

Characterization and Performance of Horizontal Axis Wind Turbine with Composite Material Blades

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Abstract:

Wind turbine blades keep on being the objective of mechanical upgrades by the utilization of better structures, materials, assembling, investigation and testing. Wind energy has pulled in a lot of consideration as of late as one of the possible option sustainable power source assets. Nearly of the neighborhood innovative work exercises in this field were coordinated to investigate, create, and ideal usage of energy systems.

The opportunity has arrived to create a usable innovation which will expand the local share in an inevitably emerging wind energy industry as the size of turbines has grown over the past decade, architects have limited the related development in sharp blades weight to not exactly would have been possible through straightforward scaling up of past approaches.

Assembling patterns and structure drivers are displayed, similar to the manners in which these plan drivers have changed. One material i.e, framework (polyester) ties together a lot of filaments or the sections of an a lot more grounded material and the subsequent material (the support) surround's these fibers. Some potential headings for future sharp blade design choices will be introduced in present paper.

These wind blade samples are utilized for examining of various air speeds and various parameters of wind turbine, for example, power developed by turbine, power created by wind, power co-efficient, speed of wind turbine are determined and contrasted and existing materials utilized in wind turbine sharp blades.

Keywords:

Flax fiber, Hand-layup fabrication technique, power created by wind turbine, power developed by wind, speed of wind turbine, power coefficient.

I. INTRODUCTION:

The interest for wind and different types of clean energy is expanding in the US and all through the world. Wind energy is additionally expected to give 14.9% of the worldwide power request by 2020. Under this scenario, a significant amount of wind turbine blades will continue to burden our current landfills until a viable recycling strategy is found. Repurposing or reusing of part of the arrangement turbine sharp edge material will give both monetary and ecological properties.

A practical procedure for managing wind turbines towards the part of the bargain life is required so as to amplify the ecological advantages of wind control from an actual existence cycle viewpoint. Most segments of a breeze turbine, for example, establishment, tower, parts of the rigging box and generator are as of now recyclable and are dealt with likewise. In any case, wind turbine edges speak to a test because of the materials utilized and their unpredictable arrangement.

II. LITERATURE SURVEY:

1.B.Nagendra Prasad, Praveen Kumar Yadav

In the present life request of power in expanding everywhere throughout the world. The creation of power is less when contrasted with utilization. By sustainable sources we can create vitality which is accessible in colossal sum and can be supplanted. Sustainable sources are vital on the grounds that to arrive at the interest of vitality, expanding cost of non-renewable energy sources utilized for different purposes and primary concern is ecological contamination. In this manner inexhaustible sources are the new methods that can deliver power and furthermore it doesn't make any natural impacts human life and environment.

2. Lijin Thomas, Ramachandra M

Numerous examinations have shown the benefits of cutting edge materials in the field of wind turbine sharp edges. Materials with certain ideal properties like, low weight to lessen gravitational powers, high solidarity to withstand wind power and gravitational power of the cutting edge, high weariness protection from withstand cyclic burden, high firmness to guarantee solidness of the ideal shape, are contemplated and audited.

3. Povl Brøndsted, Hans Lilholt, and Aage Lystrup

Wood and composites are examined as contender for rotor blades. The strands and lattices for composites are depicted, and their high firmness, low thickness, and great weakness execution are underscored. Assembling advances for composites are given and assessed regard to points of interest, issues, and modern potential. The significant advances of today are prepare (pre-impregnated) innovation and gum imbue innovation. The mechanical properties of fiber composite materials are talked about, with an attention on weakness execution. Harm and materials corruption during exhaustion are portrayed. Testing techniques for documentation of properties are audited, and weariness stacking chronicles are talked about, together with strategies for information taking care of and measurable investigation of (huge) measures of test information.

4. M. Grujicic, G. Arakere, B. Pandurangan, V. Sellappan, A. Vallejo, and M. Ozen

A multi-disciplinary structure advancement technique has been presented and utilized for the improvement of financially savvy glass-fiber fortified epoxy-network composite 5 MW Horizontal-axis wind-turbine (HAWT) blades. The work obviously uncovered the difficulties related with at the same time fulfilling the quality, strength and solidness necessities while keeping up an abnormal state of wind-vitality catch effectiveness and a lower creation cost.

