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"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (structure and Material with Honors)"

Signature: ……………………………………..

Supervisor: ……………………………………..

Date: ……………………………………….

DECLARATION

"I hereby declare that the work in this thesis sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure and Material with Honors)"

Signature: ……………………………………..

Name: ……………………………………..

Date: ……………………………………

Dedicated specially for

My beloved family

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ABSTRACT

Weight is one of the important aspects in the aerospace engineering because the increase of weight will make the needed of lift force also increase. In order to reduce weight of air spoiler on the airplane, the method of manufacturing material is the crucial factor to consider. The goal of this study is to fabricate composite specimen for hinge spoiler A320 airplane, by using Resin Transfer Molding technique. The composite material is chosen because of its characteristics such as light in weight and resist to corrosion. Initially, the hinge of the spoiler was made of metal, which have their own advantages and disadvantages. The research starts by fabricating the specimen by using Resin Transfer Molding (RTM). RTM is chosen because of low of volatiles released to the atmosphere, lower tooling cost compare to other competitive processes and has a good quality of product in term of surface finish and accuracy of the dimension. The process fabrication starts with lie the dry carbon in the mold and clamp the mold before inject the resin in the mold. Flow of the resin in the mold is by gravity pressure, to avoid formation of bubbles or porosity on specimen. Injected mold will be left to rest in the cooling process. Then the specimen will undergo testing process to obtained mechanical properties of material. Two types of specimens were designed with one and two plies of dry carbon respectively. The result of testing will be compared to the Hand Lay Up method. The result shows that the strength of the two plies of dry carbon has higher strength compared to one plies of dry carbon. The strength of the material is similar while using RTM method or Hand Lay Up method.

ABSTRAK

Berat adalah salah satu aspek yang sangat penting untuk dipertimbangkan kejuruteraan angkasa, ini kerana semakin tinggi berat semakin tinggi daya angkat yang diperlukan oleh kapal terbang tersebut. Dalam usaha untuk mengurangkan berat “spoiler” kapal terbang, material pembuatan adalah aspek yang sangat penting yang perlu dipertimbangkan. Matlamat kajian ini adalah menghasilkan bahan untuk kegunaan engsel spoiler A320 dengan menggunakan teknik “Resin Tranfer Molding”. Composite dipilih kerana ciri-ciri yang ada pada komposit seperti ringan dan tidak berkarat. Teknik RTM dipilih kerana kos pengendaliannya yg murah dan mudah. Kajian bermula dengan pembuatan sampel dari karbon kering dan epoxy. Karbon kering dikampirkan kedalam acuan dan resin masukkan kedalam acuan. Pengaliran resin adalah berdasarkan tekanan gravity, kemudian sampel akan dibiarkan untuk process pengeringan. Sample bahan akan diuji dengan kaedah tarikan. Dua jenis sample dihasilkan, iaitu sample mempunyai satu lapisan karbon kering dan dua lapisan karbon kering. Hasil ujian akan dibandingkan dengan jaedah “Hand Lay Up”. Keputusan ujian menunjukkan dua lapisan karbon kering mempunyai kekuatan yang lagi tinggi berbanding satu lapisan. Kekuatan bahan yang dihasilkan melalui teknik RTM dan Hand Lay Up adalah hampir sama.

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LIST OF ABBREVIATION

UTeM	University Teknikal Malaysia Melaka
RP	Rapid Prototyping
UV	Ultra Violet
Co_2	Carbon Dioxide
DGEBA	Dglycidyl Ether of Bisphenol
SMC	Sheet Molding Compound
RTM	Resin Transfer Molding
cP	Coefficient of Pressure
CAD	Computer Aided Design
STL	Stereo Lithography
SRIM	Stopping and Range of ions in Matter
MIN	Minutes
GFRP	Glass Reinforced Polymers
KFRP	Kevlar Fiber Reinforced
FDM	Fused Deposition Modelling
LOAM	Laminated Object Manufacturing

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

One of advance technology in aerospace technology is a spoiler technology. Spoilers are hinged, rectangular plate, like structures installed flush along the top of an aircraft wings. Just forward of the flaps. When the pilot activates the spoiler, the plate pivot up on their center hinge fitting into the airstream. The airflow over the wing is disturbed and lift is decreased. Maximum deployment of the spoiler would be about 50° from the flush position. The spoiler is a multifunctional flight control surface with three main functions, in-flight air braking for speed reduction. In-flight roll control for augment ailerons in turning, and air-braking on the ground during lift dumping. The latter dispels the remaining lift as an aircraft touches down on a runway. This increases the efficiency of the wheel brakes by applying the full weight of the aircraft on the wheels.

