Experimental Investigation of Unidirectional and Natural Fiber Composites for Ceiling Fan Blade Application

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Abstract : Ceiling fans are one of the main power consuming sources. In the recent world most of the household appliances and industrial appliances are using electric power. Because of the enormous use of Electric power, electricity shortage is main problem throughout the world. Ceiling fan is the one of the appliance that consumes electric power. This has been minimized by means of reducing the weight of the blade. The best way to reduce the power consumption without sacrificing safety is to employ fiber reinforced composite materials in the fan blades. The objective is to compare the power consumption, cost and weight of composite fan blade with that of steel fan blade. In this work the design and fabrication of composite fan blade made up of hybrid fiber reinforced polymer is carried out by which weight of the fan blade can be reduced. The properties are examined to, tensile strength, hardness and flexural strength.. This results obtained in this work were compared with that of commercial ceiling fan blade.

IndexTerms - --- ceiling fan blade, hybrid fiber, hardness, flexural strength, tensile strength

I. INTRODUCTION

A ceiling fan is a device hanging from the ceiling of a room. Ceiling fans utilize hub-mounted rotating paddles in order to produce a cooling effect as a result of air circulation. The circulation of air creates a wind-chill effect that makes a person feel cooler. The ceiling fan blades are usually made up of aluminium, steel, wood, etc. The ceiling fans have become a common appliance both in domestic and industrial applications. Though the power consumed by these fans is less, it is to be considered that these fans run on a continuous duty and this makes the power consumption significant. Energy crisis and less availability of natural resources being the major challenge, selection of better material and effective manufacturing processes, can reduce both the power consumption and the manufacturing cost. Composite materials have found a wide range of application in replacing the conventional materials with enhanced strength and mould ability.

Composites are compound materials, differ from alloys in the fact that individual components retain their characteristics but are so incorporated into composites so as to take advantages only of attributes, not that characteristics of short comings, to obtain improved materials.

Composite materials (also called composition materials or shortened to composites) are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. Properties of composites are strongly influenced by the properties of their constituent materials, their type, their distribution and the interaction between them. Like conventional materials, composites are not homogeneous and isotropic.

Composites are generally completely elastic up to failure exhibit no yield point or a region of plasticity.

At present steel is widely deployed in blade manufacturing mainly due to the advantages such as less density compared to steel, corrosion resistance and aesthetic look. Though steel has wide advantages when compared to steel, it stays back in certain properties such as less strength to weight ratio, paint coating etc. Composites have become a better replacement for conventional steel with adequate improvement of mechanical properties and their reduced weight

Though a variety of resins and fibres are available, considering the manufacturing easiness and the mechanical aspects general polymer resin and hybrid fiber is employed in the fabrication work. Hybrid fiber has good tensile and compressive strength and stiffness, good electrical properties. It is relatively low cost, but the impact resistance is relatively poor.

II. LITERATURE REVIEW

Amazing Comfortson S was et all discussed about the fabrication of composite fan blade made up of glass fiber resin forced polymer is carried out and the performance of this fan is compared with the conventional fans. Compared to existing ceiling fan blade, the composite blade saves 31% of power, an reduces the cost by 28%. The weight is reduced by 30% without sacrificing the strength thus reducing the power consumption

Ahamed Faiyaz was et all discussed about the fabrication of composite fan blade made up of glass fibre reinforced polymer is carried out and the performance of this fan is compared with the conventional fans. Compared to existing ceiling fan blade, the composite blade saves 26% of power, and reduces the cost by 28%. The weight is reduced by 27% thus reducing the power consumption. It is also determined that the flow velocity through the composite blade is 15% more than that of the conventional fan,

S.Prabhakaran was et all discussed about the design and fabrication of composite fan blade made up of glass fiber reinforced polymer is carried out by which weight of the fan blade can be reduced. Compared to existing ceiling fan blade, the composite blade saves 30% of power, and 34% less in cost. From the fabrication it was found that the weight reduction of 28% is achieved using composite material without sacrificing the strength.

