10 kW (13 m/s) 5 m Diameter Carbon Fibre Wind Turbine Blades

Abstract

A 1 kW @ 12.5 m/s (2 kW @ 17 m/s), 1.8 metre diameter wind turbine was designed and constructed using carbon fibre composites. The generator was built by converting an induction motor into a permanent magnet generator. Blade power and efficiency have been measured at different tip-speed-ratios and a maximum efficiency of 30% at a TSR of 11.6 was recorded. These results verify the accuracy of calculations from the blade calculator software. Total cost of the generator and blades was less than AU$200.

Keywords: Wind power, Permanent Magnet Generator, Induction motor to PMA conversion, 1kw wind turbine, carbon fiber wind turbine blades

LIST OF FIGURES

1. Constructing the interior of the wind turbine blades

Figure 1. Steel blade core

The airfoil shapes were printed using a computer. The printouts were glued on 1 mm steel sheet and cut out.

Figure 2. Skeleton airfoil blade one

The steel airfoil cut-outs were welded on steel tube, with the angle set using a protractor against a plumb line.

Figure 3. Skeleton airfoil blade two

Figure 4. Skeleton filled with polyurethane foam

The skeleton was filled with expanding polyurethane foam (1kg Suprasec 5005, 1kg Daltolac GP33) and sanded into shape.

Figure 5. Polyurethane foam blade after sanding

2. Constructing the exterior of the wind turbine blades

Figure 6. Blade after being covered in chop strand matt fibreglass

The blade was coated in a layer of vinyl ester resin and once the resin had cured, 220 g chop strand matt fibre glass was used to fibreglass the blades. Several layers were used with sanding to ensure a smooth finish.

Figure 7. Blade after being covered in bi-axial glass cloth fibreglass

400g bi-axial glass cloth was wrapped around the blade and fibre glassed in place. It was lightly sanded before applying another layer of chop strand matt.

Figure 8. Blade after being covered in uni-directional carbon fibre

Chop strand matt was sanded into shape before applying the final layer of 197g uni-directional carbon fibre. The carbon fibre is lightly sanded to form a smooth flat blade.

Figure 9. Blade after sanding the carbon fibre

Figure 10. Completed 5 m wind turbine blades

3. Calculated output of the wind turbine system

Output of system at maximum generator output (generator efficiency of 50%)

TSR = 9
Blade Efficiency = 0.4
Mechanical Power = 10,525.7 Watts
Rotational Speed = 446.9 RPM
Rotational Torque = 224.91 N.m

Running at a TSR of 9, the generator should output 2 kW of electrical power, requiring 4 kW mechanical power

A TSR of 12.5 is a better match to the generator

TSR = 12.5
Blade Efficiency = 0.3
Mechanical Power = 7894.3 Watts
Rotational Speed = 620.7 RPM
Rotational Torque = 121.45 N.m

Running at a TSR of 12.5 the generator should output 4 kW electrical power, requiring 8 kW mechanical power

4. Total cost of the wind turbine blades

System cost (AUD)

Steel $25
Polyurethane $40
Matt, cloth, resin and initiator (MEKP) $220
Carbon fibre *(increased strength, not essential)* $120

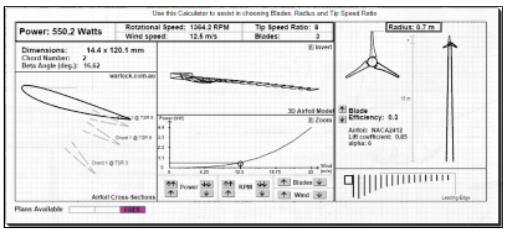
Total cost $405

Equipment used

Arc welder
Grinder
Drill
Wood saw
Sand paper
Fibreglass rollers
Paint brushes

Conclusion

At a total cost of $1,278 including the generator, a wind turbine capable of producing 4-5kW electrical power makes a very cheap alternative for power production especially in remote areas.



Design custom blades for your generator and calculate power output at each wind speed.

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