The function of hinge is to attach the aircraft spoiler to the wing of aircraft. The hinge of aircraft spoiler is made of composite material which has more toughness, high in strength, resist to corrosion and light in weight compare to the metal or alloy material, which has high corrosion in certain of condition. Metal also has high in weight and not suitable for aircraft component. The processional way in ancient Babylon, one of the lesser wonders of the ancient world, was made of bitumen reinforced with plaited straw. Straw and horse hair has been used to reinforce mud bricks improving their fracture toughness for at least 5000 years. Papers is a composites; so is concrete: both were known to the Romans. And almost all materials which must bear load-wood, bone, muscle-are composites.

The composites industries, however is much more recent. It has grown rapidly in the past 60 years with the development of fiber composites starting with glass-fiber reinforced polymers (GFRP) and Kevlar-fiber reinforced polymers (KFRP). Their use in boats, and their increasing replacement of metals in aircraft and ground transport system, is a revolution in material usage which is still accelerating.

Plywood is a lamellar composite, giving a material with uniform properties in the plane of the sheet (unlike the wood from which it is made). Sheet of GFRP or CFRP are laminated together, for the same reason. And sandwich panels-composites made of stiff skins with a low-density core-achieve special properties by combining, in a sheet, the best features of two very different components.

Cheapest of all are the particulate composites. Aggregate plus cement gives concrete, and the composites are cheaper than the cement itself. Polymers can be filled with sand, silica flour, or glass particles, increasing the stiffness and wear resistance, and often reducing the price. And one particulate composite, tungsten carbide particles in cobalt, is the basis of the cutting tool industry.

But high stiffness is not always what you want. Cushions, packaging, and crash padding require materials with moduli that are lower than those of any solid. This can be done with foams-composites of a solid and a gas which have properties that can be tailored, with great precision, to match the engineering need.

The development of hinge is by Resin Transfer Method. The resin transfer moulding (RTM) process has been the subject of a great deal of practical and theoretical development for aerospace applications since the early 1980s. This article looks at the very early developments of RTM in an aerospace setting. This development took place over a few years at the start of the 1950s. By 1956 almost all the features of RTM for aerospace applications had been introduced in a series of six patents.[14] This achievement was made without any of the theoretical infrastructure now considered critical and was the work of a small group within a single company. The developed technology dropped from view in the general aerospace composites community and had to be redeveloped 25 years after the last patent was applied for The RTM are based on liquid injection method. The composite resin will injected to the closed mold of hinge using RTM machine. RTM is not a new process. It has been used in one form or another since the early 1940's. However, its use was limited until the 1970's because of the lack of suitable resins and equipment. In the 1980's fiber preforms and low viscosity resins were developed that allowed the production of more complex geometries and parts for more diverse applications. This, combined with low capital investment and release of volatiles, has dramatically improved the popularity of RTM.

1.2 PROBLEM STATEMENT

Nowadays the properties and the behavior of the material is the crucial aspect need to be considered in developing the fabrication process. The metal material has lots of weakness such as it doesn't resist to corrosion and has higher weight. To improve the design in term of weight of material, resistance to corrosion and cost saving, the new design will be developed by using composite material. The fabrication cost of the conventional composite using autoclave is quite high. For that reason the cheaper method was chosen. After doing some research, resin transfer molding (RTM) method is founded as the cheaper method for fabrication compared to autoclave method.

1.3 OBJECTIVE

- Fabricate composite specimen by using Resin Transfer Molding at Kolej Kemahiran Tinggi Mara Masjid Tanah Melaka.
- Investigate mechanical properties of material composite made with epoxy as reinforcements and dry carbon as matrix through Tensile Test.
- Compare the composites which are fabricated by using Resin Transfer Molding and Hand Lay Up method

1.4 SCOPE

The scope of this research is to conduct reviews on laminate composite, RTM and the design of the molding. In order to produce a composite specimen, the fabricating of the specimen using RTM is at KKTM Masjid Tanah. For the last step, specimen goes through the testing process to carry out the mechanical properties of the composite material.

CHAPTER 2

LITERATURE REVIEW

2.0 MATERIAL COMPOSITE

The advanced material was developed rapidly to improve the performance of the part. The scientist and industries do some research about the material to produce material or product that is lighter, stronger and more efficient. This proved by automotive and aerospace industries, with increase of the fuel cost will influence the operation cost of the vehicle. For that reason the manufacturer makes an effort to increase fuel efficiency without increasing product cost, by increasing the product performance and achieving low cost target.

