CERTIFICATION OF APPROVAL

The Study of Sandpapering Effect on Mechanical Properties of Aircraft Materials (Aluminum Alloy and Carbon Fiber Reinforce Plastic)

by

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A project dissertation submitted to the
Mechanical Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(MECHANICAL ENGINEERING)

Approved by,

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TRONOH, PERAK

December 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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ABSTRACT

Since the dawn of aviation, successful aircraft design has depended on using the strongest, lightest materials available. In the endless quest for such materials, however, only two kinds have made the grade: aluminum alloys and composites. The objective of this project is to analyze the effect of sand papering towards mechanical strength of carbon fiber reinforced plastic (CFRP) and aluminum alloy in terms of hardness and tensile strength. Surface wear of materials might produce flaws that set as crack initiators. A correlation between the flaw depth as well as flaw density with mechanical strength should be studied. Each test on the specimen will follow a standard from *American Society of Testing and Material (ASTM D3039/D 3039-00 El)* for CFRP and ASTM B557-06 for Aluminum Alloy. The Universal Testing Machine (UTM) has been used to test each specimen for its tensile strength. Meanwhile Optical Microscope has been used to monitor the surface textural changes on each specimen after the rubbing and tests. After the experiments, we can see changes of the morphology of the specimens. It conclude that the bigger grit size of sandpaper, the less mechanical properties (tensile and hardness) will be.

ACKNOWLEDGEMENTS

First and foremost, the author would like to thank Allah, the Most Gracious and the Most Merciful for His blessings throughout the process of completing this project. The author would also like to thank his supervisor, Mr. Kamal Ariff Zainal Abidin, for the tremendous support, advice, guidance and encouragement throughout this project and in the preparation of this report. The author wishes special thanks to the Mechanical Laboratory Technicians particularly Mr. Fariz for his help and assistance during sample preparation and experiment. The author is also very grateful to his fellow friends; Mr. Hasrul Hilmi and Ms. Farah Najwa Bt. Shauqi for their advice and opinion on this project. Not forgetting, a word of thanks also goes to the author's beloved parents, Mr. Hayat Niti and Madam Ramlah Karmin for their support and encouragement which has indeed inspired the author to complete this project. Lastly, the author would like to thank all those people who have contributed in one way or another, directly or indirectly in the process of carrying out this project.

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Nowadays, people from all around the world tend to use aircraft as main transportation for a long distance journey. It is estimated that by year 2026, more than 6.8 billion airlines passengers worldwide will travel through the country using the aircraft [1].

An aircraft is a vehicle which is able to fly through the air (or through any other atmosphere). All the human activity which surrounds aircraft is called aviation. (Most rocket vehicles are not aircraft because they are not supported by the surrounding air). Initially in the aviation history, canvas and wood was used as a main material for aircraft fabrication. Then doped fabric and steel tubing were used to replace the previous material. During the era of World War II, the material was changed again to Aluminum. Until now, the revolutions of material for aircraft never stop with the present of composite.

Figure 1: Fabrication of Aircraft Fuselage [1]

The aircraft industry can be characterised by an increasing demand for transport combined with a harsh global competition between airlines and manufacturers, forcing them to cut down on the life cycle cost of the aircraft. With the use of CFRP, which belong to the composite family, what greatly improved is the weight of the materials used to build newer aircraft. Today's composite materials are stronger than more traditional materials (like steel and aluminum), but their greatest asset is that composites can be made to do the same job as metals yet weigh far less. In aerospace lingo, they call this a high strength-to-weight ratio. Future aircrafts to be produced by the manufacturer mainly Airbus and Boeing will make use of composite materials that account for more than half of the plane's structural weight. Both the fuselage and wings are composed of lightweight composites or aluminum-lithium alloys.

Boeing has stated the Boeing 787 aircraft will be 15% to 20% more efficient and burn 17% less fuel than the 767 due to the innovative use of new technology. Perhaps the most challenging of these advances is the extensive use of lightweight composite materials that make up much of the wing and fuselage structures. While composites have been widely used in aviation since the 1980s, the 787 is the first commercial airliner to use the materials for the majority of its construction. The reduced weight of its structure coupled with aerodynamic improvements to reduce drag are said to account for about a third of the 787's fuel savings.[2]

1.2 Problem Statement

Since the dawn of aviation, successful aircraft design has depended on using the strongest, lightest materials available. In the endless quest for such materials, however, only two kinds have made the grade: aluminum alloys and composites. The decision whether to use aluminum or composite in business aircraft depends on many factors, such as aircraft performance, material costs, and most recently environment performance. Some airlines operate in sandy environment and it is similar to volcanic ash effects. When it comes to the exposure to air friction (sand), it will affect the material of the parts. So the main target is to study on the changes that sandy environment made on the mechanical properties of aluminum alloys and carbon fiber.

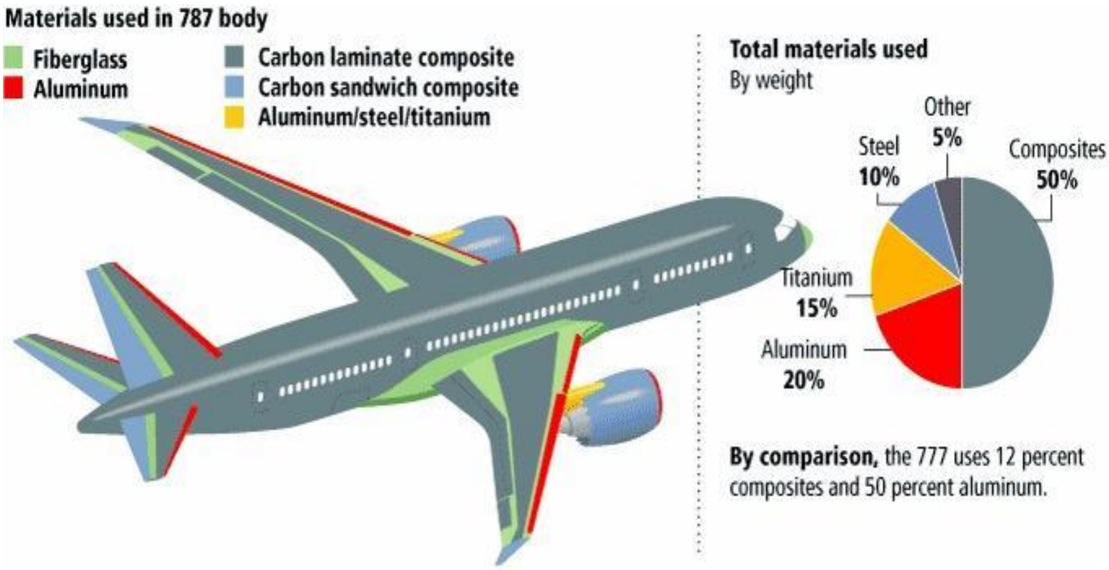


Figure 1.1: Materials used in Aircraft Body for Boeing 787.

1.3 Relevancy of the Project

This project is relevant to the Introduction to Material Science & Engineering (MAB 1063) and Engineering Materials (MAB 2023) as it concentrate on the material and mechanical properties of the material. It also focuses on the failure of the material such as brittle, necking, crack etc. And lastly it also refers to the hardness, strength and surface treatment of the material.

1.4 Objective

The objective of the project is to study the effect of various grit of sand papering towards the mechanical properties of the aluminum alloys and carbon fiber reinforce plastic in terms of hardness and tensile strength.

1.5 Scope of Study

The project will focus on:

i. Literature reviews on Aluminum Alloys and Carbon Fiber Reinforce Plastic (CFRP).
ii. Samples preparation.
iii. Hardness test and tensile test to determine the mechanical properties of the materials.
iv. Optical Microscope is used to analyze microstructure and morphology of the materials.

1.6 Feasibility of Project

The project is feasible as it utilizes the facilities in UTP's laboratory and the material (sand paper) is easily can get. This project is low in cost for analysis and brings huge benefits for the future.

