IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

CFD ANALYSIS AND FABRICATION OF BLADE OF A HORIZONTAL AXIS WIND TURBINE USING DIFFERENT

T. Mohammed Asif*, G. Praveen Kumar Yadav
Department of Mechanical Engineering, G Pulla Reddy Engineering College, Kurnool, India

ABSTRACT
We know that there is enough wind globally to satisfy much, or even most, of human energy requirements – if it could be harvested effectively and on a large scale. Horizontal axis wind turbines (HAWTs) are as efficient as vertical axis systems. They might be practical, simpler, significantly easy to build and maintain. Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Major drawbacks are pulsatory torque that can be produced during each revolution and the huge bending moments on the blades. In this project I attempted to design and fabricate a Horizontal Axis Wind Turbine Blades with different materials and measured the performance coefficient under various conditions. Such as Distance between Blower and setup stand Vs RPM of the shaft by using heaters, Distance between Blower and setup stand Vs RPM of the shaft without heaters, RPM Vs Co-efficient of power.

KEYWORDS: Horizontal Axis Wind Turbine, Blade Design, Blade materials, CFD Analysis.

INTRODUCTION
Renewable energy is generally electricity supplied from sources, such as wind power, solar power, geothermal energy, hydropower and various forms of biomass. These sources have been coined renewable due to their continuous replenishment and availability for use over and over again. The popularity of renewable energy has experienced a significant upsurge in recent times due to the exhaustion of conventional power generation methods and increasing realization of its adverse effects on the environment. If the efficiency of a wind turbine is increased, then more power can be generated thus decreasing the need for expensive power generators that cause pollution. This would also reduce the cost of power for the common people. The wind is literally there for the taking and doesn't cost any money. Power can be generated and stored by a wind turbine with little or no pollution. If the efficiency of the common wind turbine is improved and widespread, the common people can cut back on their power costs immensely. In wind turbine technology, the turbine blades play an important role as it directly comes in contact with the wind. Wind turbine blades are shaped to generate maximum power from the wind at minimum cost. The blades should be designed for longer life as they are subjected to continuous fatigue loads. The first simulation (for wind-turbine applications) with direct modelling was done by Sorensen and Hansen [1], employing a rotating reference frame and the shear stress transport SST k–ω model. Several authors have performed CFD computations at the National Renewable Energy Laboratory (NREL) unsteady aerodynamic experiment with a variety of turbulence models. Sorensen (with the SST k–ω model) and Johansen [2] performed simulations of the NREL phase VI rotor with a rotor-fixed reference frame. Madsen et al.[3] compared direct modelling with a generalized actuator approach, and concluded that the local flow angle is generally better predicted by the direct model. In the computations by Johansen and Sorensen the full 3D solution was used to extract the airfoil characteristics. In the journal full scale analysis of two horizontal axis wind turbines was carried out with exact rotor representation. The flow velocity evaluated from the CFD analysis and the available experimental results of the MOD-0A wind turbine are literally perfect. A series of full scale CFD analyses was extended to investigate the wake behaviour of a 2 MW wind turbine at different wind speeds. The major conclusions arrived at, from the simulation analysis carried out for the wind velocities of 12 m/s to 25 m/s and 90% of wake is recovered for all inflow and outflow velocities and also the recovery distance increases with an increase in the wind velocity Sanderse [4] worked on a rotating wake

surrounded by a highly turbulent shear layer as transition zone to the undisturbed fluid is reported. The lowest velocity in the wake is reached around one to two diameters downstream of the rotor and the end of the near wake region is mentioned to be between two and five diameters, when the expanding shear layer reaches the centre. Bartl et al. [5] performed on the same model wind turbines, positioned three and five rotor diameters apart. Bartl et al. inspected the influence of the separation distance on the performance of the downstream turbine in addition to wake measurements behind the two machines.

MATERIALS AND METHODS

In this work electrical power generation is done through wind energy being the non-conventional form of energy. A blower is used externally to supply the wind to the turbine blades which in turn rotates the fans for determining the performance coefficient. To know the accuracy of the wind turbine I have been used different materials with the parameters. In this I have used Aluminium, MS Steel and Paper Wood as material for manufacturing blades of a wind turbine and Aluminium Shaft and a stand which is made of iron and a air blower which is run by an external source.

2. Components:

Fig 2.1. Aluminium Blade

Fig 2.2. MS Steel Blade

Fig 2.3. Paper Wood Blade

2.1. Aluminium:

Aluminium material is used for designing the blades of a Horizontal Axis Wind Turbine and these blades are placed on the Aluminium shaft by means of a screw thread.

