to measure its maximum force and maximum stress. Using a universal testing apparatus, a three- or four-point bend fixture is used to perform this test. The main benefit of a three-point flexural test is its ease of specimen preparation and testing. The elasticity of flexural test for each RHP ratio are shown in Figure 4.4. It was demonstrated that compared to the other RHP composite ratios, the 20RH80P composite ratio demonstrated the greatest flexural strength of flexural test . The lowest flexural strength values, in contrast, were found in 80RH20P. This discovery led to the conclusion that as the RH content in RHP composites reaches 20%, the elasticity increase. Following flexural testing, Figure 4.4 shows the flexural strength data graph for five ratios of RHP composites.

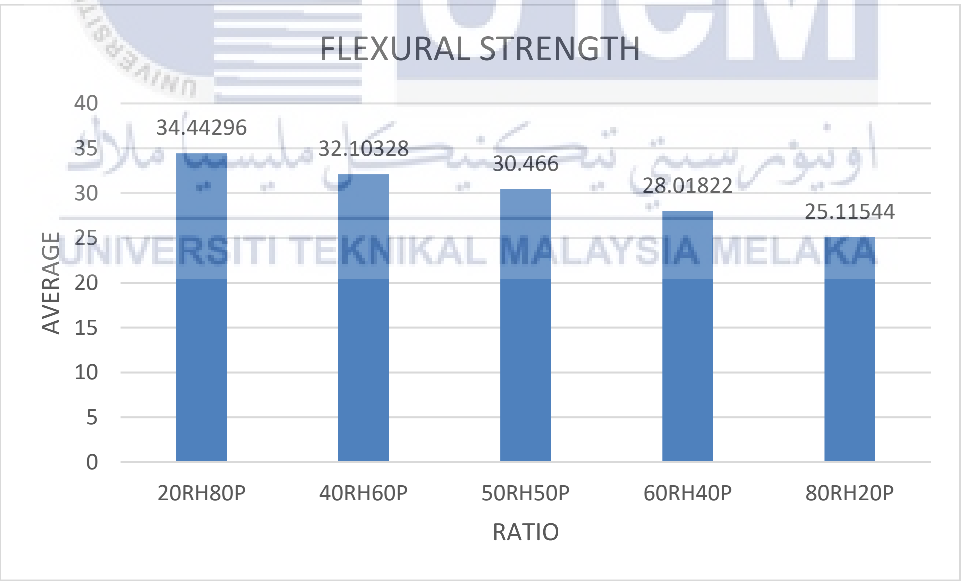


Figure 4.4 shows the flexural strength for five ratios of RHP composites from the highest to the lowest average values.

Figure 4.5 shows the specimen results after flexural testing as the specimens are broken in half.

A one-way ANOVA was then used to determine the flexural strength of the RHP composites, as indicated in Table 4.6 respectively. As a result of the P-value falling below the significance criterion of α = 0.05, the flexural strength for each of the five ratios of the RHP composites were found to be significant. Thus, was demonstrated that the flexural strength for every one of the five RHP composite ratios varied. Therefore, mixing RH and polyester in proportions of 20% and 80%, respectively, yields the best flexural performances.

Table 4.5 shows the summary of all ratios for RHP composites for flexural testing that contain sum, average and variance.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
20RH80P	5	172.2148	34.44296	0.289866
40RH60P	5	160.5164	32.10328	0.400168
50RH50P	5	152.33	30.466	0.177661
60RH40P	5	140.0911	28.01822	0.660166
80RH20P	5	125.5772	25.11544	1.014793

Table 4.6 displays ANOVA of flexural strength for five ratios of RHP composites composites to obtain *MS* value in row of within groups to show if it is significant or insignificant.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Ratios	260.8148	4	65.2037	128.2198	5.89E-14	2.866081
Within Groups	10.17062	20	0.508531			
Total	270.9854	24				

To identify means that are substantially different from one another, Tukey's test must be run since the P-value was less than the significant cut-off level of α = 0.05. The Tukey's test formula is shown below.

$$T\alpha = q\alpha\ (a, f)\ \sqrt{\frac{MS\varepsilon}{n}}$$

With α = 0.05 and f =20 degrees of freedom for error, table of percentage points of the studentized range statistic gives q0.05(5,20) = 4.24. Therefore,

$$T_{0.05} = q_{0.05}(5{,}20)\sqrt{\frac{0.508531}{5}} = 4.24\sqrt{\frac{0.508531}{5}} = 1.3522$$

Thus, any pairs of ratio averages that differ in absolute value by more than 1.3522 would imply that the corresponding pair of population means are significantly different. The five ratio averages are;

$\bar{y}_1 = 34.4430$

$\bar{y}_2 = 32.1033$

$\bar{y}_3 = 30.4660$

$\bar{y}_4 = 28.0182$

$\bar{y}_5 = 25.1154$

and the differences in averages are;

$\bar{y}1 - \bar{y}2 = 34.4430 – 32.1033 = 2.3397*$

$\bar{y}1 - \bar{y}3 = 34.4430 – 30.4660 = 3.9770*$

$\bar{y}1 - \bar{y}4 = 34.4430 – 28.0182 = 6.4248*$

$\bar{y}1 - \bar{y}5 = 34.4430 – 25.1154 = 9.3276*$

$\bar{y}2 - \bar{y}3 = 32.1033 – 30.4660 = 1.6373*$

$\bar{y}2 - \bar{y}4 = 32.1033 – 28.0182 = 4.0851*$

$\bar{y}2 - \bar{y}5 = 32.1033 – 25.1154 = 6.9879*$

$\bar{y}3 - \bar{y}4 = 30.4660 – 28.0182 = 2.4478*$

$\bar{y}3 - \bar{y}5 = 30.4660 – 25.1154 = 5.3506*$

$\bar{y}4 - \bar{y}5 = 28.0182 – 25.1154 = 2.9028*$

Starred values indicate pairs of means with substantially differing values. It should be mentioned that the Tukey technique demonstrates that every pair of means is unique. As a result, the average etch rate at each power level is distinct from the average etch rate at every other power level.

4.4 Impact Test Result

Impact testing has been done to determine how tough the material is to impact in order to evaluate the mechanical qualities of the experiment. This is the resilience and energy-absorbing ability of the material as a result of fast loading. Impact energy is the potential energy that a material can absorb when it is subjected to a shock or impact load. Impact capabilities should thus be taken into account when assessing the potential of composite materials for such applications, in addition to standard design criteria. The energy absorption variation of each of the five RHP composite ratios is shown in Figure 4.6. The results indicate that the energy absorption of the 20RH80P composite ratio is larger than that of the other RHP composite ratios. It may be inferred that as the proportion of rice husk reduced, so did the energy absorbed by RHP composites. Figure 4.7 displays the specimen's results following impact testing.