CHAPTER 2

LITERATURE REVIEW/THEORY

2.1 Aluminum Alloy

In general, Aluminum (or aluminium ;) is a silvery white and ductile member belonging to the boron group of chemical elements. Its symbol is Al and its atomic number is 13. It is insoluble in water under normal circumstances. Aluminum is the most abundant metal in the Earth's crust, and the third most abundant element overall, after oxygen and silicon.

It is remarkable for the metal's ability to resist corrosion due to the phenomenon of passivation and also for its low density. Structural components which are made from aluminum and its alloys are of extreme utility to the aerospace industry and are a major contributor in other areas of transportation and building.

Aluminum alloys are alloys in which aluminum is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminum is used for wrought products, for example rolled plate, foils and extrusions. Cast aluminum alloys yield cost effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys.

Alloys composed mostly of the two lightweight metals aluminum and magnesium have been very important in aerospace manufacturing since 1940. Aluminum-magnesium alloys are both lighter than other aluminum alloys and much less flammable than alloys that contain a very high percentage of magnesium. Aluminum alloy surfaces will keep their apparent shine in a dry environment due to the formation of a clear, protective layer of aluminum oxide. In a wet environment, corrosion can occur when an aluminum alloy is placed in electrical contact with other metals with more negative corrosion potentials than aluminum.

Moreover, aluminum alloys with a wide range of properties are used in engineering structures. Alloy systems are classified by a number system (ANSI) or by names indicating their main alloying constituents (DIN and ISO). Selecting the right alloy for a given application entails considerations of its tensile strength, density, ductility, formability, workability, weldability, and corrosion resistance, to name a few. Aluminum alloys are used extensively in aircraft due to their high strength-to-weight ratio. On the other hand, pure aluminum metal is much too soft for such uses, and it does not have the high tensile strength that is needed for airplanes and helicopters.

On the other hand, aluminum alloys typically have an elastic modulus of about 70 GPa, which is about one-third of the elastic modulus of most kinds of steel and steel alloys. Therefore, for a given load, a component or unit made of an aluminum alloy will experience a greater elastic deformation than a steel part of the identical size and shape. Though there are aluminum alloys with somewhat-higher tensile strengths than the commonly-used kinds of steel, simply replacing a steel part with an aluminum alloy might lead to problems.

Generally, stiffer and lighter designs can be achieved with aluminum alloys than is feasible with steels. For instance, consider the bending of a thin-walled tube: the second moment of area is inversely related to the stress in the tube wall, i.e. stresses are lower for larger values. The second moment of area is proportional to the cube of the radius times the wall thickness, thus increasing the radius (and weight) by 26% will lead to a halving of the wall stress. For this reason, bicycle frames made of aluminum alloys make use of larger tube diameters than steel or titanium in order to yield the desired stiffness and strength. In automotive engineering, cars made of aluminum alloys employ space frames made of extruded profiles to ensure rigidity.

2.1.1 Properties of Aluminum Alloy

1. Light Weight

   Aluminum alloy is an extremely light metal with a specific weight of just 2.7 g/cm3, which is about a third that of steel. As an example, the use of aluminum alloy in vehicles reduces dead-weight and energy consumption while simultaneously increasing load capacity. Its strength can be adapted to the application desired by modifying the composition of its alloys.

2. Corrosion Resistance

   Aluminum alloy generates a protective oxide coating and is highly resistant to corrosion. Different types of surface treatment such as anodizing, painting or lacquering can further improve upon this property. It is mostly useful in applications where protection and conservation are required.

3. Electrical and Thermal Conductivity

   An excellent conductor of heat and electricity and in relation to its weight is almost twice as good a conductor as copper. This has made aluminum alloy one of the most commonly used materials in major power transmission lines.

4. Reflectivity

   A good reflector of visible light as well as heat, and that adding up to its low weight, makes it an ideal material for all kind of reflectors in, for example, light fittings or rescue blanket.

5. Ductility

   Highly ductile and has a low melting point and density. In a molten condition it can be processed in various ways. Its ductility allows products of aluminum to be basically formed in close range to the end of the product's design.

6. Recyclability

   It is completely recyclable with no downgrading of its qualities. The re-melting of aluminum requires minimum energy: just about 5 percent of the energy needed to produce the primary metal initially is needed during the recycling process.

2.2 Carbon Fiber Reinforced plastic

A composite material typically consists of relatively strong, stiff fibers in a tough resin matrix. Better known man-made composite materials, used in the aerospace and other industries, is carbon fiber reinforced plastic (CFRP) which is stiff and strong (for the density), but brittle, in a polymer matrix, which is tough but neither particularly stiff nor strong.

Composite materials (or composites for short) are engineered materials made from two or more constituent materials that remain separate and distinct on a macroscopic level while forming a single component. There are two categories of constituent materials: matrix and reinforcement. At least one portion (fraction) of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart special physical (mechanical and electrical) properties to enhance the matrix properties. A synergism produces material properties unavailable from naturally occurring materials. Due to the wide variety of matrix and reinforcement materials available, the design potential is incredible. [3, 4]

Carbon fiber reinforced polymer (CFRP) is a kind of polymer matrix composite material reinforced by carbon fibers. The reinforcing dispersed phase may be in the form of either continuous or discontinuous carbon fibers, commonly woven into a cloth. Carbon fibers are expensive but they possess the highest specific mechanical properties per weight, such as modulus of elasticity and ultimate strength.

Moreover, CFRP is a strong, light and very expensive composite material or fiber reinforced plastic. Similar to glass-reinforced plastic, which is sometimes simply called fiberglass, the composite material is commonly referred to by the name of its reinforcing fibers (carbon fiber). The plastic is most often epoxy, but other plastics, such as polyester, vinylester or nylon, are also sometimes used.[6]

Some composites contain both carbon fiber and fiberglass reinforcement. Less commonly, the term graphite-reinforced plastic is also used. It has many applications in aerospace and automotive fields, as well as in sailboats, and notably in modern bicycles, where these qualities are of importance. It is becoming increasingly common in small consumer goods as well, such as laptop computers, tripods, fishing rods, racquet sports frames, stringed instrument bodies, classical guitar strings, and drum shells.

The choice of matrix can have a profound effect on the properties of the finished composite. One common plastic for this application is graphite epoxy, and materials produced with this methodology are generically referred to as composites. The material is produced by layering sheets of carbon fiber cloth into a mold in the shape of the final product. The alignment and weave of the cloth fibers is important for the strength of the resulting material. In professional applications, all air is evacuated from the mold, but in applications where cost is more important than structural rigidity, this step is skipped. The mold is then filled with epoxy and is heated or air cured.

The process in which most CFRP is made varies, depending on the piece being created, the finish (outside gloss) required, and how many of this particular piece are going to be produced. For simple pieces that relatively few copies are needed of (1-2 per day) a vacuum bag can be used. A fiberglass or aluminum mold is polished, waxed, and has a release agent applied before the fabric and resin are applied and the vacuum is pulled and set aside to allow the piece to cure (harden). There are two ways to apply the resin to the fabric in a vacuum mold. One is a wet layup, where the two-part resin is mixed and applied before being laid in the mold and placed in the bag. The other is a resin induction system, where the dry fabric and mold are placed inside the bag while the vacuum pulls the resin through a small tube into the bag, then through a tube with holes or something similar to evenly spread the resin throughout the fabric. Wire loom works perfectly for a tube that requires holes inside the bag. Both of these methods of applying resin require hand work to spread the resin evenly for a glossy finish without pin-holes. A third method of constructing composite materials is known as a dry layup. Here, the carbon fiber material is already impregnated with resin and is applied to the mold in a similar fashion to adhesive film. The assembly is then placed in a vacuum to cure. The dry layup method has least amount of resin waste and can achieve lighter constructions than wet layup. [7, 8]

