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"Designing and Enhancing the Mechanical Properties of Composite Fan Blades by Glass Fiber Reinforced Polymer Composites"

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ABSTRACT

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 characteristic of short comings, to obtain improved materials. Energy crisis is the major problem faced widely. Though wide range of researches is being laid in the areas of alternate energy sources, proper management of the available energy sources will contribute in controlling this energy crisis, particularly in high populous countries such as India. Ceiling fan being one of the vital electric appliances, consumes considerable electric power in most domestic and Industrial application. Imparting fiber reinforced composite in ceiling fans reduces the weight of the fan, thereby considerably reducing the power consumption. In this work the fabrication of composite ceiling fan made up of glass fiber reinforced polymer is carried out and the performance of this fan is compared with the conventional fans. Compared to existing ceiling fan, the composite fan 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 fan is 15% more than that of the conventional fan.

Keywords: *Glass Fiber, Epoxy Resin, Composite Blades*

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1. INTRODUCTION

Throughout history, the use of fans and ventilation systems has been increasing parallel to the industrial developments as well as the requirements of the situations. Although Leonardo da Vinci in the end of the 15th century described fans in his designs, the spreading of them became more important with the appearance and exploitation of the mining industry. Thus, along the 16th century, due to the extraction of coal, metal ores and other substances the ventilation became basic in order to avoid flow gas which might either asphyxiate the miners or explode with disastrous results. Indeed, the first mine ventilation system was published by Georgious Agricola (1912). Many of the sophisticated airflow systems used nowadays were embodied in his book. However, due to the lack of knowledge of the air properties, safety and health measures, non-important advances appeared until the end of 17th century thanks to the investigation of some important scientists like Galileo, Torricelli, Pascal, Boyle and Newton. Along the 18th and the beginning of the 19th century, until the First World War, the main researches were developed in United Kingdom, both in the seat of the British Government and the mine industry. The present-day applications of fans are far too numerous to list owe to the improvement achieved, highlighting the aviation industry. An axial flow fan is a machine which creates flow within a fluid (gas) in such a way that air flows linearly along the axis of it. It is composed of blades that force air to move parallel to the shaft about the axis at which the blades rotate, which are rigidly secured. Industrial axial is used in extremely conditions such as high temperature, large vibrations amplitudes or high corrosion, which cause large strains. Due to this, both the hub and the fan blades are made out of casting aluminum, which is capable to resist aggressive environments, have light weight and be easily malleable to the conditions required. However, nowadays, Akron is using a solid model, which means an increase of the material used and consequently, the cost of production is higher. Energy crisis is the major problem faced widely. Though wide range of researches is being laid in the areas of alternate energy sources, proper management of the available energy sources will contribute in controlling this energy crisis, particularly in high populous countries such as India. Ceiling fan being one of the vital electric appliances, consumes considerable electric power in most domestic and Industrial application. Imparting fiber reinforced composite in ceiling fans reduces the weight of the fan, thereby considerably reducing the power consumption. Generally, desert cooler fans are large capacity air moving devices and the conventional cast aluminium blades have a complex design with high power consumption and lower performance efficiency. Because of its high strength to weight ratio GFRP (glass fiber reinforced plastic) composite materials are used in many engineering applications.

2. MATERIALS AND METHODS

The use of a ceiling fan will allow you to operate your air conditioner at a higher thermostat setting than usual, since the air movement created by a fan produces a cooling effect on the body. Reduced weight and high

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strength to weight ratio are the major reasons for the development of composite ceiling fan over the conventional fan.

2.1. Materials Used for Fabrication Work

Epoxy resin and E-glass fiber is used. The following table provides the raw materials used in the fabrication process. Hardener is mixed with the resin to provide high viscous solution. The raw materials employed here are mixed in a definite ratio (1:10), considering the design and strength aspects of the composite fan blade. Also releasing agent is applied in the mould to make the mould free from sticking onto the composite layer formed by this process.