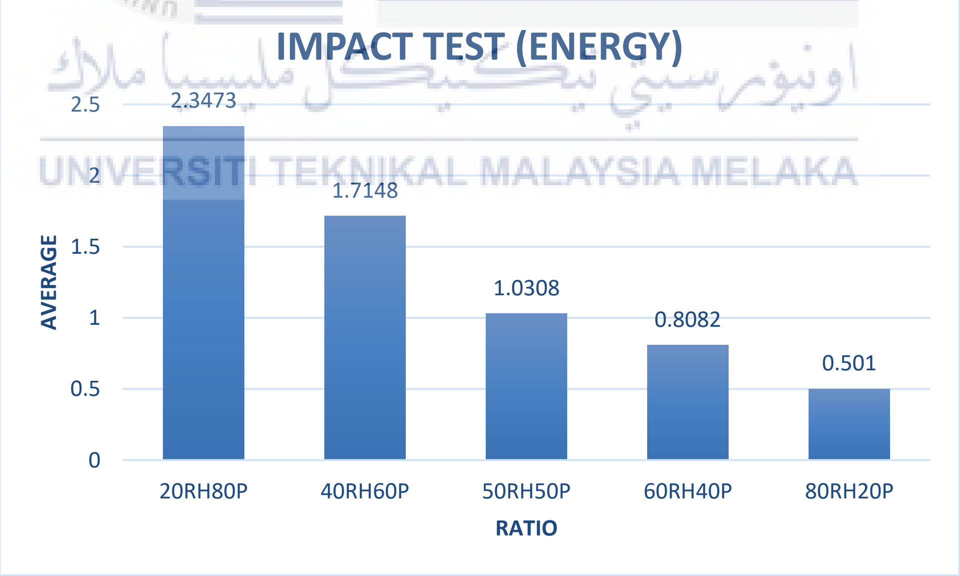


Figure 4.6 shows the absorbed energy for five ratios of RHP composites from the highest to the lowest average values.

Figure 4.7 displays the specimen results after impact testing as the specimens are broken in half .

The impact testing for five ratios of RHP composites was analysed using a one-way ANOVA, and the outcome is displayed in Table 4.8. The energy applied for each of the five RHRP composite ratios was found to be significant in the findings, as evidenced by the P-value being less than the significant cut-off threshold of α = 0.05. This result showed that, for each of the five RHP composite ratios, the average amount of energy absorbed during the impact test varied according to the force of effect.

Table 4.7 shows summary of energy absorbed for five ratios of RHP composites that include sum, average and variance.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
20RH80P	5	1.7365	0.3473	0.020272
40RH60P	5	12.174	2.4348	0.702479
50RH50P	5	4.954	0.9908	0.244079
60RH40P	5	4.866	0.9732	1.462121
80RH20P	5	8.405	1.681	0.051748

Table 4.8 contains ANOVA of energy absorbed for five ratios of RHP composites to obtain *MS* value in row of within groups to show if it is significant or insignificant.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	11.09858	4	2.774645	399.8907	8.97E-19	2.866081
Within Groups	0.13877	20	0.006939			
Total	11.23735	24				

To identify means that are substantially different from one another, Tukey's test must be run since the P-value was less than the significant cut-off level of α = 0.05. The Tukey's test formula is shown below.

$$T\alpha = q\alpha\ (a, f)\sqrt{\frac{MS\varepsilon}{n}}$$

With α = 0.05 and f =20 degrees of freedom for error, table of percentage points of the studentized range statistic gives q0.05(5,20) = 4.24. Therefore,

$$T_{0.05} = q_{0.05}(5{,}20)\sqrt{\frac{0.0069}{5}} = 4.24\sqrt{\frac{0.0069}{5}} = 0.1575$$

Thus, any pairs of ratio averages that differ in absolute value by more than 0.1575 would imply that the corresponding pair of population means are significantly different. The five ratio averages are;

$\bar{y}_1 = 2.3473$

$\bar{y}_2 = 1.7148$

$\bar{y}_3 = 1.0308$

$\bar{y}_4 = 0.8082$

$\bar{y}_5 = 0.5010$

and the differences in averages are;

$\bar{y}1 - \bar{y}2 = 2.3473 – 1.7148 = 0.6325^*$

$\bar{y}1 - \bar{y}3 = 2.3473 – 1.0308 = 1.3165^*$

$\bar{y}1 - \bar{y}4 = 2.3473 – 0.8082 = 1.5391^*$

$\bar{y}1 - \bar{y}5 = 2.3473 – 0.5010 = 1.8463^*$

$\bar{y}2 - \bar{y}3 = 1.7148 – 1.0308 = 0.6840^*$

$\bar{y}2 - \bar{y}4 = 1.7148 – 0.8082 = 0.9066^*$

$\bar{y}2 - \bar{y}5 = 1.7148 – 0.5010 = 1.2138^*$

$\bar{y}3 - \bar{y}4 = 1.0308 – 0.8082 = 0.2226^*$

$\bar{y}3 - \bar{y}5 = 1.0308 – 0.5010 = 0.5298^*$

$\bar{y}4 - \bar{y}5 = 0.8082 – 0.5010 = 0.3072^*$

Starred values indicate pairs of means that differ significantly from one another. Remember that the Tukey procedure demonstrates that there are differences between every pair of means. As a result, the average etch rate at each power level is different from the average etch rate at all other power settings.

4.5 Water Absorption Test Result

Water absorption has been done as a guide for the amount of water absorbed by a material and, subsequently, when determining the relationships between moisture absorption. and electrical or mechanical properties, dimensions, or appearance or in other words, as a guide for the effects of exposure to water or humid conditions on such properties. From the results obtained,we can see the day 25 has the greatest value among the other days included in all ratios. It is because the longer the period of time for the specimen to absorb water,the weight of the specimens increase. The water absorption for 20RH80P composite data result is shown at Figure 4.8 which included from day 1 until day 25.

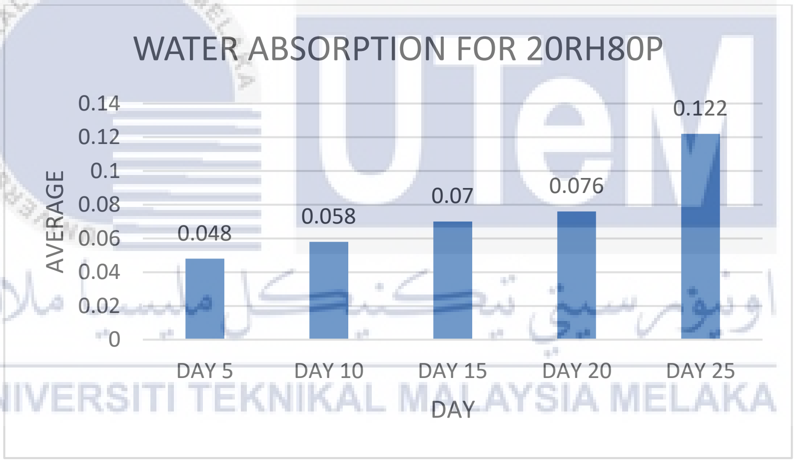


Figure 4.8 shows the graph data result of absorbed water for ratio 20RH80P composite from the least value to the biggest value followed by ascending days.

Figure 4.9 displays the immersion specimen during water absorption test for all ratios from day 1 until day 25.

The water absorption testing for ratio of 20RH80P composites was analysed using a one-way ANOVA, and the outcome is displayed in Table 4.10. The energy applied for each of the five RHRP composite ratios was found to be significant in the findings, as evidenced by the P-value being less than the significant cut-off threshold of α = 0.05. This result showed that, for each of the five RHP composite ratios, the average amount of energy absorbed during the impact test varied according to the force of effect.