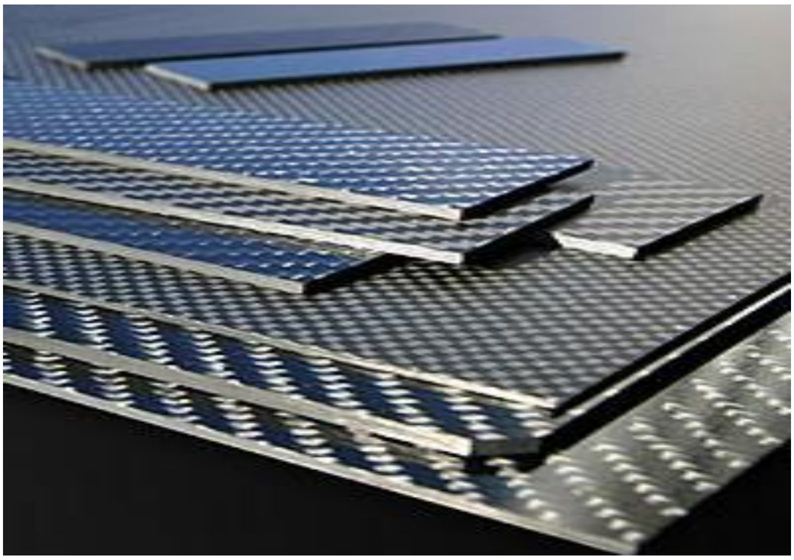


Figure 2.1: Carbon Fiber Reinforce Plastic [6]

A quicker method uses a compression mold. This is a two-piece (male and female) mold usually made out of fiberglass or aluminum that is bolted together with the fabric and resin between the two. The benefit is that, once it is bolted together, it is relatively clean and can be moved around or stored without a vacuum until after curing. However, the molds require a lot of material to hold together through many uses under that pressure.

Many CFRP parts are created with a single layer of carbon fabric, and filled with fiberglass. A chopper gun can be used to quickly create these types of parts. Once a thin shell is created out of carbon fiber, the chopper gun is a pneumatic tool that cuts fiberglass from a roll and sprays resin at the same time, so that the fiberglass and resin are mixed on the spot. The resin is either external mix, where the hardener and resin are sprayed separately, or internal, where they are mixed internally, which requires cleaning after every use. For difficult or impossible shapes (such as a tube) a filament winder can be used to make pieces.

Advantages	Disadvantages
Low density but have high tensile and strength.	Has low strain to failure.
Low thermal expansion coefficient and stable in absence of O_2 to over 3000 ^oC.	Compressive strength is low compared to tensile.
Chemical stability in strong acid particularly.	Oxidation catalyzed by an alkaline environment.
Bio compatibility and low electrical resistivity.	Tendency to oxidize and become gas on 400^oC upon heating in air.
Available in large continuous form.	Anisotropy.

Table 2.1: Advantages and Disadvantages of Carbon Fiber Composites. [6]

2.3 Sand Paper

Sandpaper is a form of paper where an abrasive material has been fixed to its surface. Sandpaper is part of the "coated abrasives" family of abrasive products. It is used to remove small amounts of material from surfaces, either to make them smoother (painting and wood finishing), to remove a layer of material (e.g. old paint), or sometimes to make the surface rougher (e.g. as a preparation to gluing). There are countless varieties of sandpaper, with variations in the paper or backing, the material used for the grit, grit size, and the bond. Materials used for the abrading particles are:

- flint — no longer commonly used
- garnet — commonly used in woodworking
- emery — commonly used to abrade or polish metal

- aluminum oxide — perhaps most common in widest variety of grits; can be used on metal (i.e. body shops) or wood
- silicon carbide — available in very coarse grits all the way through to micro grits, common in wet applications
- alumina-zirconia — (an aluminum oxide - zirconium oxide alloy), used for machine grinding applications
- chromium oxide — used in extremely fine micron grit (micrometer level) papers

Grit size refers to the size of the particles of abrading materials embedded in the sandpaper. The two most common are the United States CAMI (Coated Abrasive Manufacturers Institute, now part of the Unified Abrasives Manufacturers' Association) and the European FEPA (Federation of European Producers of Abrasives) "P" grade. The FEPA system is the same as the ISO 6344 standard. Other systems used in sandpaper include the Japan Industrial Standards Committee (JIS), the micron grade (generally used for very fine grits). The "ought" system was used in the past in the United States. Also, cheaper sandpapers sometimes are sold with nomenclature such as "Coarse", "Medium" and "Fine", but it is not clear to what standards these names refer.

In this project, I am using 60, 120, and 180 CAMI grit designation which are the average particle diameter are 265µm, 115 µm, and 82 µm.

Table 2.2: Sandpaper Grit Size Standard

	ISO/FEPA Grit designation	**CAMI Grit designation**	**Average particle diameter (µm)**
MACROGRITS			
Extra Coarse (Very fast removal of material)	P12		1815
	P16		1324
	P20		1000
	P24		764
		24	708
	P30		642
		30	632

		36	530
	P36		538
Coarse (Rapid removal of material)	P40	40	425
		50	348
	P50		336
Medium (sanding bare wood in preparation for finishing)		60	265
	P60		269
	P80		201
		80	190
Fine (sanding bare wood in preparation for finishing)	P100		162
		100	140
	P120		125
		120	115
Very Fine (final sanding of bare wood)	P150		100
		150	92
	P180	180	82
	P220	220	68
MICROGRITS			
Very Fine (sanding finishes between coats)	P240		58.5
		240	53
	P280		52.2
	P320		46.2
	P360		40.5
Extra fine		320	36
	P400		35
	P500		30.2
		360	28
	P600		25.8
Super fine (final sanding of finishes)		400	23
	P800		21.8
		500	20
	P1000		18.3
		600	16
	P1200		15.3
Ultra fine (final sanding of finishes)	P1500	800	12.6
	P2000	1000	10.3
	P2500		8.4

2.4 Tensile strength

Tensile strength σ_{UTS}, or S_U is the stress at which a material breaks or permanently deforms. Tensile strength is an intensive property and, consequently, does not depend on the size of the test specimen. However, it is dependent on the preparation of the specimen and the temperature of the test environment and material.

Tensile strength, along with elastic modulus and corrosion resistance, is an important parameter of engineering materials that are used in structures and mechanical devices. It is specified for materials such as alloys, composite materials, ceramics, plastics and wood. [8] There are three typical definitions of tensile strength:

1. Yield strength: The stress at which material strain changes from elastic deformation to plastic deformation, causing it to deform permanently.
2. Ultimate strength: The maximum stress a material can withstand.
3. Breaking strength: The stress coordinate on the stress-strain curve at the point of rupture.

2.5 Hardness

Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting. Hardness is not an intrinsic material property dictated by precise definitions in terms of fundamental units of mass, length and time.[10] A hardness property value is the result of a defined measurement procedure. Hardness of materials has probably long been assessed by resistance to scratching or cutting.

The above relative hardness tests are limited in practical use and do not provide accurate numeric data or scales particularly for modern day metals and materials. The usual method to achieve a hardness value is to measure the depth or area of an indentation left by an indenter of a specific shape, with a specific force applied for a specific time. There are three principal standard test methods for expressing the relationship between hardness and the size of the impression, these being Brinell, Vickers, and Rockwell.

CHAPTER 3
METHODOLOGY

3.1 Process Flow

Below is the process flow of my project process representing by the flow chart.