Table 1.1: Raw Materials of Composite Fan Blade

SL. No	Item	Grade
1.	EPOXY Resin	LY556
2.	Hardener	HY951
3.	E-glass fiber	Woven Roving 200
4.	Releasing agent	

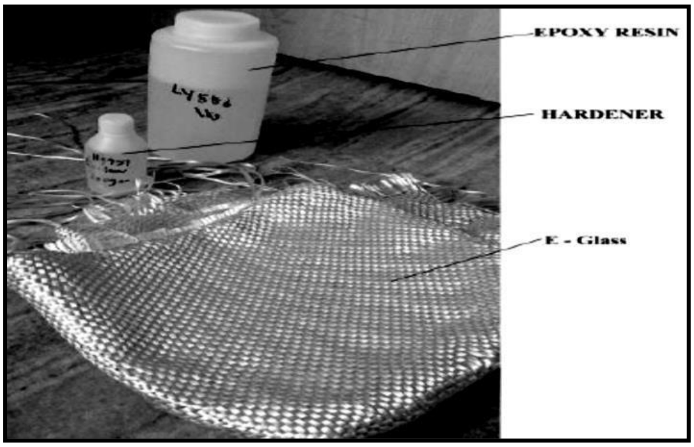

Fig.1.1: Raw Materials of Composite Fan Blade

3. EXPERIMENTAL PROCEDURE

Though small-scale fabrication of composite Fan does not yield a much advantage in manufacturing, but the reduced power consumption and the high strength to weight ratio, provides a conventional manufacturing. The composite blades provide a good reduction in the weight, thereby reducing the power consumption with great stability and stiffness. The combined stiffness and the strength of the fibrous material provide the necessary strength for the composite blades.

Table 1.2: Existing Blade Specifications

Manufacturer	Model	Existing blade weight (three blades)	Material
Vrinda Associates	HS 1400	0.48 Kg	Aluminium

3.1. Design of Composite Fan Blade

The existing design of the aluminium fan blade is taken as the design for the new composite fan blade. Higher-efficiency operation can be achieved for a ceiling fan by making its fan blades aerodynamic, and that such a ceiling fan can further reduce electrical use if it is operated properly in the residence. The aero dynamic design and other design parameters are taken same as the existing one.

3.2. Manufacturing of Composite Fan Blade

A mould is used for hand lay-up parts. Existing fan parts is used as the mould. In this process, since curing is done at room temperatures with less pressure, it is easier to fabricate. Before lay-up, the mould is

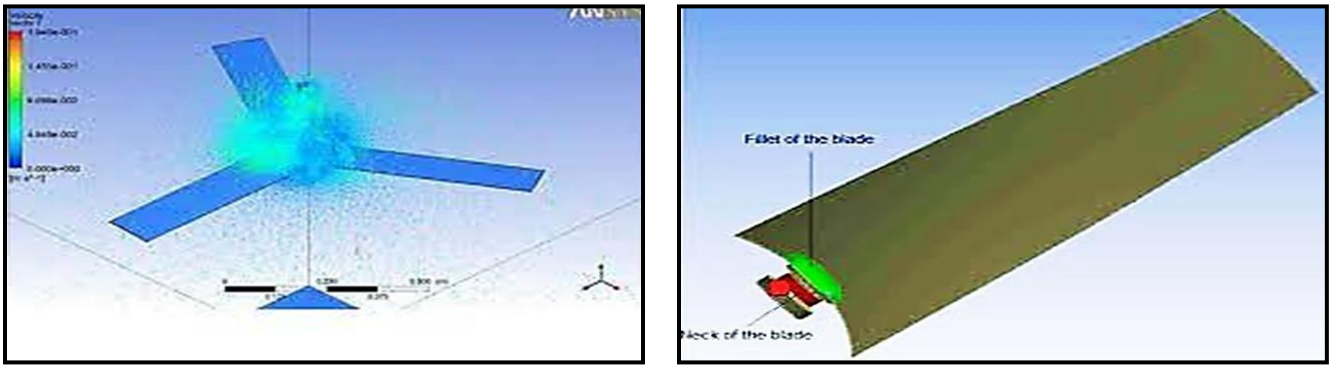

Fig.1.2: Design of the Composite Blade (Ansys V15)

prepared with a release agent to ensure that the part will not adhere to the mould. The lay-up technician is responsible for controlling the amount of resin and the quality of saturation.