Table 4.9 displays the summary of water absorption for 20RH80P composite that contains sum, average and variance followed by day 5 until day 25.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
DAY 5	5	0.24	0.048	0.00017
DAY 10	5	0.29	0.058	0.00017
DAY 15	5	0.35	0.07	0.0004
DAY 20	5	0.38	0.076	0.00018
DAY 25	5	0.61	0.122	0.01397

Table 4.10 shows ANOVA of water absorption for 20RH80P composite to obtain *MS* value in row of within groups to show if it is significant or insignificant.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.016264	4	0.004066	1.365346	0.281252	2.866081
Within Groups	0.05956	20	0.002978			
Total	0.075824	24				

To identify means that are substantially different from one another, Tukey's test must be run since the P-value was less than the significant cut-off level of α = 0.05. The Tukey's test formula is shown below.

$$T\alpha = q\alpha\ (a, f)\sqrt{\frac{MS\varepsilon}{n}}$$

With α = 0.05 and f =20 degrees of freedom for error, table of percentage points of the studentized range statistic gives q0.05(5,20) = 4.24. Therefore,

$$T_{0.05} = q_{0.05}(5{,}20)\sqrt{\frac{0.0030}{5}} = 4.24\sqrt{\frac{0.0030}{5}} = 0.1039$$

Thus, any pairs of ratio averages that differ in absolute value by more than 0.1039 would imply that the corresponding pair of population means are significantly different. The five ratio averages are;

$\bar{y}_1 = 0.0480$

$\bar{y}_2 = 0.0580$

$\bar{y}_3 = 0.0700$

$\bar{y}_4 = 0.0760$

$\bar{y}_5 = 0.1220$

and the differences in averages are;

$$\bar{y}1 - \bar{y}2 = 0.0480 - 0.0580 = -0.0100$$

$$\bar{y}1 - \bar{y}3 = 0.0480 - 0.0700 = -0.0220$$

$$\bar{y}1 - \bar{y}4 = 0.0480 - 0.0760 = -0.0280$$

$$\bar{y}1 - \bar{y}5 = 0.0480 - 0.1220 = -0.0740$$

$$\bar{y}2 - \bar{y}3 = 0.0580 - 0.0700 = -0.0120$$

$$\bar{y}2 - \bar{y}4 = 0.0580 - 0.0760 = -0.0180$$

$$\bar{y}2 - \bar{y}5 = 0.0580 - 0.1220 = -0.0640$$

$$\bar{y}3 - \bar{y}4 = 0.0700 - 0.0760 = -0.0600$$

$$\bar{y}3 - \bar{y}5 = 0.0700 - 0.1220 = -0.0520$$

$$\bar{y}4 - \bar{y}5 = 0.0760 - 0.1220 = -0.0460$$

There are no starred values indicate pairs of means that differ significantly from one another. Remember that the Tukey procedure demonstrates that there are differences between every pair of means. As a result, the average etch rate at each power level is different from the average etch rate at all other power settings.

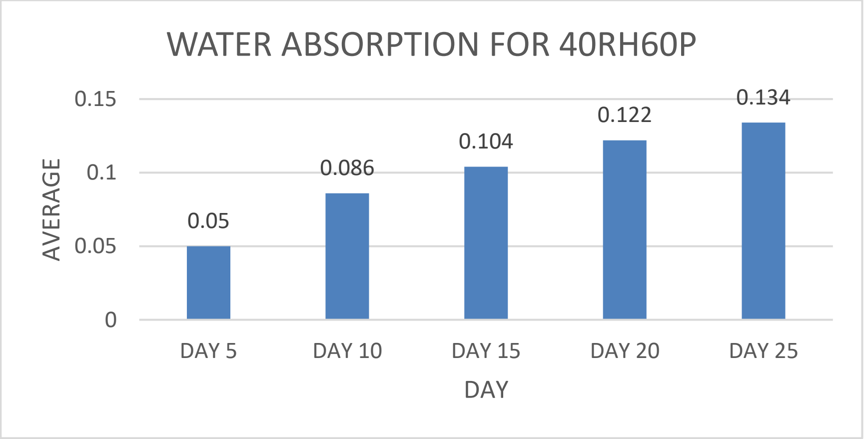


Figure 4.10 displays the absorbed water for ratio 40RH60P composite from the least value to the biggest value followed by ascending days.

Table 4.11 displays the summary of absorbed water for ratio 40RH60P composite that contains sum, average and variance followed by day 5 until day 25.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
DAY 5	5	0.25	0.05	0.00035
DAY 10	5	0.43	0.086	3E-05
DAY 15	5	0.52	0.104	0.00203
DAY 20	5	0.61	0.122	0.00032
DAY 25	5	0.67	0.134	0.00013

Table 4.12 displays ANOVA of water absorption for 40RH60P composite to obtain *MS* value in row of within groups to show if it is significant or insignificant.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.021744	4	0.005436	9.503497	0.000179	2.866081
Within Groups	0.01144	20	0.000572			
Total	0.033184	24				

To identify means that are substantially different from one another, Tukey's test must be run since the P-value was less than the significant cut-off level of α = 0.05. The Tukey's test formula is shown below.

$$T\alpha = q\alpha\ (a, f)\sqrt{\frac{MS\varepsilon}{n}}$$

With α = 0.05 and f =20 degrees of freedom for error, table of percentage points of the studentized range statistic gives q0.05(5,20) = 4.24. Therefore,

$$T_{0.05} = q_{0.05}(5{,}20)\sqrt{\frac{0.000572}{5}} = 4.24\sqrt{\frac{0.000572}{5}} = 0.0453$$

Thus, any pairs of ratio averages that differ in absolute value by more than 0.0453 would imply that the corresponding pair of population means are significantly different. The five ratio averages are;

$\bar{y}_1 = 0.0500$

$\bar{y}_2 = 0.0860$

$\bar{y}_3 = 0.1040$

$\bar{y}_4 = 0.1220$

$\bar{y}_5 = 0.1340$

and the differences in averages are;

$\bar{y}1 - \bar{y}2 = 0.0500 – 0.0860 = -0.0360$

$\bar{y}1 - \bar{y}3 = 0.0500 – 0.1040 = -0.0540$

$\bar{y}1 - \bar{y}4 = 0.0500 – 0.1220 = -0.0720$

$\bar{y}1 - \bar{y}5 = 0.0500 – 0.1340 = -0.0840$

$\bar{y}2 - \bar{y}3 = 0.0860 – 0.1040 = -0.0180$

$\bar{y}2 - \bar{y}4 = 0.0860 – 0.1220 = -0.0360$

$\bar{y}2 - \bar{y}5 = 0.0860 – 0.1340 = -0.0480$

$\bar{y}3 - \bar{y}4 = 0.1040 – 0.1220 = -0.0180$

$\bar{y}3 - \bar{y}5 = 0.1040 – 0.1340 = -0.0300$

$\bar{y}4 - \bar{y}5 = 0.1220 – 0.1340 = -0.0120$

There are no starred values indicate pairs of means that differ significantly from one another. Remember that the Tukey procedure demonstrates that there are differences between every pair of means. As a result, the average etch rate at each power level is different from the average etch rate at all other power settings.