2.2. MS Steel:

For designing the blades of a Horizontal Axis Wind Turbine I have used MS Steel material for fabrication. This material has less weight when compared to the Aluminium Blades.

2.3. Paper Wood:

Paper wood is a light weighted wood and it has a property such as it does not get affected by rain and heat. This paper wood is used in manufacturing the blades of a Horizontal Axis Wind Turbine.

2.4. Shaft:

Shaft is made of Aluminium material and it has less weight density when compared to iron shaft and it is a solid shaft with 1 inch diameter. Threads are placed along the shaft so that the blades are placed on the shaft with the help of screws.

2.5. Bearing:

Bearings are used to rotate the shaft freely when the air struck the blades of an horizontal axis wind turbine from an external source air blower and from this RPM is generated it is used to determine the power coefficient of the wind turbine. I have used the 2.54 cm of ball bearings and these ball bearings are placed on the shaft at its edges and shaft with bearings are fixed to the stand at blower level.

Fig 2.4 Aluminium Shaft

Fig 2.5 Ball Bearing

EXPERIMENTAL SETUP

Horizontal Axis Wind Turbine is fabricated and blades are designed by using different materials like Aluminium, Ms- Steel and Paper Wood. Aluminium solid shaft is placed on the stand in a way that it is at a height of blower outlet. Blades are placed on the shaft and it is being fixed with the screws. The whole setup is placed to the stand by means of the ball bearings. After the whole setup is made the air blower is allowed to run so that the air coming out of the blower will struck the blades of the horizontal axis wind turbine and it starts rotating and the RPM is generated. Here we use two types of Nozzles one is Single Nozzle and another is the Multi-Nozzle. Once the whole set up is made run through the Single Nozzle and further the whole set up is allowed to run with Multi Nozzle and this process is repeated at various distances between Blower outlet and stand setup.

Fig 3.1 Single Nozzle

Fig 3.2 Multi Nozzle

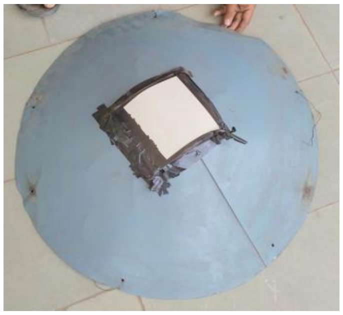

Fig 3.3 Dome

The distanced is varied by moving the stand away from the nozzle and the while process is repeated. The main parameter is the Air temperature, the temperature of air which is coming out of the blower is varied by the Air heaters which are placed in the blower. Domes are placed at the side of the stand such that the air which is coming out of the blower will struck the domes and the domes diverts the air to the blades due to this action the velocity of air will be increased and it helps in attaining the good power coefficient.

3.1. CFD Analysis:

The fabrication setup and performance test of a horizontal axis wind turbine is analysed by the Computational Fluid Dynamics (CFD). Firstly the setup design is modelled in the catia and after the module is analysed within the boundary conditions to get the analysed output.

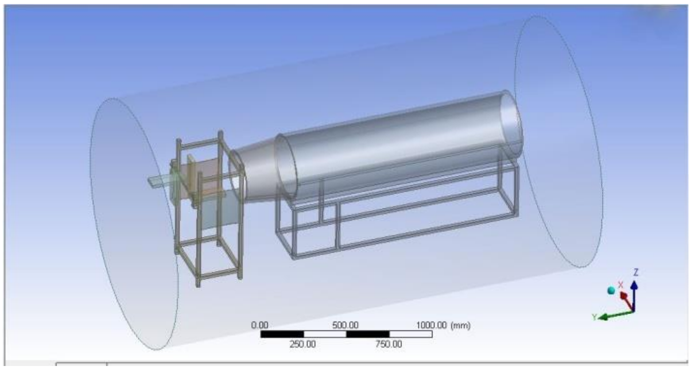

Fig 3.1.1 CFD Geometry

The above diagram shows the enclosure of the whole setup and further the analysis is done in the fluent type analysis. CFD analysis is progressed between the inlet velocity and the RPM of the shaft and it is shown in the below graph for all the materials in single and multi nozzles.

RESULTS AND DISCUSSION

The results of horizontal axis wind turbine are analysed in the CFD analysis and they are discussed in various parameters.