E. Adeeb was et all discussed about parametric study and optimization of non-linear ceiling fan blades by combining the techniques of Design of Experiments (DOE), Response Surface Methods (RSM) and Computational Fluid Dynamics (CFD). Specifically, the nonlinear (elliptical) planform shape of ceiling fan blade is investigated in conjunction with blade tip width, root and tip angle of attack. Sixteen cases are designed for three blade ceiling fan using two level full factorial model. The flow field is modeled using Reynolds-Averaged-Navier-Stokes approach. The performance variables used to formulate a multi-objective optimization problem are volumetric flow rate, torque and energy efficiency. Response Surface Method is used to generate the optimized design for non-linear ceiling fan blade profile. The results reveal that the interactions between the design variables play a significant role in determining the performance. It is concluded that the nonlinear forward sweep has a moderate effect on response parameters.

Rupesh V. Bhortake was et all discussed about ,response surface methodology is used to predict power consumption characteristics. The experiments were conducted based on the three different fans having three different blades, three room size, three different ceiling fan rod lengths three regulator knob positions and mathematical model was developed

Sravanthi C the design and analysis of composite fan blade made up of aramid fibre is carried out by determining the stresses and displacements induced in the composite fan blade.

"From the literature review, we are studied about the steel and aluminium is used in ceiling fan blade.but steel is having more weight and consume more electrical power.so, we are decided to replace the material besides steel and Aluminium. From this literature review, They are mostly used synthetic fiber and binder was phenolic resin and also studied about the glass fiber. So, we are selected the combination natural and synthetic fiber due to their properties and low cost, to replace the steel material and Polyster resin is used. Here we are selected teak wood powder, groundnut shell husky and S Glass fiber." The composite blades provide a good reduction in the weight, thereby reducing the power consumption with great stability and stiffness.

III. EXPERIMENTAL METHODOLOGY

1)Material Selection

1)S-Glass fiber

Polymer matrices are most common and widely used matrix material, because of its availability, easiness to fabrication, light weight and low cost compared to others. The matrix material used in the present work is Polyester resin. Glass fibers are most common reinforcing agent among various composite materials. Glass fibers are available in the form of woven fabric, chopped strands, long continuous fiber and short discontinuous fiber. In present research work the glass fiber was used in production of Ceiling fan blade in S glass fiber is used as reinforcing agent.

Fig 1 S-Glass Fiber

2)Teak wood powder

The purpose of teak wood powder is used as the additional material. Because it is easy to contaminated and bonded with the natural fiber material. And whether resistance property. Fig 2 shows that of teak wood powder.

Fig2.Teakwood Powder

3)Groundnut Shell

Based on fiber reinforced composites played a dominate role of long time variety of application for the high specific strength and modulus. Reinforced plastic may be synthetic or nature. The groundnut shell is also called as peanut. Fig 3 shows that of groundnut shell.

Fig. 3.Groundnut Shell

4)Husky

The husky is also called as rice hull. To protect the rice seed during growth, the hull is formed from hard materials. Also combined use of rice hull ash or rice hull flour in the protection of polymeric composite should be tested yield better products then those being made currently. Fig 4 shows that the husky

Fig 4.Husky

B)Preparation of Laminates

In the present study the hybrid composite laminate specimens are prepared using the hand layup technique and the specimen are subjected to the investigation is carried out as per the ASTM standards

1) Hand Lay-Up Method

In Hand lay-up, liquid resin is applied to the mould and then fiber glass is placed on the top. A roller is used to impregnate the fiber with resin. Another resin and reinforcement layer is applied until a suitable thickness builds up.