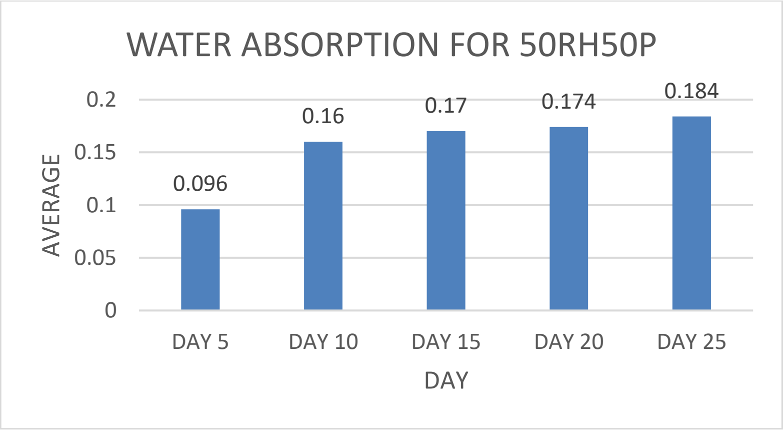


Figure 4.11 shows the absorbed water for ratio 50RH50P composite from the least value to the biggest value followed by ascending days.

Table 4.13 shows the summary of water absorption for 50RH50P composite that contains sum, average and variance followed by day 5 until day 25.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
DAY 5	5	0.48	0.096	0.00023
DAY 10	5	0.8	0.16	0.0004
DAY 15	5	0.85	0.17	0.0003
DAY 20	5	0.87	0.174	0.00033
DAY 25	5	0.92	0.184	0.00043

Table 4.14 displays ANOVA of water absorption for 50RH50P composite to obtain *MS* value in row of within groups to show if it is significant or insignificant.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.024584	4	0.006146	18.18343	1.93E-06	2.866081
Within Groups	0.00676	20	0.000338			
Total	0.031344	24				

To identify means that are substantially different from one another, Tukey's test must be run since the P-value was less than the significant cut-off level of α = 0.05. The Tukey's test formula is shown below.

$$T\alpha = q\alpha\;(a, f)\sqrt{\frac{MS\varepsilon}{n}}$$

With α = 0.05 and f =20 degrees of freedom for error, table of percentage points of the studentized range statistic gives q0.05(5,20) = 4.24. Therefore,

$$T_{0.05} = q_{0.05}(5{,}20)\sqrt{\frac{0.000338}{5}} = 4.24\sqrt{\frac{0.000338}{5}} = 0.0349$$

Thus, any pairs of ratio averages that differ in absolute value by more than 0.0349 would imply that the corresponding pair of population means are significantly different.

The five ratio averages are;

$\bar{y}_1 = 0.0960$

$\bar{y}_2 = 0.1600$

$\bar{y}_3 = 0.1700$

$\bar{y}_4 = 0.1740$

$\bar{y}_5 = 0.1840$

and the differences in averages are;

$\bar{y}1 - \bar{y}2 = 0.0960 - 0.1600 = -0.0640$

$\bar{y}1 - \bar{y}3 = 0.0960 - 0.1700 = -0.0740$

$\bar{y}1 - \bar{y}4 = 0.0960 - 0.1740 = -0.0780$

$$\bar{y}1 - \bar{y}5 = 0.0960 – 0.1840 = -0.0880$$

$$\bar{y}2 - \bar{y}3 = 0.1600 – 0.1700 = -0.0100$$

$$\bar{y}2 - \bar{y}4 = 0.1600 – 0.1740 = -0.0140$$

$$\bar{y}2 - \bar{y}5 = 0.1600 – 0.1840 = -0.0240$$

$$\bar{y}3 - \bar{y}4 = 0.1700 – 0.1740 = -0.0040$$

$$\bar{y}3 - \bar{y}5 = 0.1700 – 0.1840 = -0.0140$$

$$\bar{y}4 - \bar{y}5 = 0.1740 – 0.1840 = -0.0100$$

There are no starred values indicate pairs of means that differ significantly from one another. Remember that the Tukey procedure demonstrates that there are differences between every pair of means. As a result, the average etch rate at each power level is different from the average etch rate at all other power settings.

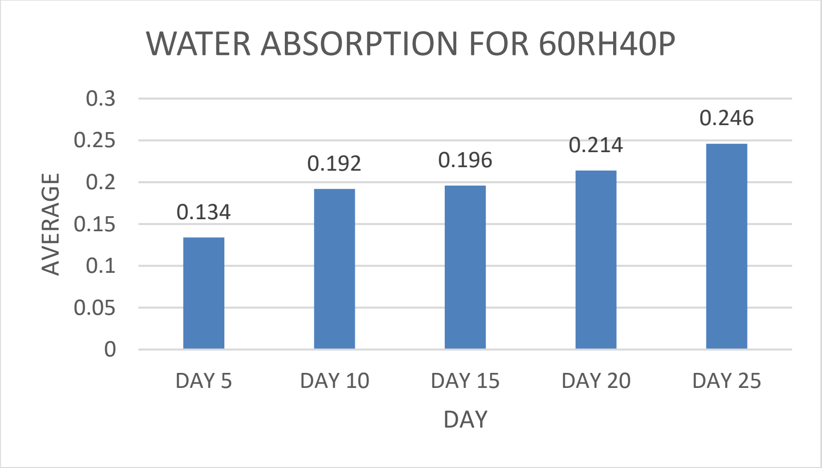


Figure 4.12 displays the absorbed water for ratio 60RH40P composite from the least value to the biggest value followed by ascending days.

Table 4.15 shows the summary of water absorption for 60RH40P composite that contains sum, average and variance followed by day 5 until day 25.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
DAY 5	5	0.67	0.134	3E-05
DAY 10	5	0.96	0.192	0.00297
DAY 15	5	0.98	0.196	8E-05
DAY 20	5	1.07	0.214	0.00013
DAY 25	5	1.23	0.246	0.00043

Table 4.16 shows ANOVA of water absorption for 60RH40P composite to obtain *MS* value in row of within groups to show if it is significant or insignificant.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.033416	4	0.008354	11.47527	5.28E-05	2.866081
Within Groups	0.01456	20	0.000728			
Total	0.047976	24				

To identify means that are substantially different from one another, Tukey's test must be run since the P-value was less than the significant cut-off level of $\alpha = 0.05$. The Tukey's test formula is shown below.

$$T\alpha = q\alpha\ (a, f)\sqrt{\frac{MS\varepsilon}{n}}$$

With $\alpha = 0.05$ and f =20 degrees of freedom for error, table of percentage points of the studentized range statistic gives $q0.05(5,20) = 4.24$. Therefore,

$$T_{0.05} = q_{0.05}(5,20)\sqrt{\frac{0.000728}{5}} = 4.24\sqrt{\frac{0.000728}{5}} = 0.0511$$

Thus, any pairs of ratio averages that differ in absolute value by more than 0.0511 would imply that the corresponding pair of population means are significantly different. The five ratio averages are;

$\bar{y}_1 = 0.1340$

$\bar{y}_2 = 0.1920$

$\bar{y}_3 = 0.1960$

$\bar{y}_4 = 0.2140$

$\bar{y}_5 = 0.2460$

and the differences in averages are;