4.1. Single Nozzle:

4.1.1. Velocity:

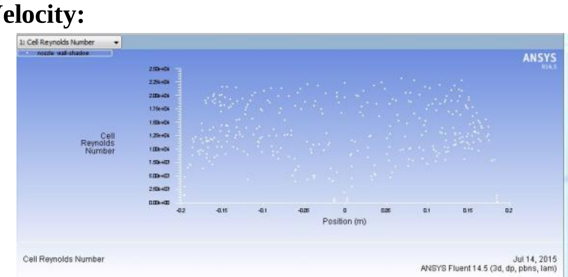

Fig 4.1.1 **Aluminium Blade**

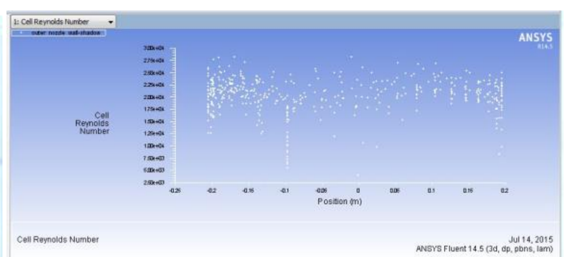

Fig 4.1.2 **MS Steel Blade**

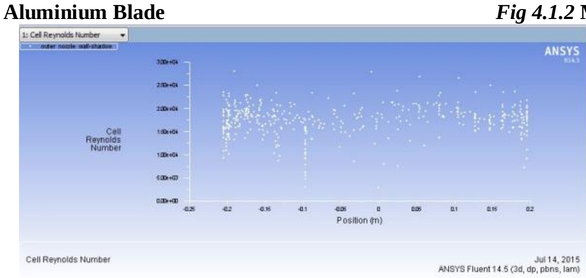

Fig 4.1.3 **Paper Wood Blade**

The above diagrams show the CFD analysis of Aluminium blade, MS Steel Blade and Paper Wood blades on Velocity parameter at different velocity inputs and analysis is done. The graph is plotted in between position Vs Cell Reynolds number. After 150 iterations the results are plotted. Considering all parameters Paper Wood showed the best result.

4.1.2. Pressure:

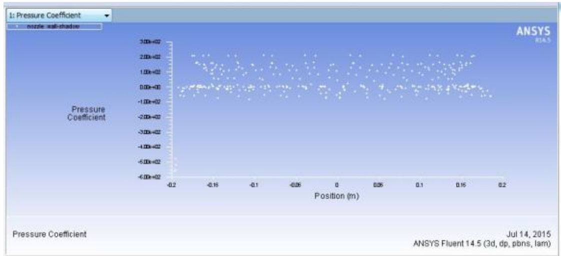

Fig 4.1.4 **Aluminium Blade**

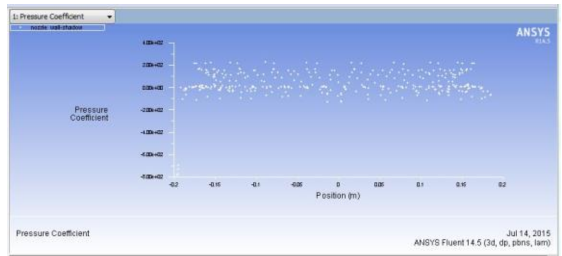

Fig 4.1.5 **MS Steel Blade**

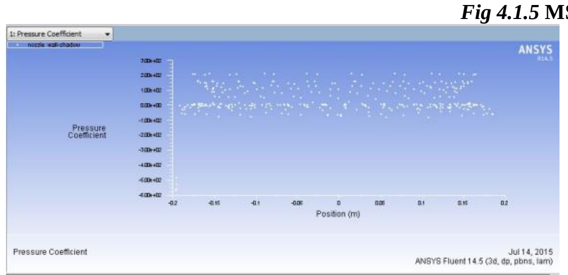

Fig 4.1.6 **Paper Wood Blade**

The above diagrams shows the CFD analysis of Aluminium blade, MS Steel Blade and Paper Wood blades on Temperature with the Pressure parameter at different velocity inputs for Single nozzle and analysis is done. The graph is plotted in between position Vs Cell Reynolds number. After 150 iterations the results are plotted. Considering all parameters Paper Wood showed the best result.

