FUSELAGE WIND TURBINE

Blades versus Wind Lens(1)

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ABSTRACT
The Fuselage Turbine (FT) design is proposed as an alternative to existing Wind Turbine (WT) equipment. FT replaces the large swinging blade structures with a small diameter enclosed blade fan. This results in tangible benefits including; safer operation, higher wind power capture, less infra sound, lower bird strike, and improved operating flexibility. When connected to the electricity grid, it is preferable to use FT equipment to pump water to hydro storages before using it to generate base load power supply.

KEYWORDS:
Fuselage Turbine**,** Wind Turbine**,** bird strike**,** infra sound**,** hydro storage**,** Betz Law, Bernoulli Principle

1) INTRODUCTION:

Previous research work compared a common Wind Turbine (WT) operation with the proposed Fuselage Turbine (FT) design.(2) The work included field testing at an exposed coastal site using a single anemometer to record wind speeds with and without the FT modifications. Results indicated the FT had a benefit over the WT alternative at all wind speeds, and when water mist spray was added to the air stream a further improvement was recorded.

However, these tests did not provide a reliable comparison between the two designs, because the anemometer needed to be modified between tests implying the wind conditions may not be identical. It was decided to run the tests again using up to three anemometers to provide identical comparisons, with the same FT nozzle and diffuser proportions.

Further discussion with members of PSI considered “Wind Power: Is the Fuselage Turbine a Better Design?”(3) which identified the hollow support mast as a source of low frequency noise (infra sound).

2) ANEMOMETERS:

Wintact WT82B anemometers were selected, because they have the necessary physical shape allowing for easy FT modification. They also have suitable recording abilities, as well as remote connectivity through a blue tooth facility.

3) METHODOLOGY:

Anemometers operate with a magnetic source embedded in the fan blade. As the blade rotates, it passes a sensor in the housing, thereby recording the speed of the wind entering the fan blades.

The first test was to see how similar the three anemometers' records were when operating under similar wind speeds. The results are shown in Figure 1.

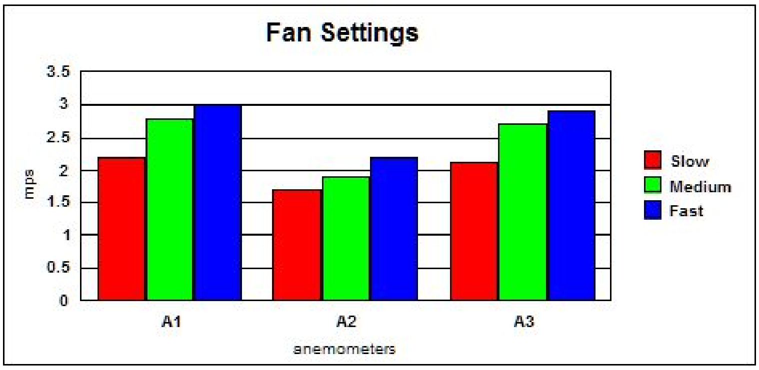

Figure 1.

Anemometer A1 recorded the fastest wind speeds, while A3 recorded slightly lower, and A2 was the lowest. We decided to average A1 and A2 for comparison calculation purposes, for comparing the effect of modifying A3 to the higher wind speeds available through the Fuselage Turbine (FT) design.

The anemometers were tested under a variety of conditions including a gimbal facing into the prevailing wind as shown in Figure 2.

Figure 2.

In practice the available wind speed proved too low at this time of year to record useful information from this setup, and an electric-fan wind generator was used instead.

A stationary electric-fan with three variable speed settings, was placed ahead of the three anemometers to record maximum wind speeds, as shown in Figure 3.

Figure 3.

4) RESULTS:

Fan setting on slow, medium and fast produced results shown in Figure 4:

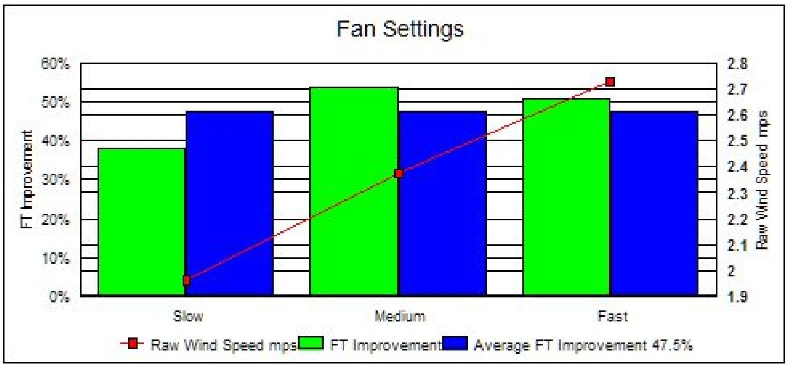

Figure 4.

The lowest wind speed recorded an improvement for the FT alternative of 37.9%. At the two higher speed settings an average improvement of 52.3% was recorded with the overall average of 47.5%, as shown in Table 1.

Fan Settings	Raw Wind Speed mps	FT Wind Reading	FT Improvement	Average FT Improvement 47.5%
Slow	1.97	2.71	37.9%	47.50%
Medium	2.38	3.65	53.7%	47.50%
Fast	2.73	4.12	50.9%	47.50%

Table 1.

