

# Performance and Analysis of Horizontal Axis Wind Turbine with Composite Material Blades

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## Abstract:

In today's life demand of electricity is increasing all over the world. The production of electricity is less when compared to consumption. By renewable sources we can produce energy which is available in huge amount and can be replaced. Renewable sources are necessary because to reach the demand of energy, increasing cost of fossil fuels used for various purposes and main thing is environmental pollution. Thus renewable sources are the new techniques that can produce electricity and also it does not cause any environmental effects to human life and surroundings. In this savonius wind turbine with three blades (Glass fibre) is designed and fabricated. For different air velocities the different parameters of wind turbine such as power developed by turbine, power developed by wind, power co-efficient, speed of wind turbine are calculated.

**Keywords — Horizontal axis wind turbine; Glass fiber blades; Aluminum blades; power coefficient; Power developed by wind; Power developed by turbine**

## I. INTRODUCTION

The principal wind turbine for electric force era was developed by the organization S.Morgan-Smith at Grandpa's Knob in Vermont, USA, in 1941. The turbine (53.3m rotor, 2 cutting edges, power rating 1.25MW) was outfitted with monstrous steel sharp edges. One of the cutting edges fizzled after just a couple of hundred hours of discontinuous operation. In this manner, the significance of the best possible decision of material and natural constraints of metal as a wind cutting edge material was exhibited exactly toward the start of the historical backdrop of wind vitality improvement. The following, entirely effective case of wind turbine for vitality era is alleged gedser coast in 1956-57. the turbine was delivered as of now with composite sharp edges, worked from steel saves, with aluminum shell upheld by wooden ribs. The turbine (three sharp edges, 24m rotor, and 200kW) was the principal example of overcoming adversity of wind vitality: it has kept running for a long time without upkeep. After 1970's, a large portion of wind turbines were delivered with composite sharp edges (Manwell et al, 2002, Brondsted et al, 2005)

Along these lines, the association between the accomplishment of wind vitality era innovation and the advancement and utilization of composite materials for turbine parts got to be apparent from the initial step

of wind vitality use: while the principal turbine, worked with steel edges, fizzled, the second one with composite cutting edges worked for a long time.

By definition, composite are materials, which comprise of two or all the more synthetically disparate constituents with various properties. Because of their prevalent mechanical properties, higher quality and lower

weight, when contrasted with numerous metals and compounds, and in addition the likelihood of fitting the microstructures, composites found a wide applications in auxiliary, common and mechanical building, car industry and also vitality applications.

Why does composite material assume the key part in the wind vitality advancement? The objective of fossil fuel independency in closest decades implies that the renewable vitality segment must be radically expanded. EU set an objective to get 20% of its vitality requirements for renewable by 2020. Keeping in mind the end goal to supply 20% of power for renewable sources to 2020, the EU seaward wind vitality limit ought to be extended by two requests of extent. The high volumes of wind vitality era, important to accomplish this objective, required the establishment and utilization of change extensive wind turbines (8-10MW and higher) remaining in wind homesteads of a few hundred MW. For this situation, the potential expense of repair and substitution of harmed wind turbine may be colossal. In perspective of this necessity,

just material with the high quality, weariness resistance and solidness i.e., composites, - can be utilized as a part of wind turbine edges. No different materials, - neither metals, nor combinations, nor wood, - can fulfill this rundown of prerequisites completely

**II. COMPOSITE FIBERS**

In industry, the bit of the pie of composites is not withstanding growing much speedier, and composites are right now comprehensively used as a piece of flying business, auto industry, marine industry, Composites or composite materials are a mix of two or more materials, in a way that you can even now perceive the diverse material stages consequent to amassing. The system can basically be any kind of plastic: epoxy, polyester, vinyl ester, polypropylene (PP), There is a noteworthy refinement amongst thermosetting and thermoplastic gums for composites.

Thermoset polymers are the network of choice for most assistant composite materials. The single most prominent purpose of enthusiasm of thermoset polymers is that they have a low thickness and can thusly be brought into fibers at low weights. Impregnation of the strands is trailed by substance curing to give a solid structure, which should usually be possible isothermally.

