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Experimental analysis of spur gear made by different composite materials

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ABSTRACT

Hybrid Composite material have evoked a keen interest in recent times for potential applications in aerospace and automotive industries owing to their superior strength to weight ratio and temperature resistance. The widespread adoption of particulate metal matrix composites for engineering applications has been hindered by the high cost of producing components. Achieving a uniform distribution of reinforcement within the matrix is one such challenge, which affects directly on the properties and quality of composite material. This paper discuss the Spur Gear model made by Agave tequilana ,black fibre, E-glass fiber and carbon fiber with isopolymer composite material and to evaluate the tensile, Hardness, wear Strength of the Composite Material.

INTRODUCTION

Composite is a combination of two or more chemically distinct and insoluble phases. Constituent materials or phases must have significantly different properties for it to combine them: thus metals and plastics are not considered as composites although they have a lot of fillers and impurities. The properties and performance of composites are far superior to those of the constituents Composites consist of one or more discontinuous phases (reinforcement) embedded in a continuous phase (matrix)

Continuous fibers have long aspect ratios, while discontinuous fibers have short aspect ratios. Continuous-fiber composites normally have a preferred orientation, while discontinuous fibers generally have a random orientation. Examples of continuous reinforcements include unidirectional, woven cloth, and helical winding. While examples of discontinuous reinforcements are chopped fibers and random mat. Continuous-fiber composites are often made into laminates by stacking single Sheets of continuous fibers in different orientations to obtain the desired strength and stiffness properties with fiber volumes as high as 60 to 70 percent [1].

Fibers produce high-strength composites because of their small diameter; they contain far fewer defects (normally surface defects) compared to the material produced in bulk [2].

OBJECTIVES

1. Study the metal properties of various materials
2. Study the experimental analysis of selected composition
3. Analyse the results obtained from testing.

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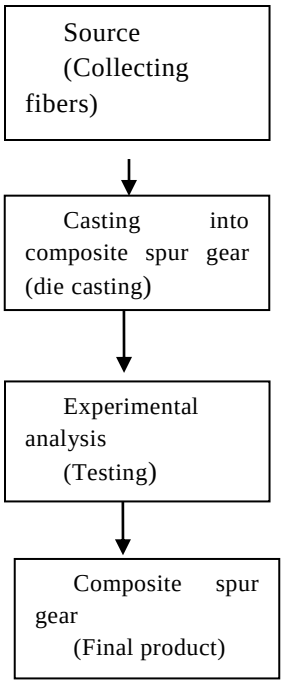
PROCESS FLOW



PROBLEM IDENTIFICATION

1. Less efficiency of spur gear.
2. Hard to replace the spur gear in tidal power plant

1. Black Fiber
2. E Glass Fiber
3. Carbon Fiber
4. Isopolymer

MAKING PROCESS

Selection of materiials

Agave Tequilana

Table. 1 Properties of Agave Tequilana

Properties	Value
Density	0.85-1.1 g/cm³
Tensile strength	175-203 MPa
Young's modulus	1.85-3.70 GPa
Elongation	1.92-3.50 %

Agave tequilana is well known for its succulent leaves and the medicinal and cosmetic properties of the gel obtained from them, which is added as pigment in composition process in order to prevent from itchiness occurred by other composite materials [3].

Table. 2 Properties of E Glass Fiber

Properties	Value
Density, gm/cc	2.58
Elongation%	4.8
Annealing point 'C (' F)	657(1215)

E-Glass - the most popular and inexpensive. The designation letter "E" means "electrical implies that the it is an electrical insulator" [4].

Table. 3 Properties of Black Fiber

Properties	Value
Density	1.68 g/m³
Tensile strength	140.5kg/cm³
Youngs modulus	5690 GPa
Elongation	6.96 %

Properties of Carbon Fiber

Carbon fiber is defined as a fiber containing at least 92 wt % carbons, while the fiber containing at least 99 wt % carbon is usually called a graphite fiber [1]. Carbon fibers generally have excellent tensile properties, low densities, high thermal and chemical stabilities in the absence of oxidizing agents, good thermal and electrical conductivities, and excellent creep resistance. They have been extensively used in composites in the form of woven textiles, prepares continuous fibers/rovings, and chopped fibers. The composite parts can be produced through filament winding, tape winding, pultrusion, compression molding, vacuum bagging, liquid molding, and injection molding [5].