$\bar{y}1 - \bar{y}2 = 0.1340 – 0.1920 = -0.0580$

$\bar{y}1 - \bar{y}3 = 0.1340 – 0.1960 = -0.0620$

$\bar{y}1 - \bar{y}4 = 0.1340 – 0.2140 = -0.0800$

$\bar{y}1 - \bar{y}5 = 0.1340 – 0.2460 = -0.1120$

$\bar{y}2 - \bar{y}3 = 0.1920 – 0.1960 = -0.0040$

$\bar{y}2 - \bar{y}4 = 0.1920 – 0.2140 = -0.0220$

$$\bar{y}_2 - \bar{y}_5 = 0.1920 - 0.2460 = -0.0540$$

$$\bar{y}_3 - \bar{y}_4 = 0.1960 - 0.2140 = -0.0180$$

$$\bar{y}_3 - \bar{y}_5 = 0.1960 - 0.2460 = -0.0500$$

$$\bar{y}_4 - \bar{y}_5 = 0.2140 - 0.2460 = -0.0320$$

There are no starred values indicate pairs of means that differ significantly from one another. Remember that the Tukey procedure demonstrates that there are differences between every pair of means. As a result, the average etch rate at each power level is different from the average etch rate at all other power settings.

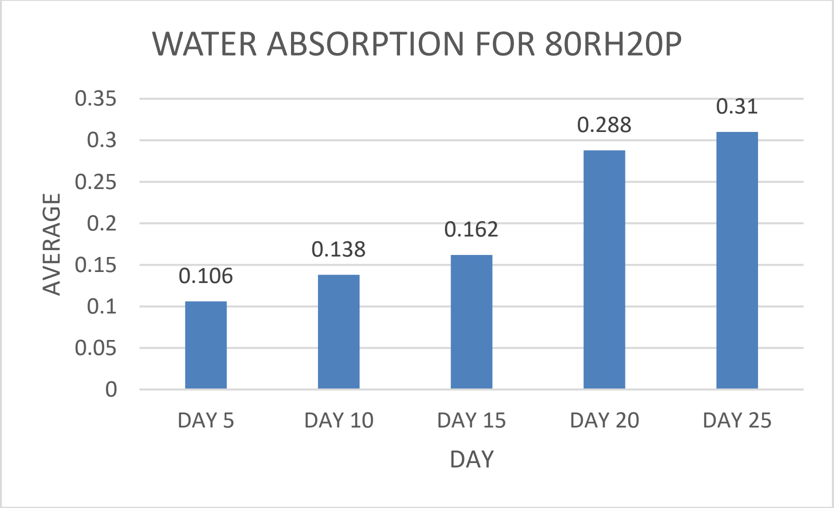


Figure 4.13 displays the absorbed water for ratio for 80RH20P composite from the least value to the biggest value followed by ascending days.

Table 4.17 shows the summary of water absorption for 80RH20P composite that contains sum, average and variance followed by day 5 until day 25.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
DAY 5	5	0.53	0.106	0.00023
DAY 10	5	0.69	0.138	0.00067
DAY 15	5	0.81	0.162	0.00197
DAY 20	5	1.44	0.288	0.00087
DAY 25	5	1.55	0.31	0.00125

Table 4.18 shows ANOVA of water absorption for 80RH20P composite to obtain *MS* value in row of within groups to show if it is significant or insignificant.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.169824	4	0.042456	42.54108	1.65E-09	2.866081
Within Groups	0.01996	20	0.000998			
Total	0.189784	24				

To identify means that are substantially different from one another, Tukey's test must be run since the P-value was less than the significant cut-off level of α = 0.05. The Tukey's test formula is shown below.

$$T\alpha = q\alpha\,(a, f)\sqrt{\frac{MS\varepsilon}{n}}$$

With α = 0.05 and f =20 degrees of freedom for error, table of percentage points of the studentized range statistic gives q0.05(5,20) = 4.24. Therefore,

$$T_{0.05} = q_{0.05}(5{,}20)\sqrt{\frac{0.000998}{5}} = 4.24\sqrt{\frac{0.000998}{5}} = 0.0599$$

Thus, any pairs of ratio averages that differ in absolute value by more than 0.0782 would imply that the corresponding pair of population means are significantly different. The five ratio averages are;

$\bar{y}_1 = 0.1060$

$\bar{y}_2 = 0.1380$

$$\bar{y}_3 = 0.1620$$

$$\bar{y}_4 = 0.2880$$

$$\bar{y}_5 = 0.3100$$

and the differences in averages are;

$$\bar{y}1 - \bar{y}2 = 0.1060 - 0.1380 = -0.0320$$

$$\bar{y}1 - \bar{y}3 = 0.1060 - 0.1620 = -0.0560$$

$$\bar{y}1 - \bar{y}4 = 0.1060 - 0.2880 = -0.1820$$

$$\bar{y}1 - \bar{y}5 = 0.1060 - 0.3100 = -0.2040$$

$$\bar{y}2 - \bar{y}3 = 0.1380 - 0.1620 = -0.0240$$

$$\bar{y}2 - \bar{y}4 = 0.1380 - 0.2880 = -0.1500$$

$$\bar{y}2 - \bar{y}5 = 0.1380 - 0.3100 = -0.1720$$

$$\bar{y}3 - \bar{y}4 = 0.1620 - 0.2880 = -0.1260$$

$$\bar{y}3 - \bar{y}5 = 0.1620 - 0.3100 = -0.1480$$

$$\bar{y}4 - \bar{y}5 = 0.2880 - 0.3100 = -0.0220$$

There are no starred values indicate pairs of means that differ significantly from one another. Remember that the Tukey procedure demonstrates that there are differences between every pair of means. As a result, the average etch rate at each power level is different from the average etch rate at all other power settings.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The mechanical characteristics of the RHP with five distinct ratios which are 20RH80P, 40RH60P, 50RH50P, 60RH40P, and 80RH20P were examined in this work. Tukey's methodologies and one-way ANOVA have also been used to examine the statistical analysis of the experiment material. The following deductions can be made in light of the analysis's findings and the experimental data:

i. Based on the tensile data, the RHP composite of 20RH80P demonstrated greater tensile strength and elasticity, outperforming the other RHP composites in these domains.
ii. It was shown that the flexural strength values in RHP composites rise when rice husk content is 20%. The RHP composite of 20RH80P exhibited higher flexural strength than the other RHP composite ratios.
iii. It has been demonstrated that 20RH80P RHP composites have higher impact performances.
iv. The most absorbed water values for all composites are at day-25 because it has the longest period of time for the specimens to absorb the water in container.

5.2 Recommendation

This study has shown that RHP with 20% RH performed better in terms of mechanical qualities. One of the best ratios for RHP has been found to be 20RH80P, based on the mechanical property analysis findings. However, more investigation and analysis for this project will yield the mechanical characteristics' peak value for impact, flexural, and tensile tests. For instance, it is worthwhile to experiment with ratios of 40% to 60% of RH to see if they result in the maximum peak value of mechanical qualities or a decline in value. Other than that,water absorption test must be in proper container to obtain optimal humid conditions of all the specimens.