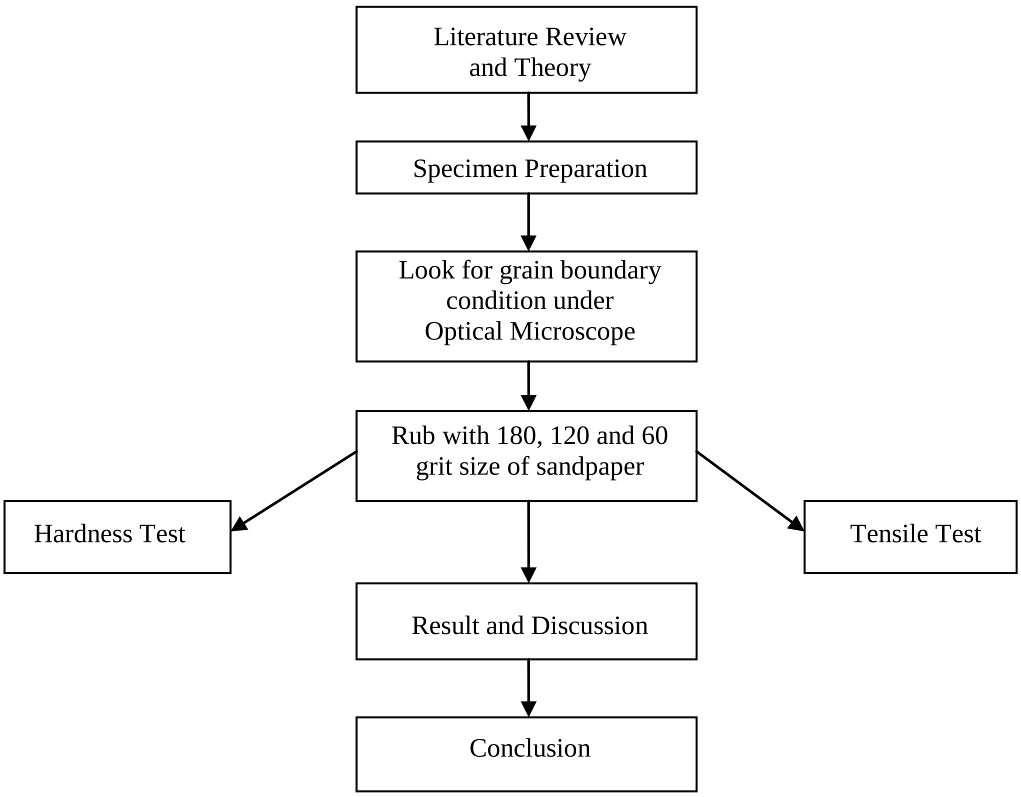


Figure 3.1: Flowchart of the Process Flow

3.2 Tools/Equipment Required

The tools and equipment which are required in this Final Year Project are a Windows based PC together with the programs such as Microsoft Office that has Words, Excel, Project, and Imaging. Besides that, sandpapers of various grit sizes (60, 120, and 180), CFRP ply, Aluminum Alloy 2024, Optical Microscope, Hardness Testing Machine and Universal Testing Machine (UTM) will also be needed for this project.

3.3 Materials

Carbon fiber reinforced plastic and Aluminum Alloy 2024 were been obtained from Sepang Aircraft Engineering Sdn. Bhd. (SAE).

3.4 Testing Technique

3.4.1 Sample Preparation

a) The CFRP then has been cut into 25mm x 250mm with the thickness is 2.5mm according to ASTM D 3039/D 3039-00 El.

Figure 3.2: CFRP Specimens

b) The Aluminum Alloy 2024 has been cut to dog bone shape according to ASTM B557-06.

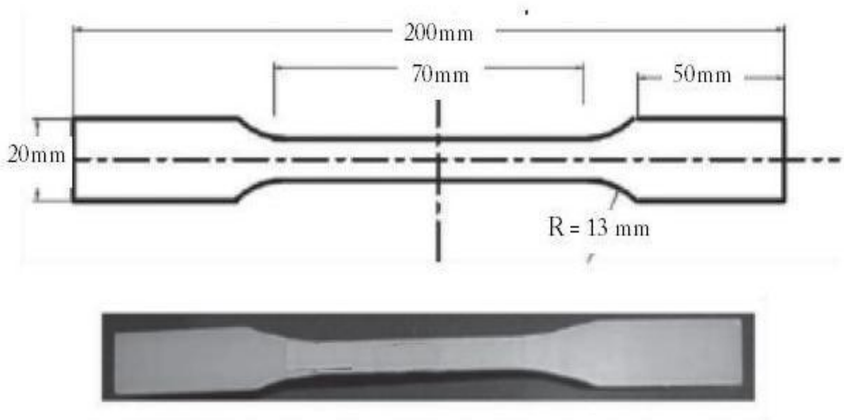


Figure 3.3: Aluminum Alloys Specimen

3.4.2 Sandpapering

The specimens of CFRP and Aluminum Alloy 2024 then been rubbed with 60, 120, and 180 grit size of sandpaper using Polish Machine. Each specimen will undergo the same period time for sandpapering effect which is 120s and the same speed of rotation of the spindle polish machine.

Figure 3.4: Sandpaper 60, 120, and 180 grit size

3.4.3 Hardness Test

The specimens will undergo the Rockwell Hardness testing after being rubbed by the sandpaper by using 1/2 steel ball with initial force of 100kg for CFRP and 1/16 steel ball with initial force of 100kg for Aluminum Alloy 2024.

Figure 3.5: Rockwell Hardness Testing Machine

Scale	Indenter	Minor Load *F0* kgf	Major Load *F1* kgf	Total Load *F* kgf	Value of *E*
A	Diamond cone	10	50	60	100
B	1/16" steel ball	10	90	100	130
C	Diamond cone	10	140	150	100
D	Diamond cone	10	90	100	100
E	1/8" steel ball	10	90	100	130
F	1/16" steel ball	10	50	60	130
G	1/16" steel ball	10	140	150	130
H	1/8" steel ball	10	50	60	130
K	1/8" steel ball	10	140	150	130
L	1/4" steel ball	10	50	60	130
M	1/4" steel ball	10	90	100	130
P	1/4" steel ball	10	140	150	130
R	1/2" steel ball	10	50	60	130
S	1/2" steel ball	10	90	100	130
V	1/2" steel ball	10	140	150	130

Table 3.1: Rockwell Hardness Scales [10]

3.4.4 Tensile Testing

Testing is performed in a Universal Testing Machine (UTM) similar to the screw-driven machine as shown in the Figure 3.6 or by a servo-hydraulic test machine. The essential characteristics of either test machine are a stiff box, or movable crosshead or hydraulic actuator, a stationary crosshead mounted at the two of the test frame, and a load measuring device. In UTM, the movable crosshead is driven precisely by twin screws at a specified speed relative to the stationary member to generate either tension or compression loads. A load cell is mounted in either tension or compression loads. Screw-hydraulic machines are constructed with a base, a vertical test frame, and a stationary cross-head. Loading is achieved through the hydraulic actuator mounted either in the base or in the stationary crosshead. The servo-hydraulic machines are controlled by computers that can generate complex wave shapes and frequency spectra to simulate actual loading histories and digitally acquire and store measured test data. A UTM with 100kN is used in this project.

Figure 3.6: Universal Testing Machine 100kN

CHAPTER 4

RESULT AND DISCUSSION

4.1 Hardness Testing (Rockwell)

The experiment was repeated five times for each criterion and takes the average reading.

No.	Initial	180 grit sandpaper	120 grit sandpaper	60 grit sandpaper
1	119.6	118.5	113.8	101.7
2	122.1	117.8	112.9	112.4
3	120.6	118.1	115.9	108.1
4	119.1	115.6	114.7	106.7
5	121.5	117.1	115.5	106.5
AVG	***120.58***	***117.42***	***114.56***	***107.08***

Table 4.1: Hardness Test value for CFRP using 1/2 steel balls with 100kg force

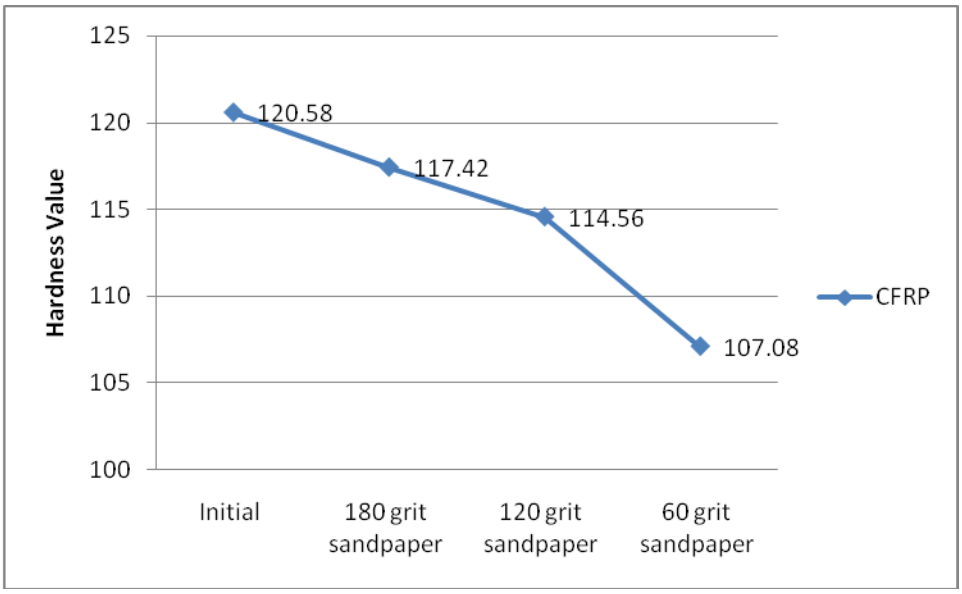


Figure 4.1: Graph of the average of Hardness versus Various Grit Size of Sandpaper for CFRP