Table. 4 Properties of Carbon Fiber

Properties	value
Density	1.77 g/m³
Tensile strength	220-240 MPa
Young's modulus	2.5-5.40 GPa
Elongation	1.5 %

Table. 5 Properties of Isopolymer

Properties	value
Density	1.15 g/m³
Tensile strength	70-80 MPa
Young's modulus	3.5 GPa
Elongation	4-6 %

Isopolymers are widely used in various industrial fields due to their merits, such as light weight, resistance to chemicals, resistance to the environment, easy processing, etc. It is difficult for polymers to be treated after use due to their resistance to the environment. When polymers are disposed of in natural environment, they remain for a long time without degradation. One of the solutions to this problem of polymers after use is the development of biodegradable polymers. Biodegradable polymers can be biodegraded eventually by microorganisms in the natural environment into carbon dioxide(CO2) and water (H2O). Various types of biodegradable plastics have been developed [7].

Die Making

The tooling involved in plastic molding is quite similar to that of stamping dies. The principal difference is that stamping requires force, while molding does not. In plastic molding, two units are required whose design is such that, when brought together, they make up a system of closed cavities linked to a central orifice. Liquid plastic is forced through the orifice and into the cavities, or molds, and when the plastic solidifies, the molds open and the finished parts are ejected [6].

Mixing Process

Two part isopolymer compounds are normally supplied in separate A - B containers, either both full or in a pre-measured kit. Under the Resin lab designation; Part A is the isopolymer resin and the Part B is the polyamine hardener, with some systems the Part B may be an anhydride. isopolymer resins are normally clear to slightly amber, high viscosity liquids which may be filled with mineral fillers to improve performance and lower cost. These sometimes can settle to the bottom of the container and must be stirred to a homogeneous consistency before adding the hardener. Isopolymer resins can cause mild skin irritation and a form of dermatitis upon repeated contact. It is important to limit skin contact with any isopolymer resin or hardener. Therefore, we recommend that you wear rubber gloves when mixing and using the isopolymer compounds.

Hardeners

The hardener, is typically a polyamine or mixture of polyamines and has can have strong ammonia-like smell. Most are considered DOT Corrosive materials and should be respected as such. They are typically light colored to dark amber liquids. The hardener, like the resin, can be filled with metal or mineral fillers to improve performance or lower costs. And just like the resin, these fillers may settle over time and must be stirred to a homogeneous consistency before mixing with the resin. Some Isopolymer hardeners are based on anhydrides rather than amines. These hardeners are more likely used in electrical potting and encapsulation applications and are likely to be heat cured in nature. Both polyamines and anhydrides are somewhat sensitive to moisture. Keep containers tightly sealed and when used in meter-mix-dispense equipment it is best to use a dry nitrogen purge or a desiccating air drier on the vent. Static Mixing Guidelines Resin lab Technical Data Sheets include this general guide for ranking the ability of a product to function acceptable in a range of applications. In general best case is a 1/1 ratio with even viscosity, worst case is a 10/1 ratio with a wide viscosity difference. The type of cartridge can also have a dramatic effect on dispense quality, especially when used in a pulsing mode. Larger and thin walled cartridges can induce a lead / lag effect where A and B show an extreme ratio change in a very short period due to the expansion and relaxation of the cartridge barrel. The thicker walled cartridges show much less tendency to produce this lead lag effect which is a primary cause on intermittent tacky areas on small pottings or casting [4].

Surface Preparation

If the surfaces that you intend to adhere together are not prepared properly, the best adhesive in the world will not hold them together. The major problems in adhesive delamination are dirt and oil. Whenever possible, the surfaces to be adhered should be abraded with sand paper or by sand or shot blasting before the adhesive is applied. Oil on the surface of steel or even oil from fingerprints can ruin a bond. If the surface to be bonded is painted, the bond of the paint to the substrate will be a limiting factor in the overall bond quality. Plastic surfaces should be abraded and when possible flame treated or corona treated to remove any plasticizer from the surface and provide an oxygen rich surface environment for the adhesive. Mixing: When hand mixing the epoxy resins and the hardeners, it is best to pour the resin, the Part A, into the mixing vessel first. The product should be weighed to the nearest gram or to the nearest 0.5%, whichever is more precise.