A multidisciplinary streamlining method has been produced for use in the plan of practical glass-fiber fortified epoxy matrix composite 5 MW HAWT sharp edges.

5. Nikoloz M. Chikhradze, Fernand D.S. Marquis, Guram S. Abashidz

The consequences of an examination concerning the generation of wind turbine cutting edges produced utilizing polymer composites fortified by mixture (carbon, basalt, glass) strands and reinforced by different Nano powders (oxides, carbides, borides) are displayed. The mixture fiber-fortified composites (HFRC) were produced with prepare innovation by embellishment pre-immersed epoxy-fortified framework strengthened texture. Execution of the made composites was evaluated with estimations of the coefficient of working condition (COC) at a moderate and raised temperature.

6. Ganesh R Kalagi, Rajashekar Patil, Narayan Nayak

Wind turbine is a gadget that changes over dynamic vitality from the breeze into electrical power. Among every one of the pieces of wind turbine, for example, edges, center point, gear box, nacelle, and tower; nacelle and wind turbine cutting edges are commonly comprised of glass filaments and carbon strands for better quality, low weight, and consumption opposition. The fundamental restrictions of these materials are the accessibility, non-biodegradable, wellbeing perilous and their creation cost, consequently the point of this exploration is to supplant these materials with characteristic strands. In this exploration work, use of characteristic strands strengthened polymer composites in wind turbine, necessities to the composites, their properties, constituents, producing innovations, and imperfections are reviewed.

III. MATERIALS & METHODOLOGY:

a) Flax Fiber:

Flax which is also known as common flax or linseed is a member of the genus in the family. It is a food and fiber yield developed in the cooler regions all around the globe. Materials delivered utilizing flax are commonly used for bed sheets, underclothes, and table fabric. Notwithstanding that the plant itself, "flax" may imply the unspun filaments of the flax plant. The plant species are alluded to similarly as a created plant and appears to have been restrained just once from the wild species called pale flax.

b) Polyester:

As a specific material, polyester most typically refers to a sort called Polyethylene terephthalate (PET). Response of liquor with carboxylic acid outcomes in the development of esters. Polyester holds its shape and hence is useful for making outdoor clothing for harsh climates. Polyester fibers are incredibly solid.

c) Fabrication:

By using hand layup method in a square moulds with flax fiber and polyester by taking fiber of 5%, 10%, 15%, 20%, 25% weights respectively and these moulds are removed and the test for tensile strength, flexural strength and impact strength are connected. By considering these results the percentage weight of fiber to be used in turbine blade making is selected.

d) Rough Engineering outline:

As per the design specifications of NACA primarily we designed and engineered an outline.

Length of Chord	700mm
Blade Chord Tip	30mm
Blades Length	200mm
Number of Turbines Blades	3
Thickness of Fiber	3mm
Height of Nacelle	600mm

e) Pre-form making:

By cutting an outline in the CNC machine we construct a pre-structured in wood or any other metals. Once the pre-structure is completed we can move on to the mould making process.

f) Mould making and component casting:

We move onto shape making after wooden sample is made. In this process, we have to apply wax for the wooden sample. In the next step for clearing dust stockpiling on the wooden sample we need to do is rubbing cotton. Next, we need to apply a PVA which fills in as a discharging operator as it is in the fluid form. Next with resin gel coat it for two times. In the next step, applying glass fabric by doping and finishing with water paper. Component casting is as same as the mould making process. Here the required fiber blades mould is made by applying the same process of mould making.

A. Final Finished Assembly:

By placing threaded bolts which are 5mm diameter finally finished blades are made which is arranged with a nut with locking system where we can change it to different angles.



Fig.1: Flax Fibres with Polyester Blades



Fig.2: Patterns made for Fibre Blades

B. Supply of Wind:

We used a wind tunnel for the forced wind. This wind tunnel gives the required amount of wind.