A composite material is made by combining two or more materials to give a unique combination of properties. The above definition is more general and can include metals, alloys, plastic co-polymers, minerals, and wood. Fiber-reinforced composite materials differ from the above materials in that the constituent materials are different at the molecular level and are mechanically separable. [14] In bulk form, the constituent materials work together but remain in their original forms. The final properties of composite materials are better than constituent material properties.

The concept of composites was not invented by human being; it is found in nature. An example is wood, which is a composite of cellulose fibers in a matrix of natural glue called lignin. The shell of invertebrates, such as snails and oysters, is an example of a composite. Such shells are stronger and tougher than man-made advanced composites. Scientist has found that the fibers taken from a spider's web are stronger than synthetic fibers. In India, Greece, and other countries, husks or straws mixed with clay have been used to build houses for several hundred years. Mixing husk or sawdust in a clay is an example of a short-fiber composite. This reinforcement is done to improve performance.[10]

Typically, composite material is formed by reinforcing fibers in matrix resin. The reinforcements can be made from polymers, ceramics, and metals. The fibers can be continuous, long, or short. Composites made with a polymer matrix have become more common and are widely used in various industries.

The reinforcing fiber or fabric provides strength and stiffness to the composites, whereas the matrix gives rigidity and environmental resistance. Reinforcing fibers are found in different forms, from long continuous fibers to woven fabric to short chopped fibers and mat. Each configuration results in different properties. The properties strongly depend on the way the fibers are laid in the composites. All of the above combinations or only one form can be used in a composite. The important thing to remember about composites the fiber carries the load and its strength is greatest along the axis of the fiber. Long continuous fibers in the direction of the load result in a composite with properties far exceeding the matrix resin itself. The same material chopped into short lengths yields lower properties than continuous fibers. Depending on the type of application structural or nonstructural and manufacturing method, the fibers form is selected. For structural application, continuous fibers or long fibers are recommended.

2.0.1 Carbon Fibers

Carbon and graphite fiber are produced by using PAN-based or pitch-based processors. The precursor undergoes a series of operations. In the first step, the precursor is oxidized by exposing them to extremely high temperatures. Later, they go through carbonization and graphitization process. During these processes, precursors go through chemical changes that yield high stiffness to weight and strength to weight properties. The successive surface treatment and sizing process improves its to resin compatibility and handle ability.[5]

PAN refers to polyacrylonitrile, a polymer fiber of textile origin. pitch fiber is obtained by spinning purified petroleum or coal tar pitch. PAN-based fibers are most widely used for the fabrication of carbon fibers. Pitch-based fibers tend to be stiffer and more brittle. During oxidation and carbonization process, the weight reduces to almost 50% of the original weight. The fabrication method for the production of carbon fibers is slow and capital intensive. Therefore, higher tow count is produced to lower the cost of the fibers. There are limitation of size.[2]

Pitch-based carbon fibers are produced in the same way as PAN-based fibers but pitch is more difficult to spin and resultant fiber is more difficult to handle. Pitch itself costs pennies a kilogram, but processing and purifying it to the fiber form are very expensive. Generally, pitch-based are more expensive than PAN-based fibers.[3]

The cost of carbon fibers depends on the strength and stiffness properties as well as on the tow size (number of filaments in a fiber bundle). Fibers with high stiffness and strength properties cost more. The higher the tow size, the lower the cost will be.[3]

2.0.1.1 Dry Carbon

Carbon fibers are very strong and stiff, it has 3 to 10 times stiffer than glass fiber. Usually carbon fiber used for aircraft structural applications, such as floor beams, stabilizers, flight controls and primary fuselage and wing structure. Advantages of the dry carbon are it has high strength and good corrosion resistance. The disadvantages of dry carbon are lower of conductivity. A lightening protection mesh or coating is necessary for aircraft parts that are prone to lightning strikes. Another disadvantage of carbon fiber is its high of cost. Carbon fiber is gray or black in color as figure 2.1 and is available as dry fabric and prepreg material. Carbon fibers have a high potential for causing galvanic corrosion when used with metallic fasteners and structures.[4]