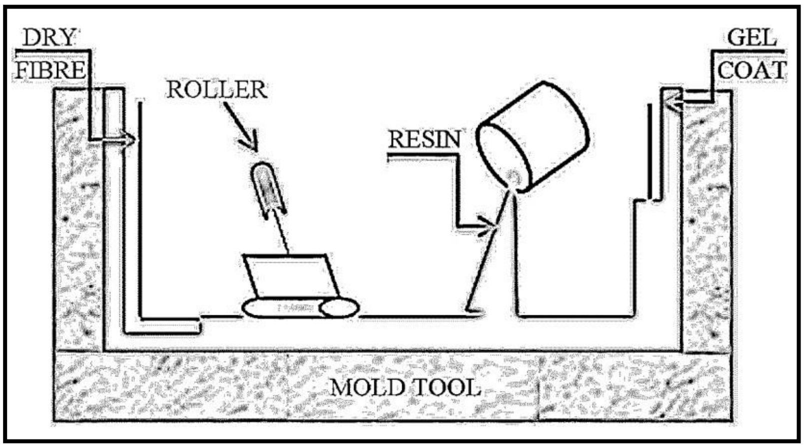

Fig.1.3: Hand-Layup Process

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 are applied until a suitable thickness builds up. 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 labour intensive.

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4. RESULTS AND DISCUSSION

The main objective of this paper is calculating the power conservation using the composite blade ceiling fan over the existing fans. Also, the cost for manufacturing the composite blade, the weight of the fabricated composite blade and the velocity of flow is compared with that of the existing aluminium blade ceiling fan.

4.1. Weight Comparison

The weight of the existing fan and the composite fan were determined using an electronic weighing machine. The weights of the blades were tested individually and the mean values of the three blades are considered for the weight comparison.

- **Aluminium Blade:**

  Weight of aluminium blade (1 unit) = 160 gm

  Weight of aluminium blades (3×160) = 480 gm

- **Composite blade:**

  Weight of composite blade (1 unit) = 116 gm

  Total weight of composite blades (3×116) = 348 gm

- **Fan base:**

  Weight of fan base= 340 gm

- **Composite base:**

  Weight of composite base= 260 gm

- **Percentage saving in weight:**

  Reduction in weight = 220 gm %

  saving in weight = 27.5 %

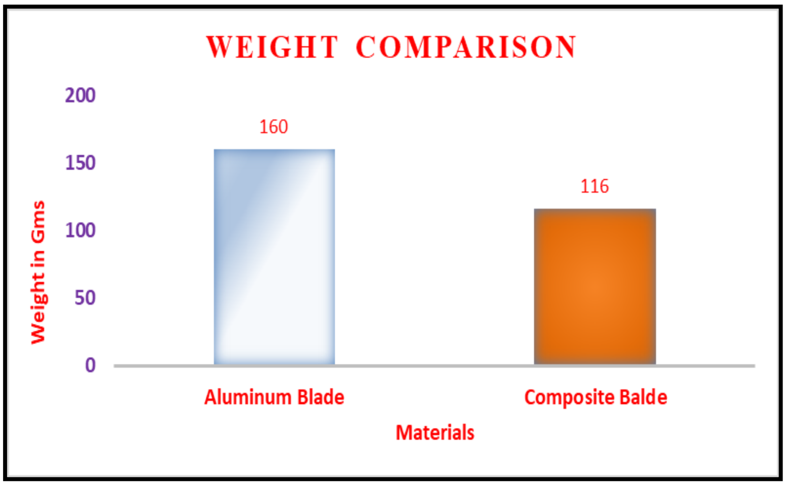

Fig.1.4: Weight Comparison Between Two Materials

From the weight determined in both the cases, it is clear that the replacement of aluminium blade by composite blade has reduced the weight by 132 gm. Thus experimentally, it is clear that the weight gets reduced by 27.5% by replacing the existing aluminium blades with composite blade.