- The blower consist of 400mm
- The nozzle wind tunnel is 300mm
- The motor is of 3HP
- The motor has RPM of 1500rpm



Fig.3 Wind turbine made of flax fiber blades near wind tunnel

C. Experimental procedure of fibre blades with wind tunnel:

- Aerofoil blades of laboratory model wind mill set at various angles of attack namely 0° , 45° , 90° , 135° , 180° .
- The procedure has be repeated for the 60cm, 90cm, and 120cm distance respectively.
- Temperature of air is taken into account to evaluate wind energy associated with it at inlet.
- The distance of wind mill should be kept constant while doing the experiment.
- Power supply should be given to the blower to suck air into suction zone of wind tunnel.
- Using rotating type of anemometer at a inlet outlet of wind mill the velocity of air is to be measured.

IV. Calculations:

$$\text{Power Developed By Wind (PW)} = \frac{1}{2} \rho A V_I^3$$

$$\rho = \text{Density of air } \frac{P}{RT} \text{ (P) atmospheric air} = 1.01325 \times 10^5 \text{ N/m}^2$$

$$(R) \text{ Gas constant} = 287 \text{ J/Kg-K}$$

$$(T) \text{ Temperature} = 300\text{K}$$

$$A = \text{area of rotor } \left(\frac{\pi}{4} * (2(l+r))^2 \text{ m}^2 \right)$$

$$V = \text{Velocity at inlet of blade (m/sec)}$$

$$\text{Power Developed By Turbine (PT)} = \frac{1}{4} (V_I + V_O) (V_I^2 - V_O^2) \rho A$$

$$V_I = \text{Velocity at inlet of blade (m/sec)}$$

$$V_O = \text{Velocity at outlet of blade (m/sec)}$$

$$\text{Power Coefficient (C}_p\text{)} = \frac{P_T}{P_W}$$

$$P_T = \text{Power developed by Turbine (watts)}$$

$$P_W = \text{Power developed by wind (watts)}$$

$$\text{Length (l)} = 0.23\text{m}$$

$$\text{Radius (r)} = 0.0505\text{m}$$

$$\text{Area of rotor (A)} = 0.2472 \text{ m}^2$$

$$\text{Density of air } (\rho) = 1.1768$$

V. EXPERIMENTAL RESULTS:

The flax fiber with Polyester specimen are cut according to the standard lengths and to under go the tests like flexural and tensile in the conventional UTM machine and the digital readings are taken in the same way specimens undergoes impact test in the charpy impact testing machine and the readings are noted. The results obtained are as show below.