5.3 Project potential

These composites can be characterised as materials with many applications across several industries. For instance, panels, frames, interior elements, and other components for machines and automobiles are now made of composite materials. The usage of composites in building has also resulted in the replacement of many conventional materials in the production of window frames, doors, fixtures, roofs, wall panels, and even swimming pools all of which are utilised in both residential and commercial architecture. Other than that, the manufacturing of hybrid composite acknowledges community on reducing negative impact to the environment as the waste of natural fibres can be used in other applications instead of open combustion disposal, thus can reduce the cost usage of fibres. In addition, these hybrid composites can be categorized as an innovative material that gives beneficial matter which is made these resources a better substitution for advanced structural parts.

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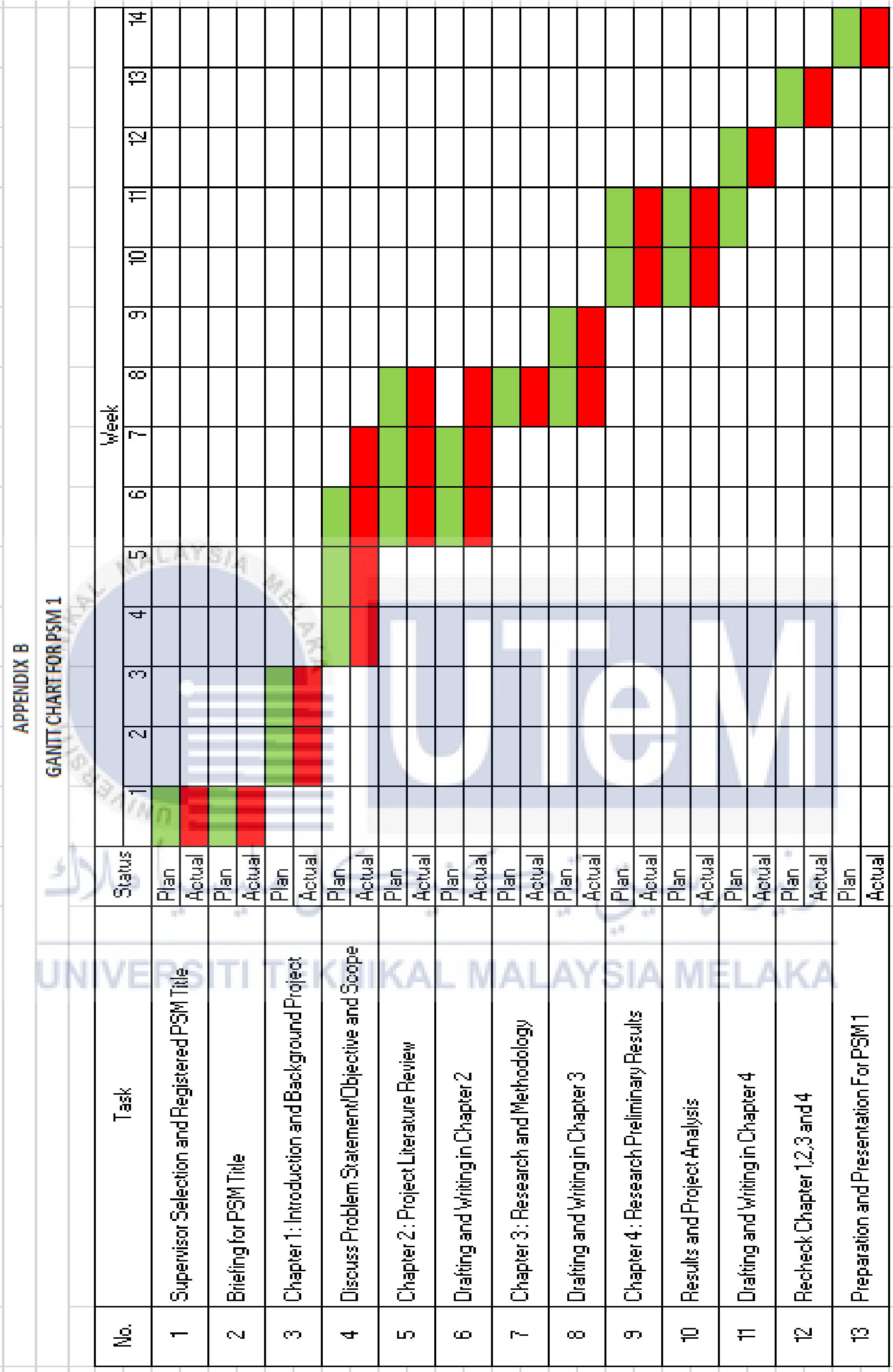
APPENDICES