Next, the Part B is added using the same weighing procedure. Mix the two components using a stir stick or a paint mixer in a drill or drill press. Mix the product for at least 3 minutes by the clock. Scraping the sides and bottom of the mix vessel frequently. [Remember, it's just like baking a cake!] After the products have been thoroughly mixed, the mixture should be poured into the mold or used in the adhesive step. Often, the end product must be totally free of voids and bubbles. If this is the case,

The mix must be vacuumed before being poured into the mold. This is done by putting the mix vessel into a vacuum chamber and pulling a vacuum of at least 28" Hg. This will usually degas the product within 5 minutes. The reaction mixture will bubble and froth. You should have a mix container at least 4 times the volume of the liquid in the container for vacuum degassing. Therefore,

1 quart of the liquid product will require a 1 gallon bucket to degas the mixture. If you intend to vacuum degas a product, make sure that you tell Star Technology about your wishes. We will need to formulate to product with a delayed gel time and extra air release additives to allow sufficient time to accomplish the process.

Reaction Rates

Now is probably a good time to talk about the reaction rate of the mixture and what affects it. Reaction rates are usually stated at a certain temperature and at a certain mass of material. If you are working with a larger mass, the reaction time will be shorter. Lower masses and thin films will be much longer. If the reaction starting temperature is higher, the reaction rate will be faster. A rule of thumb is that for every 10 degrees C that you increase the temperature of the reactants, the reaction rate will double the gel time will be cut in half. That is why larger masses will react more quickly than small masses. As the reaction proceeds, it generates its own heat. The heat builds up inside the mixing vessel and the reaction goes faster, which makes more heat, which makes the reaction go even faster [7].

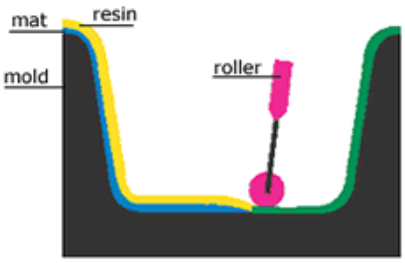


Fig.1. Hand Lay-Up

PROCESS

Gel coat is first applied to the mold using a spray gun for a high quality surface. When the gel coat has cured sufficiently, roll stock fiber glass reinforcement is manually placed on the mold. The laminating resin is applied by pouring, brushing, spraying, or using a paint roller. FRP rollers, paint rollers, or squeegees are used to consolidate the laminate, thoroughly wetting the reinforcement and removing entrapped air. Subsequent layers of fibre glass reinforcement are added to build laminate thickness. Low density core materials such as end-grain balsa, foam, and honeycomb, are commonly used to stiffen the laminate. This is known as sandwich construction.

MOLDS

Simple, single cavity molds of fiber glass composites construction are generally used. Molds can range from small to very large and are low cost in the spectrum of composites molds.

MATERIALS PREPARATIONS

The Agave tequilana, black fiber, e glass fiber and carbon fiber which is taken as reinforcement in this study is collected from local sources. The epoxy resin and the hardener are supplied. Wooden mould having been first manufactured for composite fabrication. The fiber material is mixed isopolymer resin by simple mechanical stirring and the mixture was poured into various moulds, keeping in view the requirement of various testing conditions and characterization Standard.

The composite sample of different composition are prepared composite of mixing ratio agave tequilana 10% , black fiber10%,E-glass fiber 15% and carbon fiber10% with mixing of isopolymer resin 55%. The different type of fiber is used, while keeping the length of the glass of composite materials. A releasing agent is used on the mould release sheets to facilitate easy removal of the composite from the mould after curing. The entrapped air bubbles are removed carefully with a sliding roller and the mould is closed for curing at a temperature Of 30 degree C for 24 hours at a constant load of 50kg, after curing

the specimen of suitable dimension is cut using a diamond cutter for mechanical test as per the ASTM standards.

MECHANICAL PROPERTY TESTS

Tensile tests are performed for several reasons. The results of tensile tests are used in selecting materials for engineering applications. Tensile properties frequently are included in material specifications to ensure quality. Tensile properties often are measured during development of new materials and processes, so that different materials and processes can be compared. Finally, tensile properties often are used to predict the behavior of a material under forms of loading other than uniaxial tension.

The strength of a material often is the primary concern. The strength of interest may be measured in terms of either the stress necessary to cause appreciable plastic deformation or the maximum stress that the material can withstand. These measures of strength are used, with appropriate caution (in the form of safety factors), in engineering design. Also of interest is the material's ductility, which is a measure of how much it can be deformed before it fractures. Rarely is ductility incorporated directly in design rather, it is included in material specifications to ensure quality and toughness.