**Table 1:** Resins Types

Thermosetting resins	Thermoplastic resins
Epoxy	Polypropylene (PP)
Unsaturated polyester (UP)	Thermoplastic polyesters (PET, PBT)
Vinyl ester	Polyether sulphide (PES)
Polyurethane (PUR)	Polyphenylene sulphide (PPS)
Phenolic resin	Polyether imide (PEI)
Acrylic resin	Polyether ether ketone (PEEK)

Thermoplastic polymers tend to have melt viscosities some place around 500 and 1000 times that of thermosets, which requires higher weights, causes planning challenges and incorporates cost. On the other hand, ideal position of thermoplastics is that the trim should be possible non- isothermally, i.e. a hot melt into a cold mold, in order to fulfill snappy

procedure lengths. Thermoplastic composite polymers can in like manner be speedily reused. Dense, more than 90% of polymers used as a piece of composites are thermo sets, with thermoplastic composites still a claim to fame market, principally in view of the difficulties in get ready.

The fibers are typically glass, carbon (graphite) or aramid (trade name Kevlar). The fiber stronghold can take any structure: a mat of short cut fibers, a woven fabric, a unidirectional course of action of strands, a turn, a weave.

**III. FIBER BLADES**

**3. glass fiber:**

Glass fibres are most commonly used fibres. They come in two forms:

- Continuous fibres
- Discontinuous or “staple” fibres
- Chemically, glass is silicon di-oxide (SiO<sub>2</sub>). Glass fibres used for structural applications come in two “flavours”: E-Glass, and S-Glass. E-glass is produced in much larger volumes vis-à-vis S glass.

**• Principal advantages:**

- Low cost
- High strength

**• Limitations:**

- Poor abrasion resistance causing reduced usable strength
- Poor adhesion to specific polymer matrix materials
- Poor adhesion in humid environments
- Glass fibres are coated with chemicals to enhance their adhesion properties. These chemicals are known as “coupling agents”.
- Many of coupling agents are silane compounds

**3.1 Epoxy:**

Epoxies address without a doubt the most versatile tars available to the composite creator. Generally, in all characterizations of work, the engineer/repairer will comprehend the best level of bond quality, waterproofing and solidness with particularly arranged epoxies. New period epoxies are VOC free and have curing structures which are sans phenol (addressing a secured stride forward for all tar customers). Whether an area or repair is made of wood, carbon, Kevlar, fiberglass, focus material or half and parts of the above, epoxies will wet and for record-breaking stick to the

composite.

### 3.2 CASTING:

Process of Casting:

1. Rough Engineering drawing
2. Pre-form matching
3. Mould making
4. Component casting
5. Final finished assembly

#### 1) Rough Engineering Drawing:

Firstly we designed an engineering drawing with certain dimensions as per the design parameters of NACA

Chord length = 70mm  
Tip of blade chord = 30mm  
Length of blades = 200mm  
No of blades = 3 blades  
Fibre Thickness = 3mm  
Nacelle height = 600mm  
Blades of Hollow fibre blades

#### Pre-form Making:

Build up a pre-structure in wood or POP on any of alternate metals by cutting the profile in CNC machines

By making this pre-structure design we can undoubtedly make an example which is of reproduction of a completed item this aides in making the work simple and basic yet ought to be done with gifted work. Once in the wake of finishing the pre-structure item we can facilitate continue to Mold making here we can proceed for the further procedure.

#### 2) Mould making:

Once a wooden example is made we continue to shape making. In mold making we need to finish the wax on the wooden example where we coat a wax finish for simple evacuation of examples

Next we need to do cotton rubbing for clearing dust stockpiling on the wooden example. Apply PVA (Poly vinyl Alcohol) which is a fluid shape this fills in as a discharging operator.

There after we have to apply gel coat 2 times with Resin (cobalt). This further continues by applying glass fabric with tar (cosmetics methyl, ethyl, cornerstone, peroxide) completing with water paper.

#### 3) Component Casting:

Rehashing mold making by the required measurements and apply the same procedure like need to finish the wax on the wooden example where we coat a wax finish for simple expulsion of examples

Next we need to do cotton rubbing for clearing dust stockpiling on the wooden example. Apply PVA (Poly vinyl Alcohol) which is a fluid frame this fills in as a discharging specialist.



Fig fiber pattern



Fig Patterns made for fiber Blades

There after we need to apply gel coat 2 times with Resin (cobalt). This further proceeds by applying glass cloth with resin (makeup methyl, ethylene, keystone, peroxide) finishing with water paper

A finished product is ready and an pattern is used for multiple design blades.

#### Final Finished Assembly:

Finished blades are casted with placing an threaded bolts which are of 5mm diameter here this bolts are arranged with looking system with a nut where we can change the angles to a desired angle of blade.