APPENDIX A GANTT CHART PSM 1

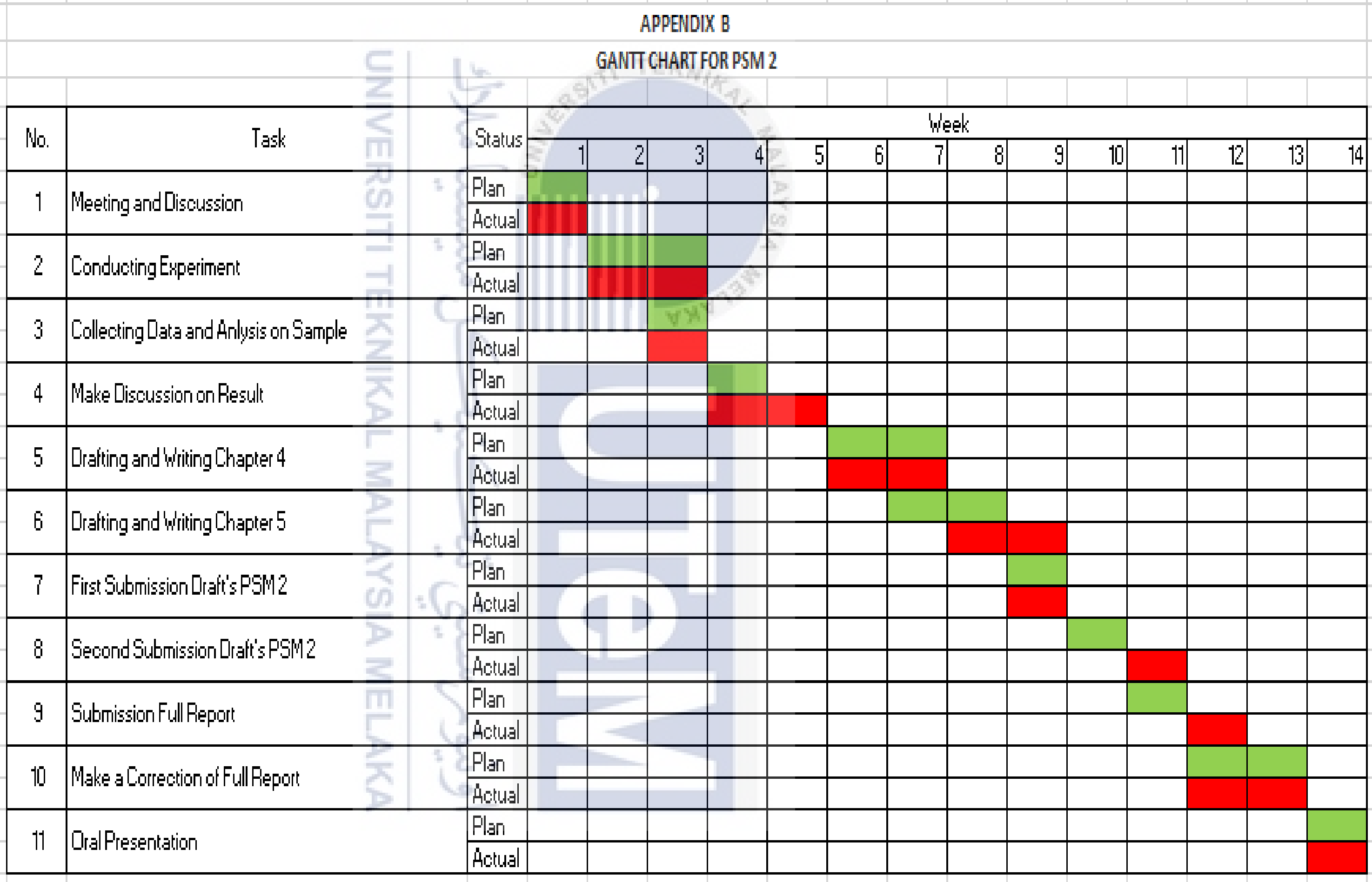


APPENDIX B

GANTT CHART FOR PSM 1

No.	Task	Status	Week 1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Supervisor Selection and Registered PSM Title	Plan	🟩													
		Actual	🟥													
2	Briefing for PSM Title	Plan	🟩													
		Actual	🟥													
3	Chapter 1: Introduction and Background Project	Plan		🟩	🟩											
		Actual		🟥	🟥											
4	Discuss Problem Statement/Objective and Scope	Plan				🟩	🟩	🟩								
		Actual				🟥	🟥	🟥	🟥							
5	Chapter 2 : Project Literature Review	Plan						🟩	🟩	🟩						
		Actual						🟥	🟥	🟥						
6	Drafting and Writing in Chapter 2	Plan						🟩	🟩							
		Actual						🟥	🟥	🟥						
7	Chapter 3 : Research and Methodology	Plan								🟩						
		Actual								🟥						
8	Drafting and Writing in Chapter 3	Plan								🟩	🟩					
		Actual								🟥	🟥					
9	Chapter 4 : Research Preliminary Results	Plan										🟩	🟩			
		Actual										🟥	🟥			
10	Results and Project Analysis	Plan										🟩	🟩			
		Actual										🟥	🟥			
11	Drafting and Writing in Chapter 4	Plan											🟩	🟩		
		Actual												🟥		
12	Recheck Chapter 1,2,3 and 4	Plan													🟩	
		Actual													🟥	
13	Preparation and Presentation For PSM 1	Plan														🟩
		Actual														🟥

APPENDIX B GANTT CHART PSM 2



APPENDIX B

GANTT CHART FOR PSM 2

No.	Task	Status	Week													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Meeting and Discussion	Plan	🟩													
		Actual	🟥													
2	Conducting Experiment	Plan		🟩	🟩											
		Actual		🟥	🟥											
3	Collecting Data and Anlysis on Sample	Plan			🟩											
		Actual			🟥											
4	Make Discussion on Result	Plan				🟩										
		Actual				🟥	🟥									
5	Drafting and Writing Chapter 4	Plan						🟩	🟩							
		Actual						🟥	🟥							
6	Drafting and Writing Chapter 5	Plan							🟩	🟩						
		Actual								🟥	🟥					
7	First Submission Draft's PSM 2	Plan									🟩					
		Actual									🟥					
8	Second Submission Draft's PSM 2	Plan										🟩				
		Actual											🟥			
9	Submission Full Report	Plan											🟩			
		Actual												🟥		
10	Make a Correction of Full Report	Plan												🟩	🟩	
		Actual												🟥	🟥	
11	Oral Presentation	Plan														🟩
		Actual														🟥