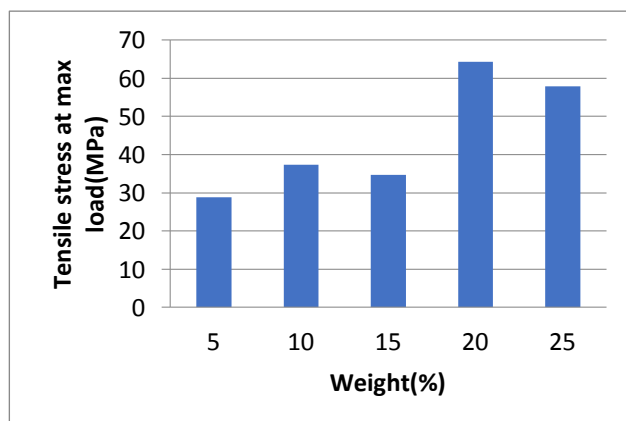


Fig.4: Weight vs. Tensile stress at max load

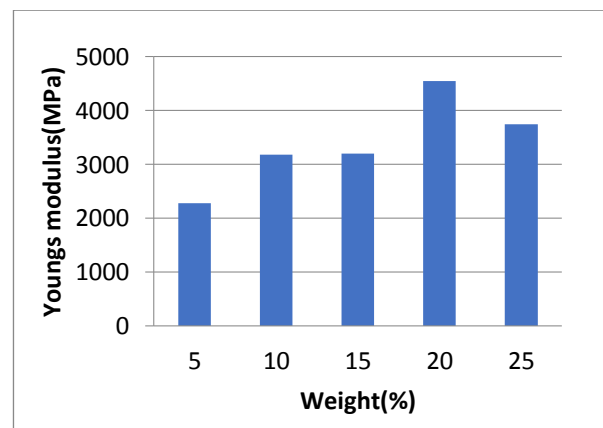


Fig.5: Weight vs. Young's modulus

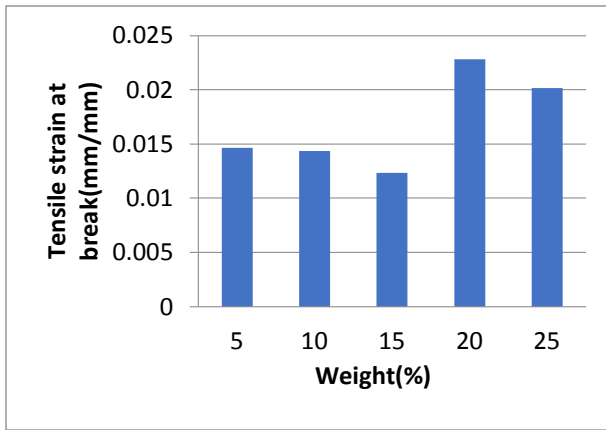


Fig.6: Weight vs. Tensile strain at break

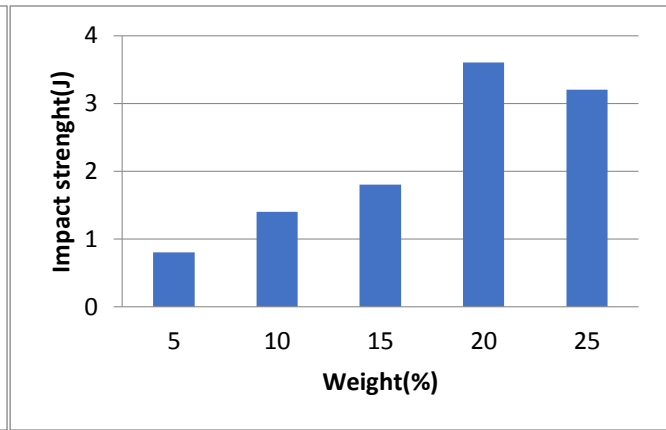


Fig.7: Weight vs. Impact strength

Angle (Degrees)	Speed (Rpm)	Atm Temp (K)	Inlet velocity (m/sec)	Outlet velocity (m/sec)	Power input (kW)	Power output (kW)	Power Co-efficient
0	80	300	16.2	14.2	6.2×10^{-3}	1.33×10^{-3}	0.22
45	360	300	16.2	12.8	6.2×10^{-3}	2.07×10^{-3}	0.33
90	420	300	16.2	7.7	6.2×10^{-3}	3.53×10^{-3}	0.57
135	630	300	16.2	11.8	6.2×10^{-3}	2.50×10^{-3}	0.40
180	150	300	16.2	13.7	6.2×10^{-3}	1.62×10^{-3}	0.26

Table1: With flax fiber body at a distance of 60cm from wind tunnel

Angle (Degrees)	Speed (Rpm)	Atm Temp (K)	Inlet velocity (m/sec)	Outlet velocity (m/sec)	Power input (KW)	Power output (KW)	Power Co-efficient
0	180	300	16.2	14.8	6.2×10^{-3}	0.97×10^{-3}	0.16
45	350	300	16.2	13.5	6.2×10^{-3}	1.73×10^{-3}	0.28
90	400	300	16.2	13	6.2×10^{-3}	1.98×10^{-3}	0.32
135	780	300	16.2	11.2	6.2×10^{-3}	2.69×10^{-3}	0.43
180	200	300	16.2	13.4	6.2×10^{-3}	1.78×10^{-3}	0.39