Fig Glass fiber with epoxy blades with bolt in bottom

**WIND SUPPLY:**

We used wind tunnel to give the wind its an forced wind, as we known this wind tunnel can be helpful in giving the wind supply

The blower consist of an fan of diameter = 400mm

The nozzle of the wind tunnel is = 300mm

The motor is of = 3hp

The rpm of motor is = 1500rpm



Fig wind tunnel with wind turbine made of aluminum blades

**EXPERIMENTAL RESULTS:**

**TABLES AND GRAPHS:**

At a distance of 60 cm from wind tunnel with aluminium body

Angle	speed	Atm Temp	Inlet velocity	outlet velocity	power input	power output	power coefficient
0	190	300	16	15.2	5.9x10 <sup>-3</sup>	0.56x10 <sup>-3</sup>	0.1
45	300	300	16	14.2	5.9x10 <sup>-3</sup>	1.18x10 <sup>-3</sup>	0.2
90	90	300	16	12	5.9x10 <sup>-3</sup>	2.26x10 <sup>-3</sup>	0.38
135	720	300	16	13.2	5.9x10 <sup>-3</sup>	1.71x10 <sup>-3</sup>	0.29
180	110	300	16	14.2	5.9x10 <sup>-3</sup>	1.18x10 <sup>-3</sup>	0.21

At a distance of 60 cm from wind tunnel with glass fiber body

Angle	speed	Atm Temp	Inlet velocity	outlet velocity	power input	power output	power coefficient
0	180	300	16	14.8	5.9x10 <sup>-3</sup>	0.83x10 <sup>-3</sup>	0.14
45	350	300	16	13.5	5.9x10 <sup>-3</sup>	1.57x10 <sup>-3</sup>	0.25
90	400	300	16	13	5.9x10 <sup>-3</sup>	1.52x10 <sup>-3</sup>	0.26
135	780	300	16	11.3	5.9x10 <sup>-3</sup>	2.5x10 <sup>-3</sup>	0.42
180	200	300	16	13.4	5.9x10 <sup>-3</sup>	2.5x10 <sup>-3</sup>	0.27