From the data tabulated above, the initial value for the hardness of CFRP before being rubbing with any grit of sandpaper is 120.58. After being rubbed with sandpaper grit 180, the value decrease to 117.42. Then the value decrease to 114.56 after being rubbed with sandpaper grit 120. When using sandpaper grit 60, the hardness value became 107.8. From the experiment we can see that the hardness value is decreasing when the sandpaper grit size is decreasing. We can say that the more rough the sandpaper the less value for the hardness.

No.	Initial	180 grit sandpaper	120 grit sandpaper	60 grit sandpaper
1	125.7	126.7	125.6	120
2	126.3	126.2	125.2	122.7
3	126.9	124.6	124.2	121.9
4	127.2	126.7	123.1	122.5
5	126.8	125.2	124.3	123.1
AVG	**126.58**	**125.88**	**124.48**	**122.04**

Table 4.2: Hardness Test value for Aluminum Alloy 2024 using 1/16 steel balls with 100kg force

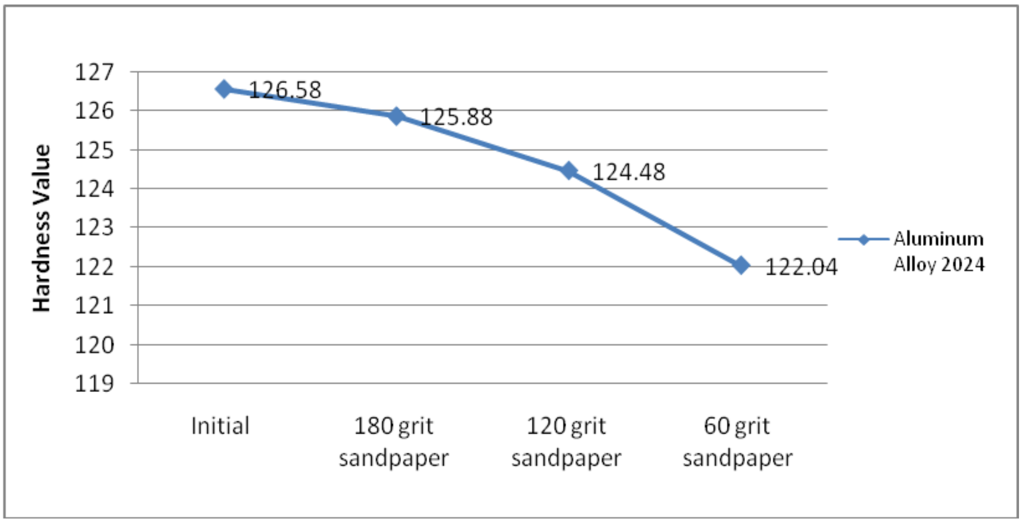


Figure 4.2: Graph of the average of Hardness versus Various Grit Size of Sandpaper for Aluminum Alloy 2024

From Figure 4.2, it shows that the initial value for the hardness of Aluminum Alloy 2024 before being rubbing with any grit of sandpaper is 126.58. After being rubbed with sandpaper grit 180, the value decrease to 125.88. Then the value decrease to

124.48 after being rubbed with sandpaper grit 120. When using sandpaper grit 60, the hardness value became 122.04. This is due to the fact that the more rough the sandpaper the less value for the hardness.

4.2 Tensile Testing

Breaking Point (kN)	Initial	180 grit sandpaper	120 grit sandpaper	60 grit sandpaper
#1	47.77	44.52	42.39	40.34
#2	48.21	44.1	42.07	40.82
#3	47.66	42.39	41.78	41.18
AVG	**47.88**	**43.67**	**42.08**	**40.78**

Table 4.3: Tensile Test Value for Carbon Fiber Reinforce Plastic (CFRP)

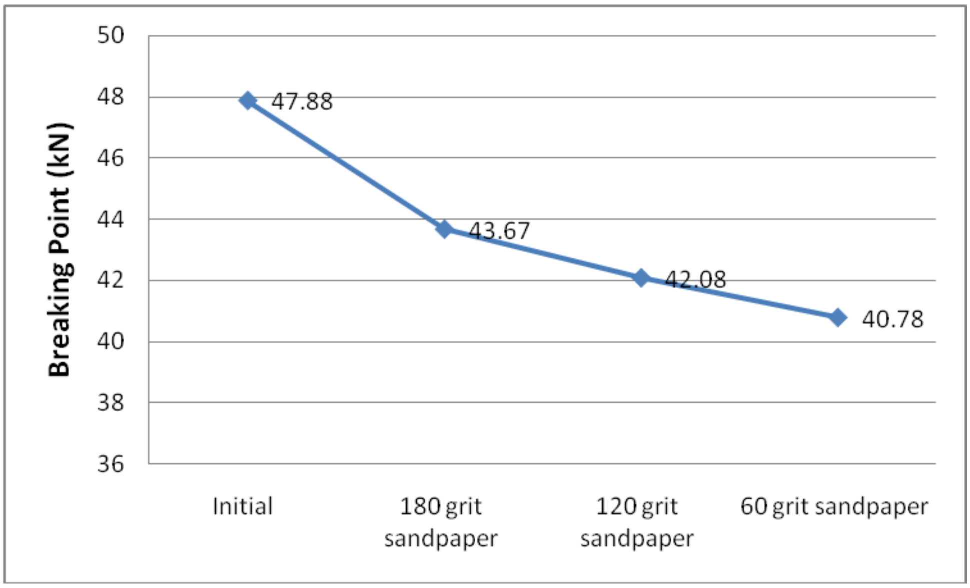


Figure 4.3: Graph Average of Breaking Point versus Various Grit Size of Sandpaper for CFRP

From the result, it shows that the average breaking point for the specimen before being rubbed with sandpaper is the highest with 47.88 kN, then decrease to 43.67 kN after being rubbed with sandpaper grit 180 followed by the average breaking point of 42.08 kN and 40.18 kN after being rubbed with sandpaper grit 120 and grit 6o. It shown that the more rough the sandpaper it will reduce the tensile strength of the material.

Breaking Point (kN)	Initial	180 grit sandpaper	120 grit sandpaper	60 grit sandpaper
#1	17.978	17.933	17.555	17.329
#2	18.011	17.875	17.48	16.961
#3	17.967	17.671	17.511	17.112
AVG	**17.99**	**17.83**	**17.52**	**17.13**