5) DISCUSSION:

Anemometers are considerably smaller than the wind turbines they simulate. However, the power generated by a wind turbine is directly related to the available wind speed passing over the blades. This is the most important contributor to WT power as shown in Figure 5.(4) The aim of this study is to demonstrate that wind speed through the anemometer fan can be increased by the addition of both nozzle and diffuser attachments. Power improvement is therefore anticipated for wind turbine (WT) applications.

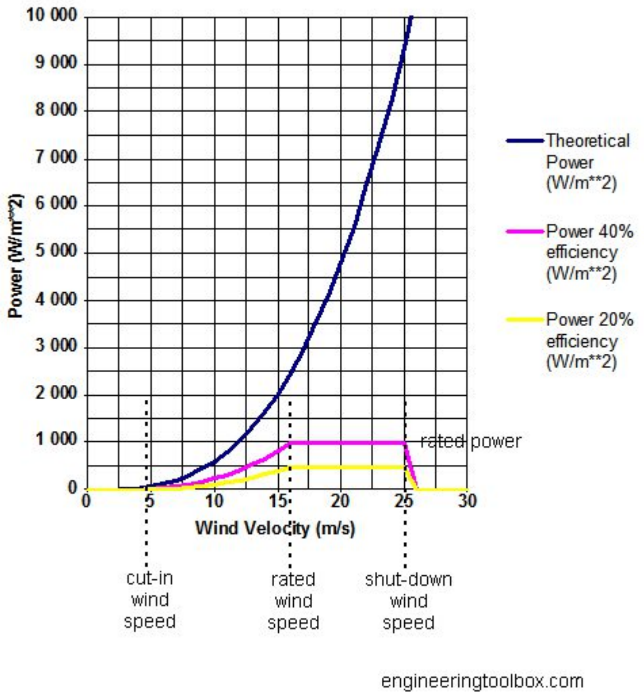

Figure 5.

The FT design showed increased wind speeds, relative to the WT design, because it avoids the limitation imposed by Betz Law(5), which calculates the maximum possible capture of wind energy is 59.3%. In practice this figure is usually closer to 35%, due to cut-in and cut-out wind speed restrictions.

The perforated FT nozzle captures an increased area of wind compared to the area of the fan alone as shown in Table 2. The critical design feature here is the nozzle perforations ahead of the fan. These allow additional air to be drawn into the fan through the operation of Bernoulli's Principle. Also the diffuser attachment reduces the back pressure on the fan limitation identified in Betz's law. These two design features add significantly to the overall wind generator efficiency.

diameter nozzle	mm	49.6
area nozzle	mm^2	38.96
diameter anemometer	mm	37.7
area anemometer	mm^2	29.61
Increased area		31.56%

Table 2.

FT design acts as a ‘wind lens’ which effectively captures wind from a wider area of influence than the blades of a WT can reach, and there are also several FT operational advantages resulting in higher utilization recorded in reference (2) which include:

+ The wind mill is a large highly stressed structure with generating capacity limited by the size of blades that can be used. FT replaces these with smaller diameter blades.
+ WT cannot operate in high winds and are shut down, as per Figure 5. Gusty wind conditions may also cause a shut down. This occurs because of asymmetric loadings on blades, and a requirement to keep blade tips operating below sonic velocities. FT avoids these limitations with shorter blades, no gear box, and asynchronous electrical connection.
+ Cold weather leads to icing on the blades which can be hazardous in a number of ways. FT may reduce this hazard with defreeze additive injected into the nozzle air supply, and an enclosed fan.
+ At low wind speeds WT is 100% ineffective requiring an alternate (or stored) power supply to be always on standby for power critical applications. This problem is mitigated if wind turbines are used to pump hydro water for base load generating purposes when the wind fails.
+ Keeping the blades below sonic velocity often leads to a requirement for one or more gearbox drives, although some installations exist where customised multi pole generators are direct coupled to a WT and operate in phase-synchronisation with the reticulated grid supply. FT can use multiple fans in the same housing ensuring that no fan blades operate above sonic velocity.
+ Large Wind Turbines have mechanical controls to ensure they always ‘point’ correctly. These can be problematic. FT self points due to the large diffuser attachment.
+ Foundation costs (particularly at offshore installations) are high and about the same price regardless of WT size. This aspect favours a more productive FT unit.
+ A moving blade light shadow associated with WT operation is a significant consideration at some locations and has precluded the siting of other units. FT has an enclosed fan eliminating moving shadows.
+ Noise levels are generally very low, but at the rural and coastal siting of many WT installations, noise is cited as having signification impact due to the incessant, throbbing, low-pitched tone. This is particularly noticeable at low wind speeds when natural noise levels are not present. FT avoids blades passing a support column. This eliminates a potential source of infra sound.
+ Birds and bats frequently die due to blade impacts at WT sites. FT has enclosed blades in a visible structure which is not susceptible to casual bird or bat contact. The large nozzle and diffuser structures may be decorated to warn off avian intruders.

6) CONCLUSIONS:

+ The FT design offers significant benefits over the WT alternative, and the improvements identified in previous report Wind Turbine Research (2) are verified, as well as the related reports "Wind Into Water"(6), “Wind Into Wine”(7), and “Saving The Outback”(8).
+ The next stage of FT development is to build a working generator with a blade diameter of about 2m, and include a water spray injection feature. This unit would preferably find use as a water pump.

7) REFERENCES:

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