**IV. CALCULATIONS**

$$\text{Power input (Pi)} = \frac{1}{2} \rho a v_i^3$$

$$\text{Area of the rotor (a)} = \frac{\pi}{4} (2(l+r))^2$$

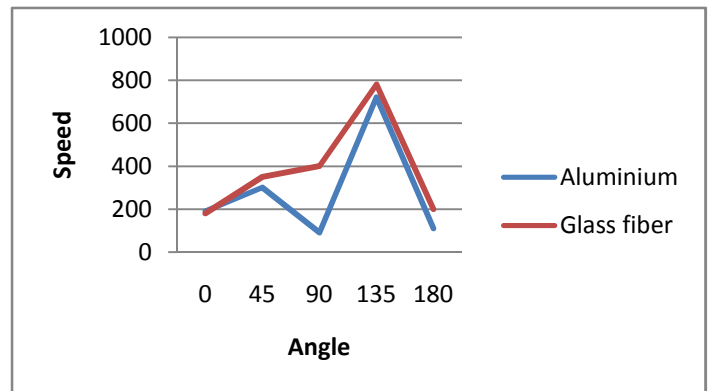
$$\text{Length (l)} = 0.23\text{m}$$

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

$$\text{Power out put (Po)} =$$

$$(v_i + v_o)(v_i^2 - v_o^2) \rho a$$

$$\text{Power coefficient (Cp)} = \frac{P_o}{P_i}$$

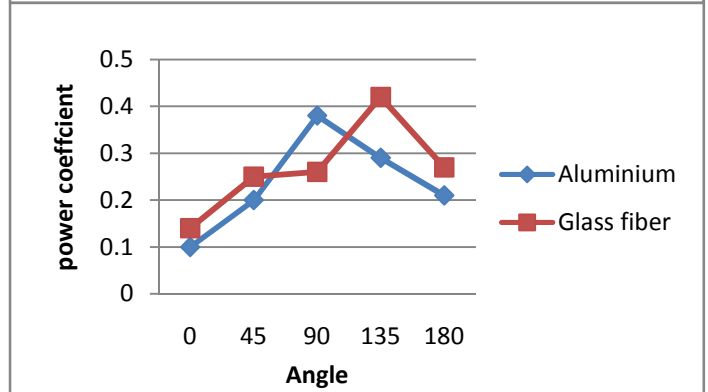
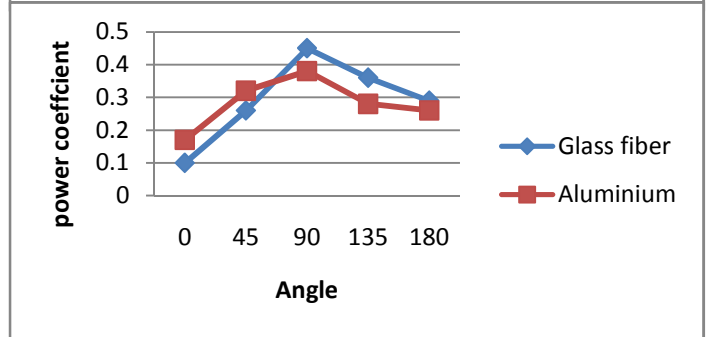
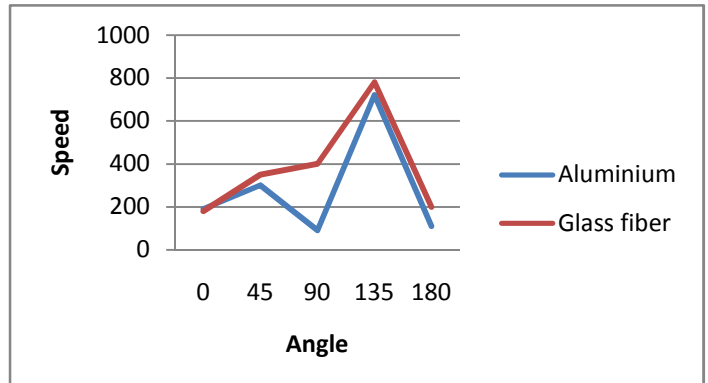


A graph at 60cm distance from wind tunnel for speed comparison



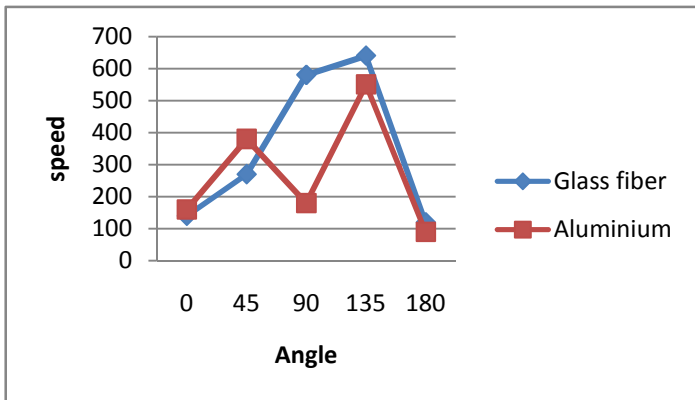
At a distance of 90 cm from wind tunnel with glass fiber body

Angle	speed	Atm Temp	Inlet velocity	outlet velocity	power input	power output	power coefficient
0	140	300	14.8	14	$4.6 \times 10^{-3}$	$0.47 \times 10^{-3}$	0.1
45	270	300	14.8	12.6	$4.6 \times 10^{-3}$	$1.23 \times 10^{-3}$	0.26
90	580	300	14.8	10.2	$4.6 \times 10^{-3}$	$2.07 \times 10^{-3}$	0.45
135	640	300	14.8	11.5	$4.6 \times 10^{-3}$	$1.65 \times 10^{-3}$	0.36
180	120	300	14.8	12.3	$4.6 \times 10^{-3}$	$1.33 \times 10^{-3}$	0.29



At a distance of 90 cm from wind tunnel with aluminium body

Angle	speed	Atm Temp	Inlet velocity	outlet velocity	power input	power output	power coefficient
0	160	300	14.8	13.4	$4.6 \times 10^{-3}$	$0.8 \times 10^{-3}$	0.17
45	380	300	14.8	12	$4.6 \times 10^{-3}$	$1.45 \times 10^{-3}$	0.32
90	180	300	14.8	11.2	$4.6 \times 10^{-3}$	$0.75 \times 10^{-3}$	0.38
135	550	300	14.8	12.4	$4.6 \times 10^{-3}$	$1.28 \times 10^{-3}$	0.28
180	90	300	14.8	12.6	$4.6 \times 10^{-3}$	$1.22 \times 10^{-3}$	0.26