Table 4.4: Tensile Test Value for Aluminum Alloy 2024

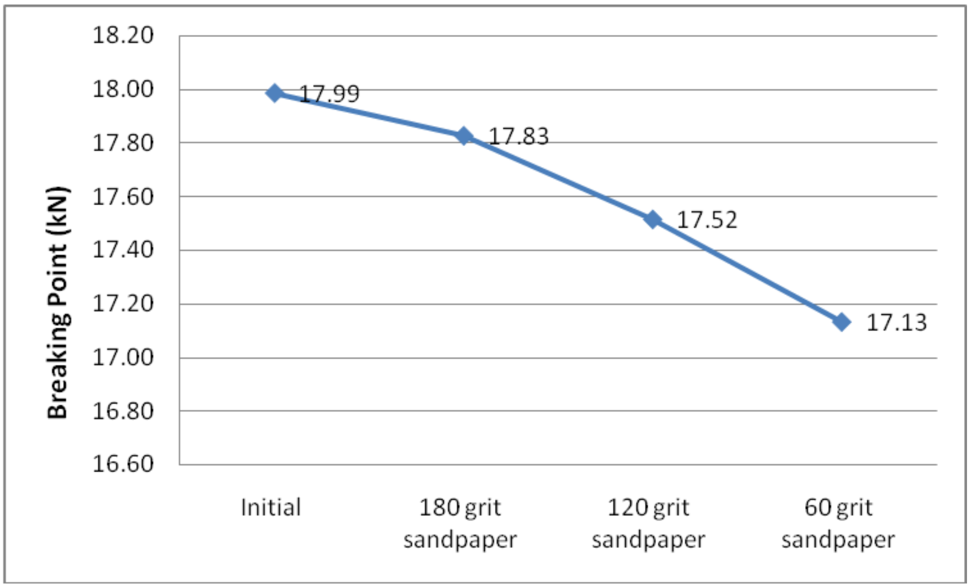
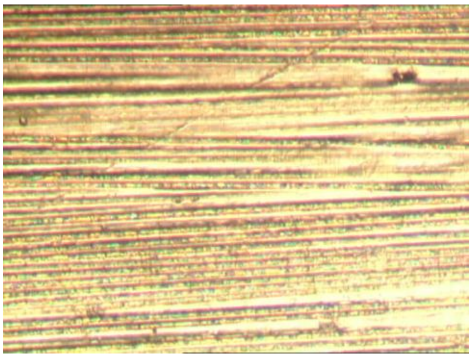


Figure 4.4: Graph Average of Breaking Point versus Various Grit Size of Sandpaper for Aluminum Alloy 2024

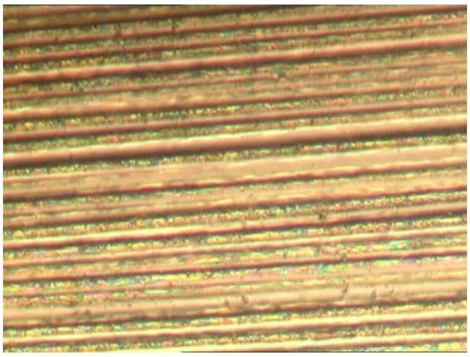
Figure 4.4 shows the average breaking point for Aluminum Alloy 2024 before being rubbed with sandpaper and after being rubbed with sandpaper with 180 grit, 20 grit and 60 grit size of sandpaper. It shows that the trends of average breaking point are similar to the average breaking point of CFRP. Before being rubbing with any grit of sandpaper, the initial value of the average breaking point is 17.99 kN. After being rubbed with sandpaper grit 180, the value decrease to 17.83 kN. Then the value decrease to 17.52 kN after being rubbed with sandpaper grit 120. When using sandpaper grit 60, the hardness value became 17.13 kN. It shown that the more rough the sandpaper it will low the tensile strength of the material.

4.3 Image with Optical Microscope

Here are the images of CFRP for initial condition and after been rubbed with 180, 120, 60 grit size of sandpaper.



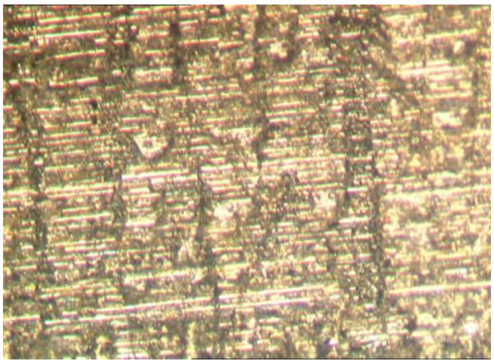
100X



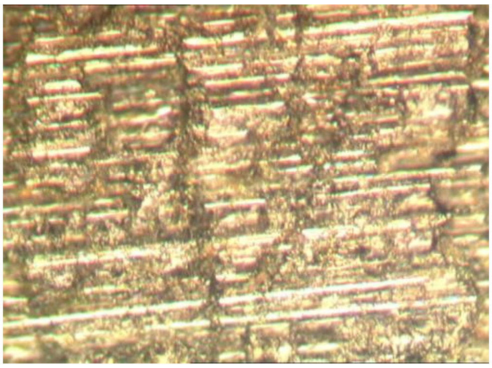
200X

Figure 4.5: Initial image of CFRP under 100x and 200x Optical Microscope

For Figure 4.5, these are images taken before the samples undergo any test (rubbing with various grit size of sand papering). Carbon Fiber Reinforce Plastic (CFRP) are typically organized in a laminate structure, such that each lamina (or flat layer) contains an arrangement of woven fiber fabrics embedded within a thin layer of light polymer matrix material as shown in the morphology above. There is also some crack and dirt maybe a defect during the fabrication and sample preparation for CFRP.



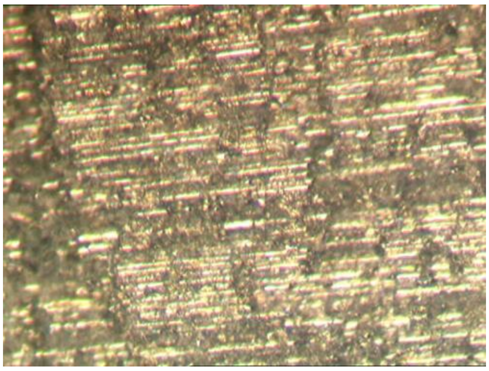
100X

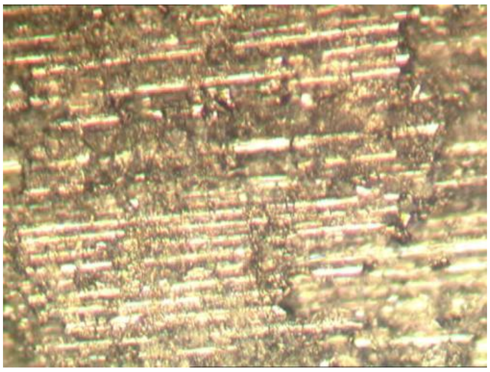


200X

Figure 4.6: Image of CFRP after been rubbed with 180grit sandpaper

Figure 4.6 shows the images of the CFRP after been rubbed with 180 grit size of sandpaper; there is almost no change in the overall structure but for certain area there is a little bit cracks at the fiber and matrix.

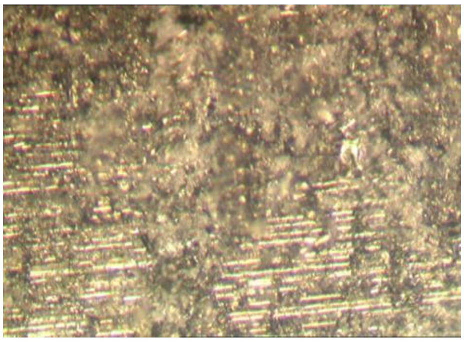


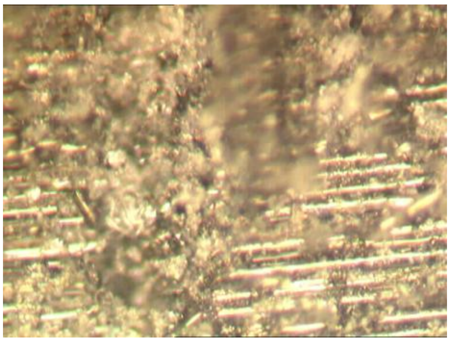


100X 200X

Figure 4.7: Image of CFRP after been rubbed with 120grit sandpaper

Figure 4.7 shows the images of the CFRP after been rubbed with 120 grit size of sandpaper, there is found a little bit degraded and got many cracks at the fiber and the matrix of the overall structure.





100X 200X

Figure 4.8: Image of CFRP after been rubbed with 60 grit sandpaper

Figure 4.8 shows the images of the CFRP after been rubbed with the 60 grit size of sandpaper, the fibers are found degraded and the matrix of the CFRP is totally deformed. It also affects the physical look of the specimen.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In the hardness test, we can see that the hardness value for Aluminum Alloys is decreasing from 0.55% to 3.6% and for CFRP the hardness value is decreasing from 2.6% to 11.2%. It is shown that the hardness value is decreasing when the sandpaper grit size is decreasing.