Table.2: With a Glass fiber body at a distance of 60cm from wind tunnel

Angle (Degrees)	Speed (Rpm)	Atm Temp (K)	Inlet velocity (m/sec)	Outlet velocity (m/sec)	Power input (KW)	Power output (KW)	Power Co-efficient
0	130	300	14.9	12.2	4.8×10^{-3}	1.44×10^{-3}	0.32
45	380	300	14.9	10.9	4.8×10^{-3}	1.93×10^{-3}	0.40
90	620	300	14.9	7.2	4.8×10^{-3}	2.73×10^{-3}	0.56
135	690	300	14.9	10.4	4.8×10^{-3}	2.09×10^{-3}	0.43
180	90	300	14.9	10.5	4.8×10^{-3}	2.09×10^{-3}	0.43

Table.3: With flax fiber body at a distance of 90cm from wind tunnel

Angle (Degrees)	Speed (Rpm)	Atm Temp (K)	Inlet velocity (m/sec)	Outlet velocity (m/sec)	Power input (KW)	Power output (KW)	Power Co-efficient
0	160	300	14.9	13.4	4.81×10^{-3}	0.87×10^{-3}	0.18
45	380	300	14.9	12	4.81×10^{-3}	1.52×10^{-3}	0.32
90	180	300	14.9	11.2	4.81×10^{-3}	1.83×10^{-3}	0.38
135	550	300	14.9	12.4	4.81×10^{-3}	1.35×10^{-3}	0.28
180	90	300	14.9	12.6	4.81×10^{-3}	1.36×10^{-3}	0.26

Table.4: With Glass fiber body at a distance of 90cm from wind tunnel

Angle (Degrees)	Speed (Rpm)	Atm Temp (K)	Inlet velocity (m/sec)	Outlet velocity (m/sec)	Power input (KW)	Power output (KW)	Power Co-efficient
0	30	300	13.2	9.6	3.3×10^{-3}	1.36×10^{-3}	0.41
45	340	300	13.2	7.9	3.3×10^{-3}	1.71×10^{-3}	0.52
90	120	300	13.2	6.8	3.3×10^{-3}	1.86×10^{-3}	0.56
135	450	300	13.2	9.1	3.3×10^{-3}	1.48×10^{-3}	0.45
180	145	300	13.2	10.3	3.3×10^{-3}	1.16×10^{-3}	0.35

Table.5: With flax fiber body at a distance of 120cm from wind tunnel

Angle (Degrees)	Speed (Rpm)	Atm Temp (K)	Inlet velocity (m/sec)	Outlet velocity (m/sec)	Power input (KW)	Power output (KW)	Power Co-efficient
0	60	300	13.2	10.3	3.34×10^{-3}	1.16×10^{-3}	0.35
45	350	300	13.2	9.6	3.34×10^{-3}	1.36×10^{-3}	0.41
90	110	300	13.2	9.2	3.34×10^{-3}	1.45×10^{-3}	0.43
135	470	300	13.2	10	3.34×10^{-3}	1.25×10^{-3}	0.37
180	120	300	13.2	10.2	3.34×10^{-3}	1.19×10^{-3}	0.36

Table.6 with Glass fiber body at a distance of 120cm from wind tunnel

VI. RESULTS AND CONCLUSIONS:

From the above diagrams and tables it is clear that at 90° the greatest power co-efficient is noted as 0.57 for flax fiber sharp edges at a separation of 90cm from wind tunnel and at 135° , the most extreme power co-efficient is noted as 0.43 at a separation of 90cm from the turbine edges with flax fiber and polyester works more productively as power co-efficient continues expanding in the middle of 90° and 135° .

In flax fiber cutting edges the most elevated speed is noted as 780 rpm which is at 135° and as the speed is relative to control power co-efficient. We can see that power co-efficient is higher for flax fiber edges. In aluminium edges we have obtained the maximum speed as 720 rpm which is not as much as flax fiber sharp edges.

Most of the time Aluminium cutting edges are less effective than that of flax fiber edges, the power created in flax fiber edges is more than aluminium sharp edges. Our works of fiber composites carried out successfully.

In aluminium, the Thermal conductivity is greater than fibers and strength is long-lasting to wind speed however contrast fibers has low thermal conductivity, better quality and high durability.

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