APPENDIX C TABLE OF UPPER PERCENTAGE POINTS OF THE STUDENTIZED RANGE DISTRIBUTIONS

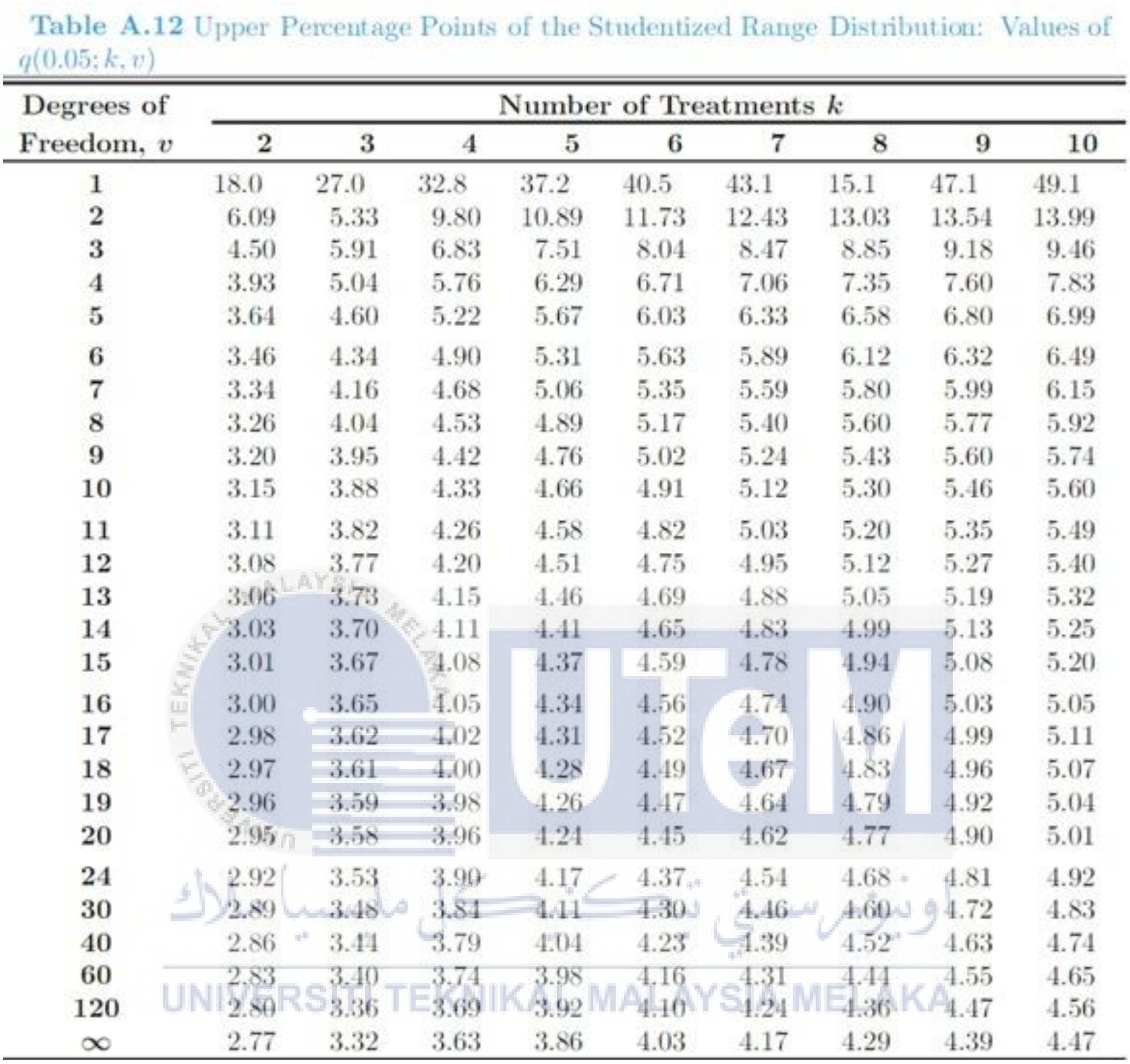
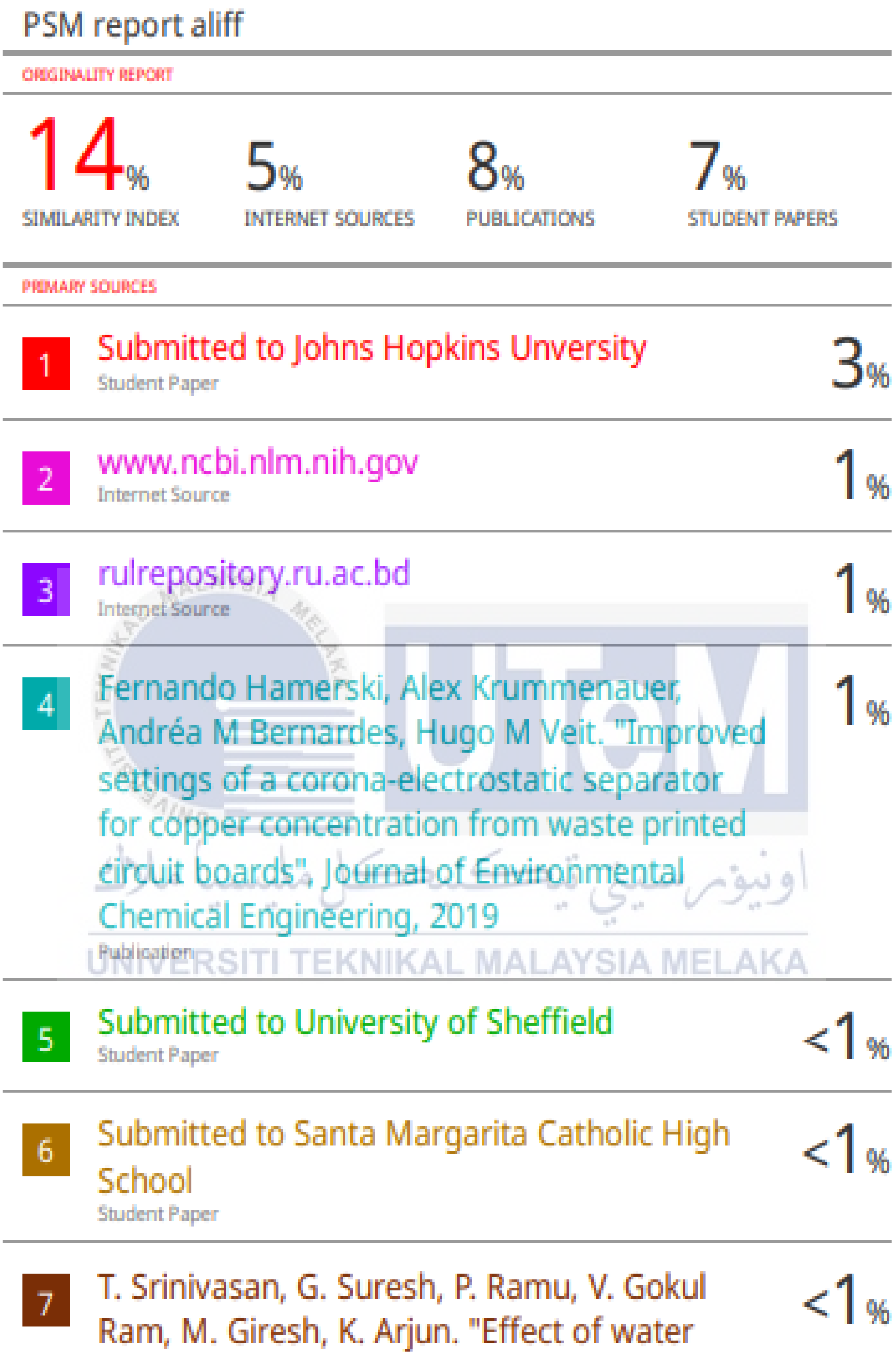


Table A.12 Upper Percentage Points of the Studentized Range Distribution: Values of $q(0.05; k, v)$

Degrees of Freedom, v	Number of Treatments k								
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	18.0	27.0	32.8	37.2	40.5	43.1	15.1	47.1	49.1
2	6.09	5.33	9.80	10.89	11.73	12.43	13.03	13.54	13.99
3	4.50	5.91	6.83	7.51	8.04	8.47	8.85	9.18	9.46
4	3.93	5.04	5.76	6.29	6.71	7.06	7.35	7.60	7.83
5	3.64	4.60	5.22	5.67	6.03	6.33	6.58	6.80	6.99
6	3.46	4.34	4.90	5.31	5.63	5.89	6.12	6.32	6.49
7	3.34	4.16	4.68	5.06	5.35	5.59	5.80	5.99	6.15
8	3.26	4.04	4.53	4.89	5.17	5.40	5.60	5.77	5.92
9	3.20	3.95	4.42	4.76	5.02	5.24	5.43	5.60	5.74
10	3.15	3.88	4.33	4.66	4.91	5.12	5.30	5.46	5.60
11	3.11	3.82	4.26	4.58	4.82	5.03	5.20	5.35	5.49
12	3.08	3.77	4.20	4.51	4.75	4.95	5.12	5.27	5.40
13	3.06	3.73	4.15	4.46	4.69	4.88	5.05	5.19	5.32
14	3.03	3.70	4.11	4.41	4.65	4.83	4.99	5.13	5.25
15	3.01	3.67	4.08	4.37	4.59	4.78	4.94	5.08	5.20
16	3.00	3.65	4.05	4.34	4.56	4.74	4.90	5.03	5.05
17	2.98	3.62	4.02	4.31	4.52	4.70	4.86	4.99	5.11
18	2.97	3.61	4.00	4.28	4.49	4.67	4.83	4.96	5.07
19	2.96	3.59	3.98	4.26	4.47	4.64	4.79	4.92	5.04
20	2.95	3.58	3.96	4.24	4.45	4.62	4.77	4.90	5.01
24	2.92	3.53	3.90	4.17	4.37	4.54	4.68	4.81	4.92
30	2.89	3.48	3.84	4.11	4.30	4.46	4.60	4.72	4.83
40	2.86	3.44	3.79	4.04	4.23	4.39	4.52	4.63	4.74
60	2.83	3.40	3.74	3.98	4.16	4.31	4.44	4.55	4.65
120	2.80	3.36	3.69	3.92	4.10	4.24	4.36	4.47	4.56
∞	2.77	3.32	3.63	3.86	4.03	4.17	4.29	4.39	4.47



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