For the tensile test, we notice that the breaking point value for Aluminum Alloys is decreasing from 0.88% to 4.7% and for CFRP the breaking point value is decreasing from 8.8% to 14.8%. It is shown that the breaking point value is decreasing when the sandpaper grit size is decreasing.

As the Carbon Fiber Reinforce Plastic (CFRP) and Aluminum Alloy were exposed to the sandpapering effect, it will affect the mechanical properties of materials because of the friction happened between them.

For the conclusion, the methodology which is used in this project can support the objective in the project which is to compare various grit of sand paper towards the mechanical strength of the CFRP and Aluminum Alloy. It is proved that sandpapering effect the hardness and the tensile strength of the materials. It will reduce the mechanical properties when surface finish is applied on the materials.

5.2 Recommendation

For the future work and continuation of this project, I would suggest simulating and modeling the project using Fluent/Gambit or Ansys (engineering software) so that the result will be more accurate and the effect of sandpapering can be varied. And try to do other test to study the Mechanical Properties of the material such as stiffness (Young's Modulus), fracture toughness, and ultimate strength. The result will be more accurate if there are many experiments and tests have been conducted (repeat 5 times) and more material is provided.

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APPENDIX A – GANTT CHART FYP 1

No	Detail / Week	1	2	3	4	5	6	7	Mid –semester Break	8	9	10	11	12	13	14
1	Find source on material															
2	Find journal regarding the title															
3	Discuss Chapter 2 (literature review)															
4	Submission of Preliminary Report				▲											
6	Project work															
7	Submission of Progress Report									▲						
8	Seminar									▲						
9	Project work continues															
10	Submission of Interim Report Final Draft															▲
11	Oral presentation															▲

APPENDIX B – GANTT CHART FYP 2

No	Detail / Week	1	2	3	4	5	6	Mid –semester Break	7	8	9	10	11	12	13	14
1	Project work (sample preparation)															
2	Submission of Progress Report 1				▲											
3	Project work (Identification of equipment & experiment setup)															
4	Submission of Progress Report 2									▲						
5	Seminar									▲						
6	Submission of Poster												▲			
7	Project work (Laboratory experiment)															
8	Submission of Dissertation													▲		
9	Oral presentation														▲	
10	Submission of Hardbound Dissertation															▲

APPENDIX C

Figure C1: Graph tensile test for Aluminum Alloy before being rubbed with sandpaper

Figure C2: Graph tensile test for Aluminum Alloy after being rubbed with sandpaper grit size 180

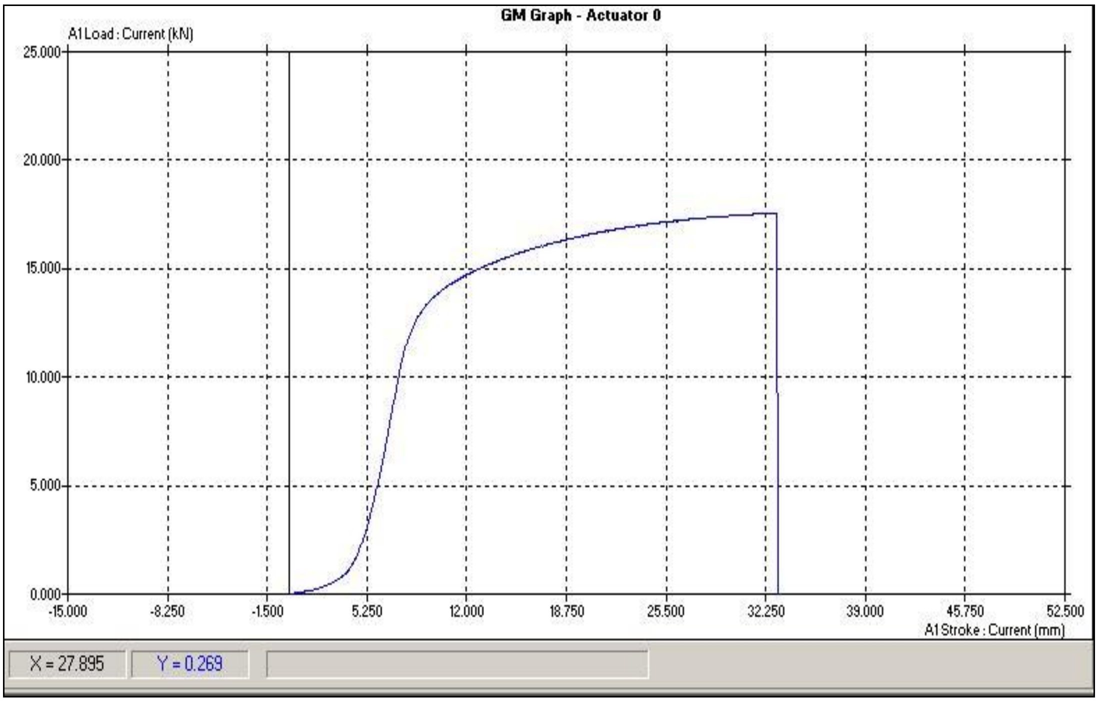

Figure C3: Graph tensile test for Aluminum Alloy after being rubbed with sandpaper grit size 120

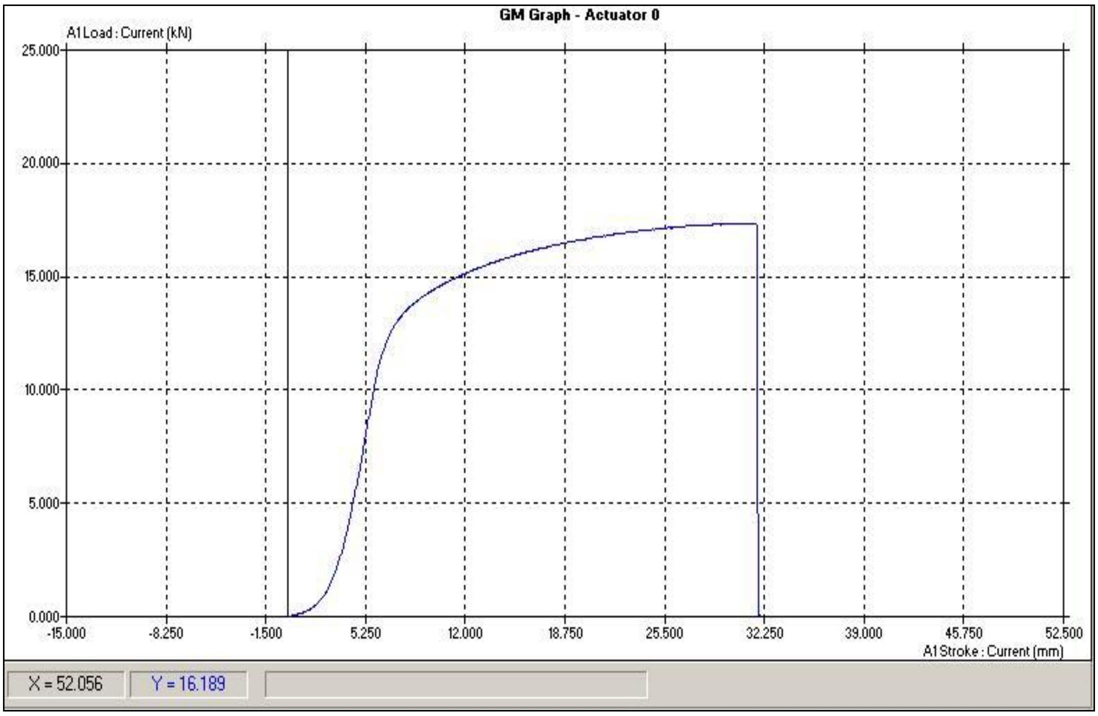

Figure C4: Graph tensile test for Aluminum Alloy after being rubbed with sandpaper grit size 60

Figure C5: Graph tensile test for initial Carbon Fiber Reinforce Plastic (CFRP) before being rubbed with sandpaper