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4.2. Power Consumption

Power consumption being the main objective of this paper, the power consumed by the composite blade ceiling fan is compared with that of the existing aluminium blade fans. The existing blades are fitted with the fan hub and tests are conducted. After the power consumed is noted down, the composite blades are fitted with the fan hub and the tests are conducted, and the power consumed is found out. The calculation is done considering an average run time of 8 hours per day. The cost for running one unit is Rs.7/- (for institutions and industries).

- **Aluminium Fan:**

  Unit consumed for one hour by existing fan = 0.06318 units

  Power consumed for one year = 0.06318 units*8 hours*30 days*12 months = 182 units

  Cost for running existing fan at Rs.7 per unit = Rs. 1274/-

- **Composite Fan:**

  Unit consumed for one hour = 0.04643 units.

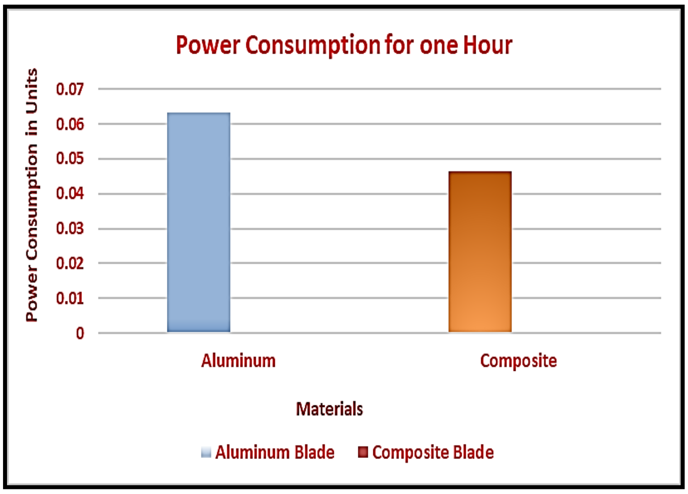
  Power consumed for one year = 0.04643 units*8 hours*30 days*12 months = 134 units.

  Cost for running at Rs.7 per unit = Rs. 938/-

- **Percentage of power consumed:**

  Cost saved for one year = Rs. 336/-

  Percentage of power saved = 26 %



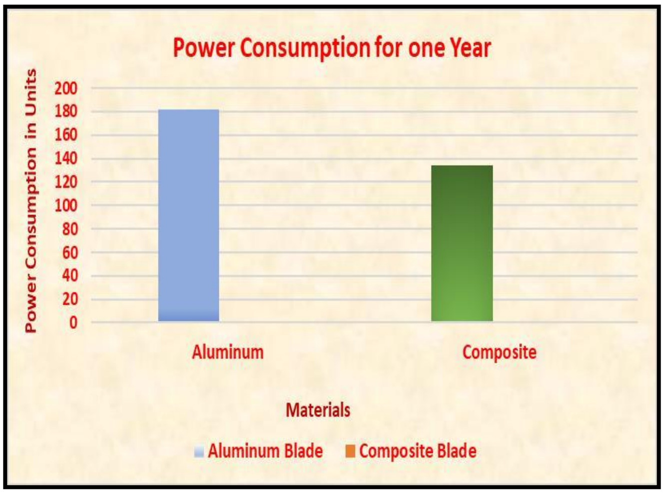


Fig.1.5: Power Consumption of Materials in Hour and Year

The power consumed is saved by 26% by replacing the aluminium blade with composite blade in the ceiling fan. Thus, the aim in fabricating the composite blade is stabilized. The main objective of this paper is to calculate power conservation of the composite ceiling fan blade compared to the existing ceiling fan blade. For that the experiments are conducted for both blades. First the existing blade is fitted with fan hub and tests are conducted to find the power consumption. After that the composite blade is fitted with the fan hub. Again, the tests are conducted, and power consumption are found out.