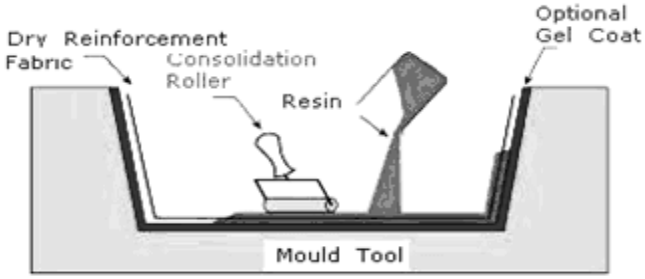

Fig-5.Hand Layup Method

It is very flexible process that allows the user to optimize the part by placing different types of fabric and mat materials. Because the reinforcement is placed manually, it is also called the hand lay-up process. Though this process requires little capital, it is labor intensive .

The groundnut shell, husky and teak wood powder fibers are used as reinforcement for preparing the laminates. The resin is mixed along with the filler material in a mechanical stirrer. A roller is used for better infiltration of resin in the fiber layers. Numbers of layers are changed for various thickness values of the laminates. Steps involved in compression molding process are:

- Cleaning the aluminum blade 405*105mm of blade by using suitable releasing agent on the surfaces. Usually wax is used as releasing agent.
- Commercially available general polymer resin is used for preparing the laminates. 1.5 wt. % of accelerator (cobalt napththanate) and 1.5 wt. % of catalyst methyl-ethyl-ketone peroxide (MEKP) is mixed with the resin and used as the matrix material.
- Accelerator is mixed with resin first. Before starting the layup just a second mix the catalyst and layup them.
- Fiber reinforcement of desired size is placed inside the mold and resin is applied uniformly using a roller.
- Clean the brush, roller and hands with acetone after processing.
- The part is then allowed to cure in room temperature for 4 hours and then disassembled from the mold and post cured for 72 hours

Fig.6.Prepared Laminates

C. Testing of Laminates

After the fabrication of laminates, the laminates are tested for their mechanical properties. The composition and description of composite used in this study are listed in Table 1. The mechanical properties like tensile, flexural, impact and hardness tests are obtained for these laminates and are studied.

Table 1 Designation of composite

S.NO	Specimen No	Compositions
1	S1	Husky + Teak wood powder + S glass fiber + GP Resin
2	S2	Groundnut Shell + S glass fiber + GP Resin
3	S3	Husky + Teak wood powder + Groundnut shell + S glass fiber + GP Resin

D. Mechanical Testing

1).Tensile Testing.

Tensile testing utilizes the classical coupon test geometry as shown below and consists of two regions: a central region called the gauge length, within which failure is expected to occur, and the two end regions which are clamped into a grip mechanism connected to a test machine. Typical tensile composite test specimen (all dimensions in mm) These ends are usually tabbed with a material such as aluminum, to protect the specimen from being crushed by the grips. This test specimen can be used for

longitudinal, transverse, cross- ply and angle- ply testing It is a good idea to polish the specimen sides to remove surface flaws, especially for transverse tests

.

The tensile test is conducted on all the samples as per ASTM638 test standards. Specimens are positioned in the grips of universal testing machine and a uniaxial load is applied through both the ends until it gets failure fig. 7 shows the experimental setup for the tensile test.

Fig.7- Universal Testing Machine

2 Flexural Testing

Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. A flexure test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to the top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is the flexural strength of that particular sample.

The two most common types of flexure test are three point and four point flexure bending tests. A three point bend test consists of the sample placed horizontally upon two points and the force applied to the top of the sample through a single point so that the sample is bent in the shape of a "V". A four point bend test is roughly the same except that instead of the force applied through a single point on top it is applied through two points so that the sample experiences contact at four different points and is bent more in the shape of a "U". The three point flexure test is ideal for the testing of a specific location of the sample, whereas, the four point flexure test is more suited towards the testing of a large section of the sample, which highlights the defects of the sample better than a 3-point bending test is similar to a flexure test in the type of hardware and test procedure involved. Bend tests are used with ductile materials whereas flexural tests are used with brittle materials. The flexural test is conducted on all the samples as per ASTM790 The flexural test UTM machine is shown in fig 8