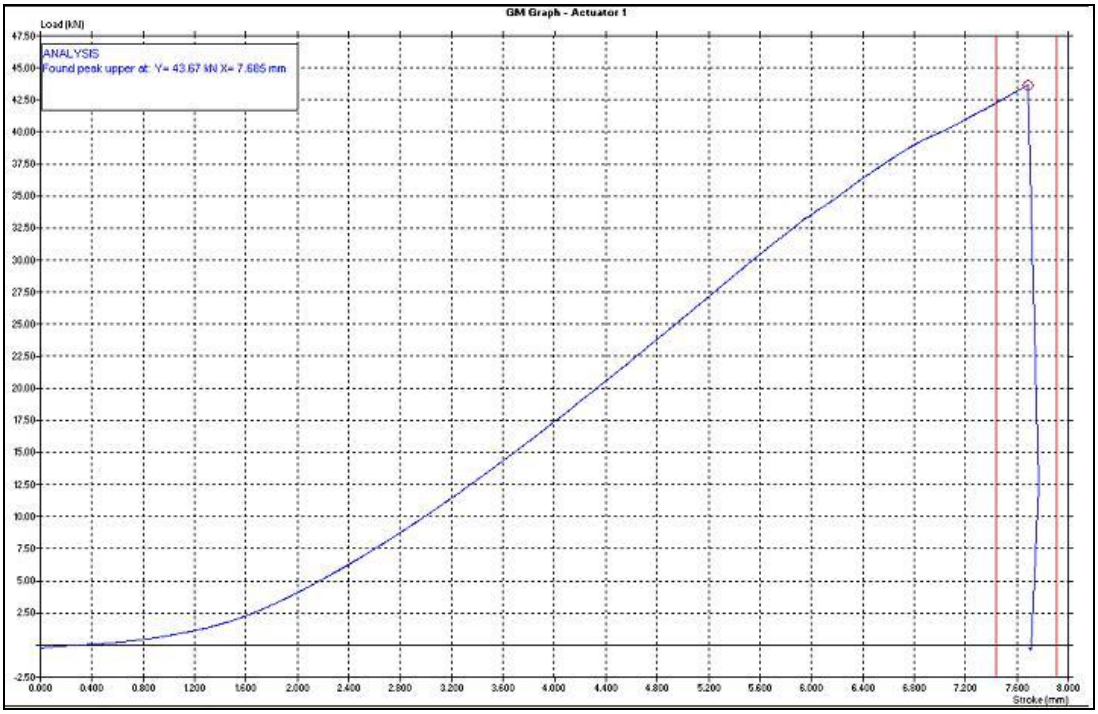

Figure C6: Graph tensile test for Carbon Fiber Reinforce Plastic (CFRP) after being rubbed with sandpaper grit size 180

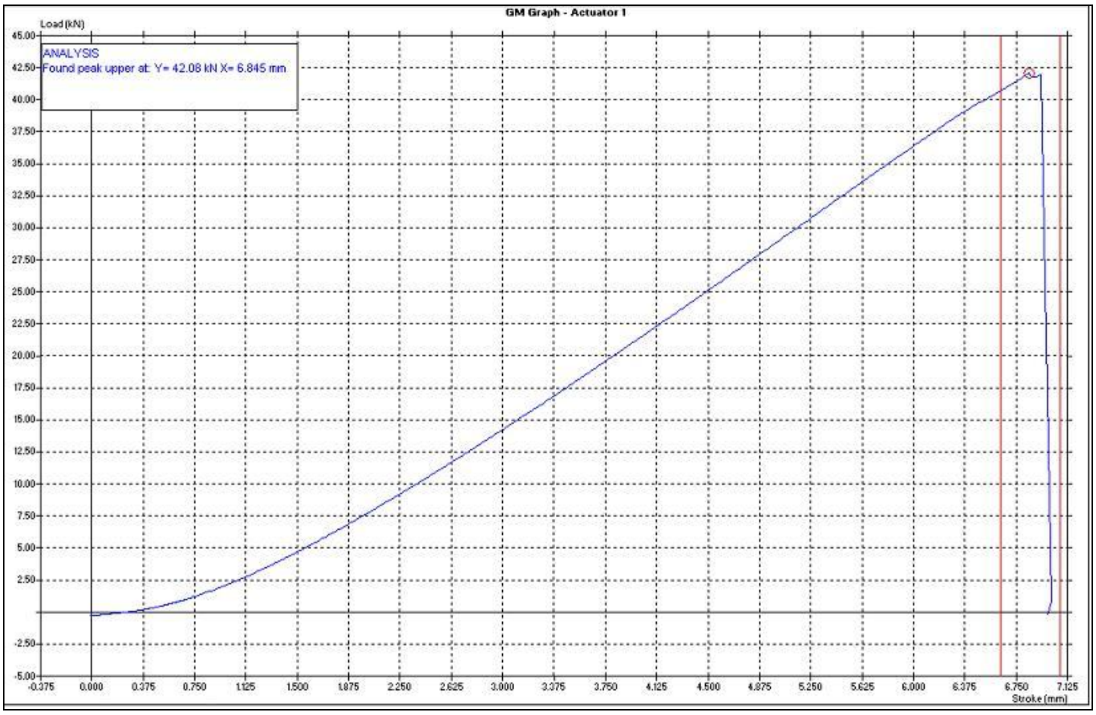

Figure C7: Graph tensile test for Carbon Fiber Reinforce Plastic (CFRP) after being rubbed with sandpaper grit size 120

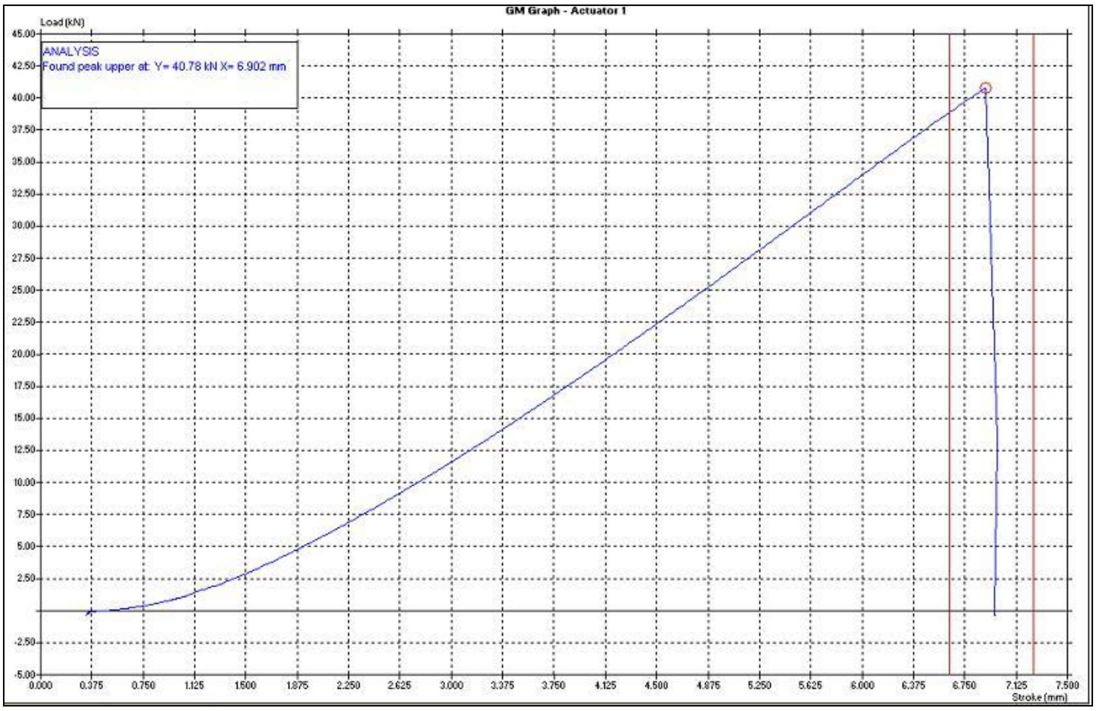

Figure C8: Graph tensile test for Carbon Fiber Reinforce Plastic (CFRP) after being rubbed with sandpaper grit size 60