Low ductility in a tensile test often is accompanied by low resistance to fracture under other forms of loading. Elastic properties also may be of interest, but special techniques must be used to measure these properties during tensile testing, and more accurate measurements can be made by ultrasonic techniques. This chapter provides a brief overview of some of the more important topics associated with tensile testing. These include

1. Tensile specimens and test machines
2. Stress-strain curves, including discussions of elastic versus plastic deformation, yield points, and ductility
3. True stress and strain.
4. Test methodology and data analysis.

TENSILE SPECIMENS AND TESTING MACHINES

Consider the typical tensile specimen. It has enlarged ends or shoulders for gripping. The important part of the specimen is the gage section. The cross-sectional area of the gage section is reduced relative to that of the remainder of the specimen so that deformation and failure will be localized in this region.

The gage length is the region over which measurements are made and is centered within the reduced section. The distances between the ends of the gage section and the shoulders should be great enough so that the larger ends do not constrain deformation within the gage section, and the gage length should be great relative to its diameter. Otherwise, the stress state will be more complex than simple tension. Detailed descriptions of standard specimen shapes are given in Chapter 3 and in sub-sequent chapters on tensile testing of specific materials.

TENSILE STRENGTH

The tensile test of the composites was performed as per the ASTM D3039 standards. The test was done using a universal testing machine (Tinius Olsen H10KS).The specimen of required dimension was cut from the composite cast. The test was conducted at a constant strain rate of 2 mm/min.

Tensile test is used to determine the tensile strength of the specimen, % elongation of length and % reduction of area. Tensile test is usually carried out in universal testing machine.

A universal testing machine is used to test tensile strength of materials. It is named after the fact that it can perform many standard tensile and compression tests on materials, components, and structures. The specimen is placed in the machine between the grips and an extensometer if required can automatically record the change in gauge length during the test. If an extensometer is not fitted, the machine itself can record the displacement between its cross heads on which the specimen is held. However, this method not only records the change in length of the specimen but also all other extending / elastic components of the

testing machine and its drive systems including any slipping of the specimen in the grips. Once the machine is started it begins to apply an increasing load on specimen. Throughout the tests the control system and its associated software record the load and extension or compression of the specimen.

Tensile test is used to find out

1. Tensile strength
2. Yield strength
3. % Elongation
4. % Reduction

HARDNESS TEST

This gives the metals ability to show resistance to indentation which show it's resistance to wear and abrasion. Hardness testing of welds and their Heat Affected Zones (HAZs) usually requires testing on a microscopic scale using a diamond indenter. The Vickers Hardness test is the predominant test method with Knop testing being applied to HAZ testing in some instances. Hardness values referred to in this document will be reported in terms of Vickers Number, HV.

PIN ON DISC WEAR TESTER

Surface engineering point of view, wear test is carried out to evaluate the potential of using a certain surface engineering technology to reduce wear for a specific application, and to investigate the effect of treatment conditions (processing parameters) on the wear performance, so that optimized surface treatment conditions can be realized. In a pin-on-disc wear tester, a pin is loaded against a flat rotating disc specimen such that a circular wear path is described by the machine. The machine can be used to evaluate wear and friction properties of materials under pure sliding conditions.

Either disc or pin can serve as specimen, while the other as counter face. Pin with various geometry can be used. A convenient way is to use ball of commercially available materials such as bearing steel, tungsten carbide or alumina (Al2O3) as counter face, so that the name of ball-on-disc is used.

RESULT

Thickness Mm	Width Mm	CSA mm^2	YL KN	YS N/mm^2
8 to 9	31.4	282.6	5.76	517.43

TL KN	TS N/mm^2	IGL Mm	FGL Mm		%E
8.44	642.48	100.24	108.78	7.98	

Table. 7 Hardness and Impact test

Impression(Hardness value in HRB)	42.7&44.2
Impact value in joules	8

Table. 8 Wear test

Material	Sliding speed(m/s)	Load(N)	Wear rate (mm^3/m)
Fiber gear	2	20	0.0030
Fiber gear	2	40	0.0034

CONCLUSION

Then the study in weight reduction and stress distribution of spur gear for Agave Tequilana, black, e-glass and carbon fiber composite materials has been done. On the basis of that study, the analysis of both cast AL and fiber composite materials are analyzed in the application of gear which is used in automobile vehicles.

From the analysis we got the hardness and impact values for fiber composite materials weight and cost is less. So from these analyses mechanical behavior results are mentioned above.

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