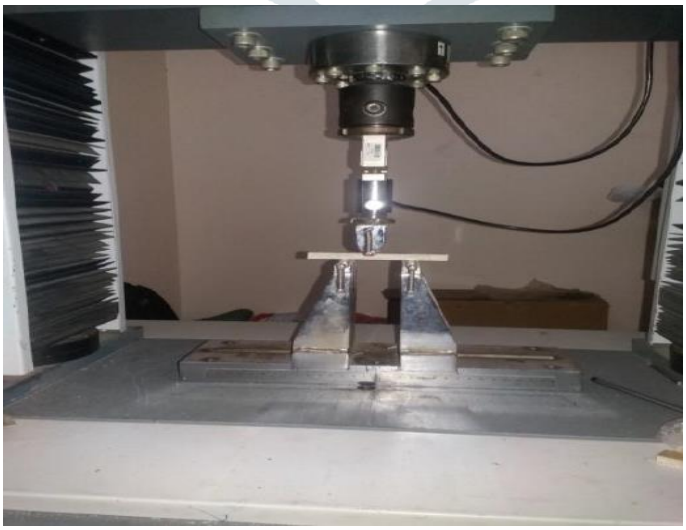

Fig.8- Flexural Testing Machine

3.Barcol Hardness Testing

The Barcol hardness test characterizes the indentation hardness of materials through the depth of penetration of an indentor, loaded on a material sample and compared to the penetration in a reference material. The method is most often used for composite materials such as reinforced thermo setting resins or to determine how much a resin or plastic has cured. The test complements the measurement of glass transition temperature, as an indirect measure of the degree of cure of a composite. It is inexpensive and quick, and provides information on the cure throughout a part. The Barcol hardness test method as used to determine Barcol hardness is defined in ASTM E10 Barcol testing often use a very high test load (3000 kgf) and a 10mm diameter indenter so that the resulting indentation averages out most surface and sub-surface inconsistencies. The Barcol method applies a predetermined test load (F) to a carbide ball of fixed diameter (D) which is held for a predetermined time period and then removed.

The resulting impression is measured with a specially designed Barcol microscope or optical system across at least two diameters – usually at right angles to each other and these results are averaged (d). Although the calculation below can be used to generate the Barcol number, most often a chart is then used to convert the averaged diameter measurement to a Barcol hardness number. Common test forces range from 500kgf often used for non-ferrous materials to 3000kgf usually used for steels and cast iron. There are other Barcol scales with load as low as 1kgf and 1mm diameter indenters but these are infrequently used. The fig 9 shows that the barcol hardness testing machine.

Fig.9- Barcol Hardness Testing Machine

IV. RESULTS AND DISCUSSION

The preparation polymer matrix composite was used for ceiling fan blade application. In this research S glass fiber with husky, teak wood powder and groundnut shell material was prepared by hand layup method. This laminates were prepared at different layer. The laminates preparing method was given. After the preparation of laminates, the various mechanical testing like Tensile strength, Flexural test and Hardness test

1). Tensile strength

The Tensile strength was done using a universal testing machineThe complete set of samples to achieve Tensile test. The samples were subjected to tensile force, loaded continuously until failure occurred. The load at which failure occurred was then recorded, Table 2 shows the tensile strength for new hybrid composite material developed.Fig 10 shows that after tensile test.

Fig10-After Tensile Test Specimen

Table 2. Tensile Strength of Composites

S.NO	SAMPLE	AREA ($mm^{2)}$	GAUGE LENGTH (mm)	Fmax (KN)	UTS (MPa)
1	S1	92.03	50.00	5.91	64.23
2	S2	382.72	50.00	2.35	6.13
3	S3	422.09	50.00	1.83	4.34

2 FLEXURAL STRENGTH

The flexural strength was done using a flexural testing machine. The complete set of sample to achieve fluxral test. The samples were subjected to flexural force, loaded continuously until failure occurred. The flexural test specimen after test is shown in Figure 4.3 and Table 3 shows that flexural strength for new hybrid composite materials developed.