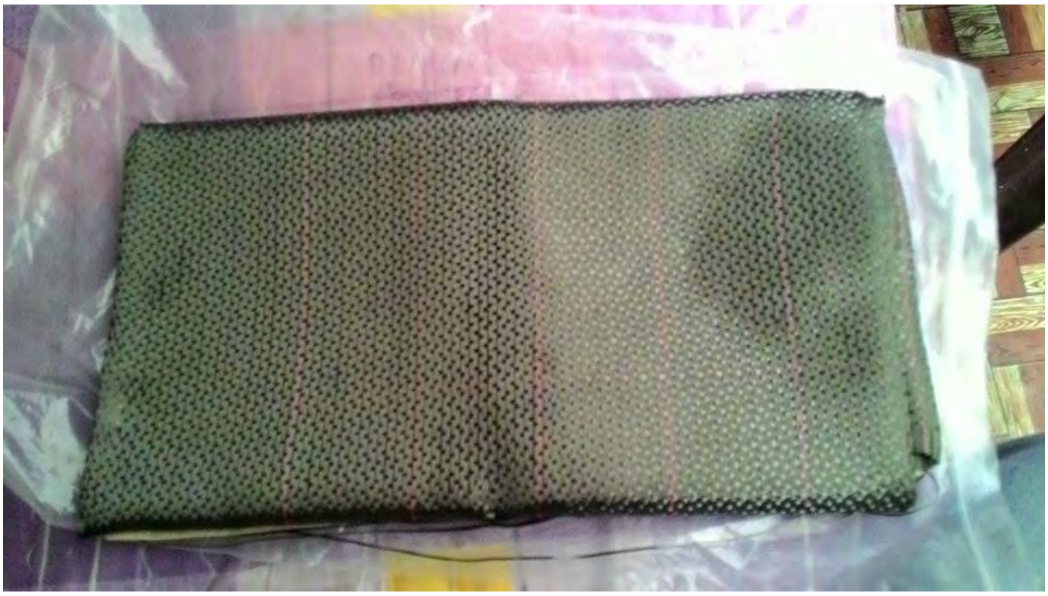

Figure 2.1 Dry Carbon

2.1 THERMOSET RESIN

Thermoset material once cured cannot be remelted or reformed. During curing, they form three-dimensional molecular chains, cross linking. Due to cross linking, the molecules are not flexible and cannot be remelted and reshape. The higher the number of cross linking, the more rigid and thermally stable the material will be. In rubbers and other elastomers, the densities of cross links are much less and therefore they are flexible. Thermoset may soften to some extent at elevated temperature. This characteristic is sometimes used to create a bend or curve in tubular structure, such as filament wound tube. Thermosets are brittle in nature and are generally used with some form of filler and reinforcement. Thermoset resins provide easy processability and better fiber impregnation because the liquid resin is used at room temperature for various process such as filament winding, pultrusion, and RTM. Thermosets offer greater thermal and dimensional stability, better rigidity, and higher electrical, chemical, and solvent resistant. The most common resin material used in thermoset composites are epoxy, polyester, vinylester, phenolics, cynate esters, bismaleimeides, and polyimides.[12]

2.1.1 Epoxy

Epoxy is a very versatile resin system, allowing for a broad range of properties and processing capabilities. It exhibits low shrinkage as well as excellent adhesion to a variety of substrate materials.[10] Epoxies are the most widely, used resin materials and are used in many applications, from aerospace to sporting goods. There are varying grades of epoxies with varying levels of performance to meet different application needs. They can be formulated with other materials or can be mixed with other epoxies to meet a specific performance need. By changing the formulation, properties of epoxies can be changed; the cure rate can be modified, the processing temperature requirement can be changed, the cycle time can be changed, the drape and take can be varied, the toughness can be changed, the temperature resistance can be improved. Epoxies are cured by chemical reaction with amines, anhydrides, phenols, carboxylic acids, and alcohols. An epoxy is a liquid resin containing several epoxide groups, such as dglycidyl ether of bisphenol A (DGEBA), which has two epoxide groups. In an epoxide group, there is a three-membered ring of two carbon atoms and one oxygen atom. In addition to this starting material, other liquids such as diluents to reduce its viscosity and flexibilizers to increase toughness are mixed. The curing reaction which is cross-linking takes place by adding a hardener or curing agent. During curing DGEBA molecules form cross links with each other. These cross-links grow in a three-dimensional network and finally form a solid epoxy resin. Cure rates can be controlled through proper selection of hardeners and catalyst. Each hardener provides different cure characteristics and different properties to the final product. The higher the cure rate, the lower the process cycle time and thus higher production volume rates.[5]

Epoxy- based composites provide good performance at room and elevated temperatures. Epoxies can operate well up to temperatures of 200 to 250 F , and there are epoxies that can perform well up to 400 F. for high-temperature and high-performance epoxies, the cost increases, but they offer good chemical and corrosion resistance.[5]