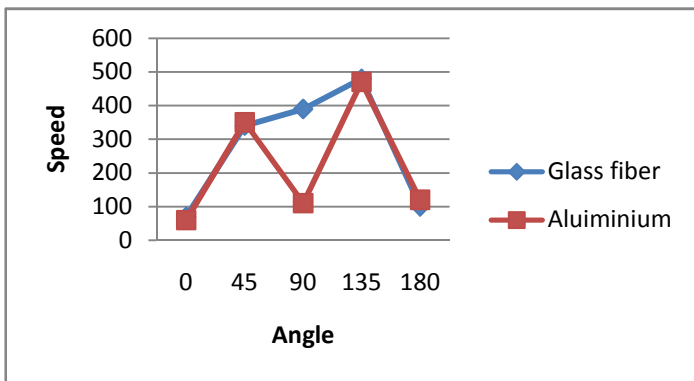


A graphs at 90cm distance from wind tunnel for speed and Cp comparison

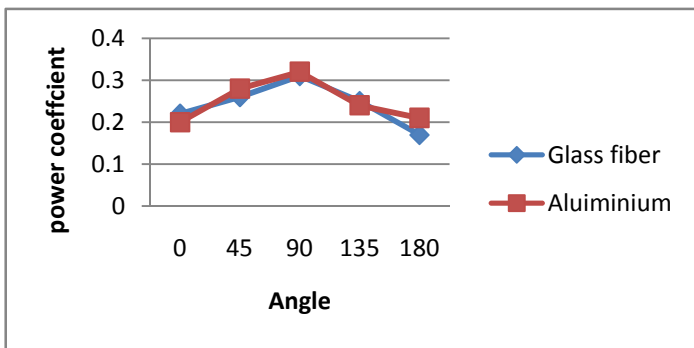
At a distance of 120 cm from wind tunnel with glass fiber body

Angle	speed	Atm Temp	Inlet velocity	outlet velocity	power input	power output	power coefficient
0	70	300	11.6	10.2	$2.25 \times 10^{-3}$	$0.5 \times 10^{-3}$	0.22
45	340	300	11.6	9.8	$2.25 \times 10^{-3}$	$0.6 \times 10^{-3}$	0.26
90	390	300	11.6	9.3	$2.25 \times 10^{-3}$	$0.7 \times 10^{-3}$	0.31
135	480	300	11.6	9.9	$2.25 \times 10^{-3}$	$0.57 \times 10^{-3}$	0.25
180	100	300	11.6	10.5	$2.25 \times 10^{-3}$	$0.38 \times 10^{-3}$	0.17

A graph at distance of 120cm from wind tunnel for speed comparison



A graph at distance 120cm from wind tunnel for power coefficient comparison



At a distance of 120 cm from wind tunnel with aluminium body

Angle	speed	At m Temp	Inlet velocity	outlet velocity	power input	power output	power coefficient
0	60	300	11.6	10.3	$2.25 \times 10^{-3}$	$0.45 \times 10^{-3}$	0.2
45	350	300	11.6	9.6	$2.25 \times 10^{-3}$	$0.64 \times 10^{-3}$	0.28
90	110	300	11.6	9.2	$2.25 \times 10^{-3}$	$0.71 \times 10^{-3}$	0.32
135	470	300	11.6	10	$2.25 \times 10^{-3}$	$0.55 \times 10^{-3}$	0.24
180	120	300	11.6	10.2	$2.25 \times 10^{-3}$	$0.48 \times 10^{-3}$	0.21

## V. RESULTS AND CONCLUSION:

- Aluminium verses fibre- at 135° the maximum power coefficient is 0.45, in distance of 600mm & 900mm from the wind tunnel with fibre blades, and @ 135° the maximum power coefficient is recorded as 0.42, in distance of 600mm from the wind tunnel with aluminium blades and in-between 135° & 90° the power coefficient keep on increasing here the turbine in glass fibre with epoxy works more effectively than Aluminium.
- Glass fibre blades speed- At 135° the rpm is more, here the highest rpm keeps effective in 135° & 90° as rpm is proportional to power coefficient there we always absorb that power coefficient is also effective in fibre we see maximum rpm as 780rpm, but in aluminium we see 720 as highest rpm.

So fibre is most efficient than aluminium blades, the power generated in aluminium blades is less than the power generated in fibre blades. The mechanism of fibre composites is worked out very effectively.

- In fibres the material has good strength and durability as well low thermal conductivity, whereas in aluminium the thermal conductivity is more than the fibres and strength is sustainable to wind velocity

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