Table 3. Flexural strength of composites

S.NO	SAMPLE	AREA ($mm^{2)}$	GAUGE LENGTH (mm)	Fmax (KN)	FLEXURAL STRENGTH (Mpa)
1	S1	203.56	50.00	0.98	68
2	S2	729.77	50.00	1.28	78
3	S3	765.77	50.00	0.64	64

Fig11-After Flexural Test Specimen

3).Hardness

Hardness is one of the most important factors that affect the wear property of materials. The hardness test was done by Barcol hardness Machine (BHN). During hardness test filler phase and matrix phase pressed together and interface can transfer load more effectively although interfacial bond strength may be poor which results in improved hardness. Table 4 shows that the barcol hardness for new composite materials developed.

Table 4 Barcol Hardness of Composites

S.NO	SAMPLES	LOAD (kg)	BHN	BHN	BHN
1	S1	100	78	76	78
2	S2	100	48	48	46
3	S3	100	49	48	48

Finally we conclude based on above results The mechanical properties of the Hybrid composites at different fiber loading Table 5.The fig 12 shows that comparison of mechanical properties of composites. It is observed from Table 8 that specimen 1(Husky + Teak wood powder + S glass fiber + GP Resin) better Tensile and Hardness as compared to others composites specimen. But flexural strength slightly lower than specimen 2(Groundnut Shell + S glass fiber + GP Resin) because groundnut shell have higher specific strength, stiffness and fatigue characteristics.

Table 5: Mechanical Properties of Composites

S.NO	SAMPLE	UTS (MPa)	FS (Mpa)	BHN
1	S1	64.23	68	78
2	S2	6.13	74	48
3	S3	4.34	66	49

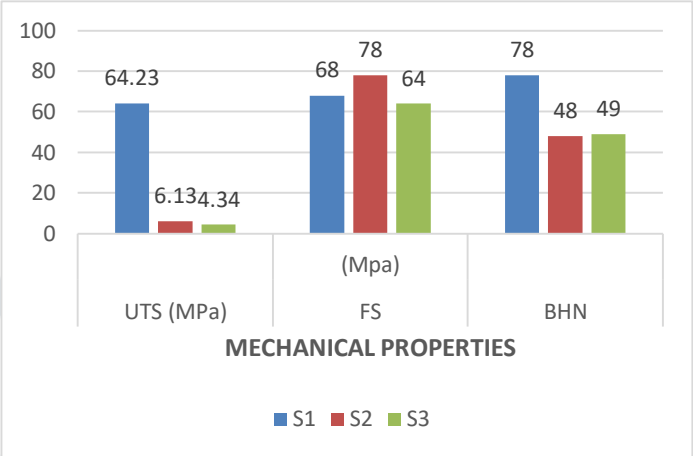

Fig. 12: Compartion of Composites

V. CONCLUSION

This experimental investigation of mechanical behavior of hybrid fiber reinforced polyester resin composites leads to the following conclusions. The composite material manufacturing method was performed at better level the hand lay-up method of laminate preparation was various fiber and resin also used. The specimen as per ASTM standard has been prepared. The various mechanical and tribological testing methods were discussed and the ultimate tensile strength have compared with other composite laminate. The ultimate tensile strength values have been increased. When compared to other laminates, the sample 1 has more tensile strength because the ratio of S glass fiber range will be high that result to better tensile strength. The result of flexural test indicates that the sample 2 has better flexural strength because groundnut shells naturally having the better property than other fibers. The sample 1 has better hardness value because teak wood powder has well whether properties and having better hardness strength. From the study, it is concluded that specimen 1 (Husky + Teak wood powder + S glass fiber + GP Resin) is a suitable material for manufacturing the composite ceiling fan blade. For future scope work is this hybrid composite material compare to existing fan blade material.

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