4.3. Cost Comparison

- **Composite fan Cost:**

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Cost of composite blade (3 unit) = Rs.330 /-

- **Aluminium blades Cost:**

  Total cost of existing ceiling fan blades = Rs. 410/-

- **Base cost:**

  Composite base-Rs.420/-

  Metal base –Rs.650/-

- **Percentage saving in cost:**

  Total cost saved = Rs. 310/-

  % Saving in cost = 28 %

  It is clear that by replacing the aluminium with composite ceiling fan results in a total reduction of 28 % in the cost incurred for the fan.

4.4. Flow Velocity

The velocity of the air flow through the ceiling fan employing both the composite blade and the existing aluminium fan is determined using an anemometer. At a pre-determined height, the velocity of the flow is determined. Since the air flow rate is a direct measure of the flow velocity, the comparison of the flow velocity is considered to be significant. As 1.65 feet above the ground level, the flow velocity of both the composite and the aluminium blade is determined using anemometer.

Flow velocity through Aluminium blade ceiling fan = 393.7 ft/min.

Flow velocity through Composite blade ceiling fan = 452.76 ft/min.

Difference in flow velocity = 59.06 ft/min.

% Increase in flow velocity = 15%.

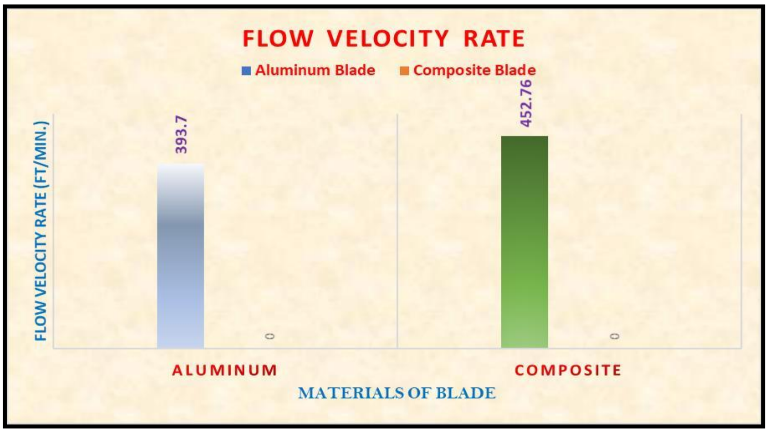

Fig.1.6: Flow Velocity Rate of Aluminum and Composite Fan blade Materials

On experimental analysis, it is found that the replacement of the existing aluminium blade with composite ceiling fan blade increases the flow velocity by 15%, which shows that there will be increase in air flow through the fan employing composite blade in place of aluminium blade.

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4.5. Total Comparison

Thus, the design and fabrication of the glass fiber reinforced polymer composite ceiling fan is done. Also, the composite fan is compared with the existing aluminium fan and the results are discussed.

Table 1.3: Total Comparison

Description	Existing blade	Composite blade	% Reduction
Weight	820 gm	608gm	27 %
Power Consumption	0.06318 units	0.04643 units	26 %
Cost of Blades	Rs. 1060/-	Rs. 750/-	28 %
Flow Velocity	393.70 ft/min	452.76 ft/min	15 %

It is tested that the power consumed by the aluminium blade (0.06318 units) is more than that of the composite one (0.04643 units). So, the usage of the composite fan reduces the power consumption by 26 %. The weight of the existing fan blade is 480 gm, whereas the weight of the composite blade is 348 gm, contributing to a reduction of 27% in weight. The cost of composite ceiling fan blade is Rs.294/- which is 28 % less than the existing aluminium blade ceiling fan. The flow velocity through the composite blade is determined to be 15% more than the flow through the conventional aluminium blade.

CONCLUSION

Thus, from the research work the following results are drawn:

1. Usage of glass fiber reinforced polymer ceiling fans reduces the weight of the fan thereby reducing the power consumption by 26%.
2. Air flow velocity through the fan increases by 15% by employing glass fiber blades.
3. Cost of the ceiling fan reduces by imparting fiber glass polymer in place of existing metal.
4. Wholly Enhancement of the Proper Air flow distribution throughout the room takes place.
5. Maximize the air flow (cfm) per input watt.
6. Enhanced and maintained the optimum cooling rate.
7. Maintained the Quietness of operation.

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