4.2. Multi Nozzle:

4.2.2. Velocity:

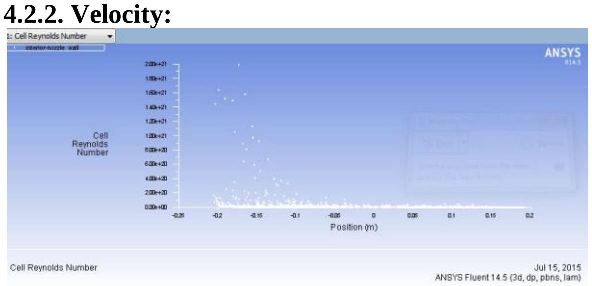

Fig 4.2.1 **Aluminium Blade**

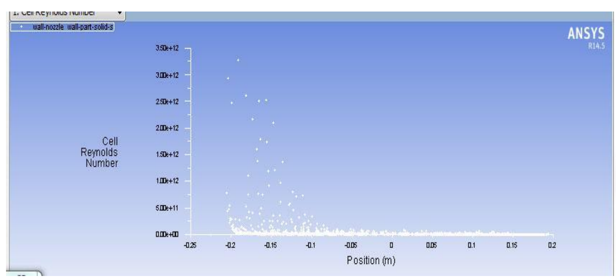

Fig 4.2.2 **MS Steel Blade**

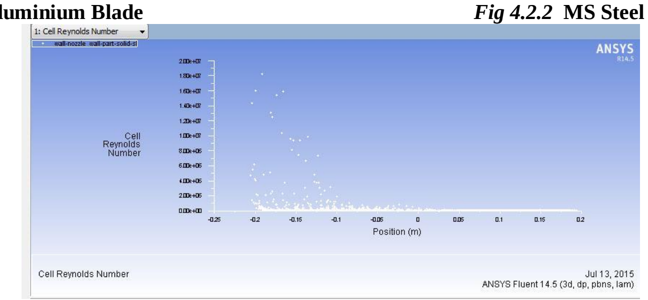

Fig 4.2.3 **Paper Wood Blade**

The above diagrams shows the CFD analysis of Aluminium blade, MS Steel Blade and Paper Wood blades on Velocity parameter at different velocity inputs for Single nozzle and analysis is done. The graph is plotted in between position Vs Cell Reynolds number. After 150 iterations the results are plotted. Considering all parameters Aluminium Baldes showed the best result.

4.2.2. Pressure:

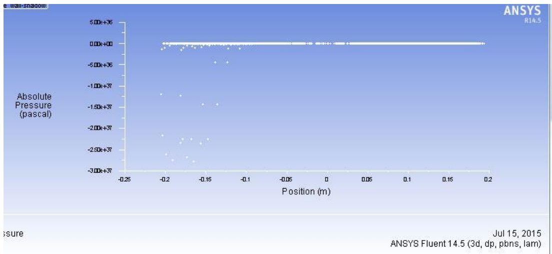

Fig 4.2.4 **Aluminium Blade**

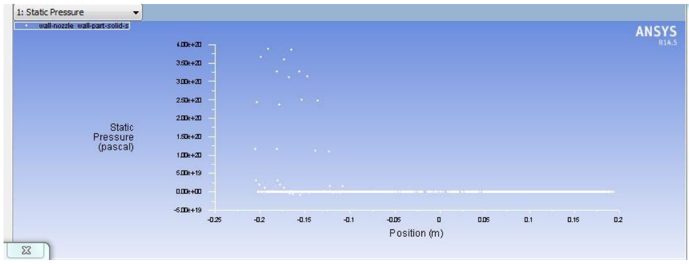

Fig 4.2.5 **MS Steel Blade**

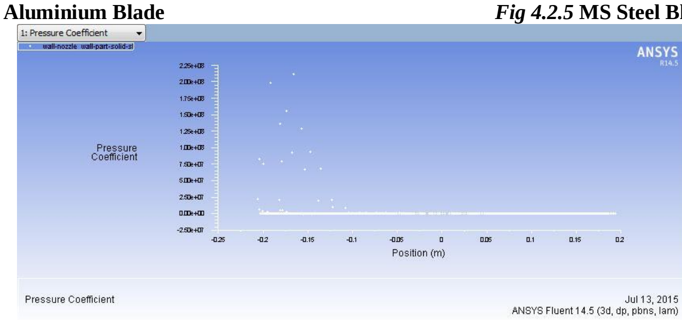

Fig 4.2.6 **Paper Wood Blade**

The above diagrams shows the CFD analysis of Aluminium blade, MS Steel Blade and Paper Wood blades on Temperature with the Pressure parameter at different velocity inputs for Single nozzle and analysis is done. The graph is plotted in between position Vs Cell Reynolds number. After 150 iterations the results are plotted. Considering all parameters Aluminium Blades showed the best result.

CONCLUSION

In this project testing of blades of a Horizontal Axis Wind Turbine are tested with different material.

- Paper Wood Blades is considered, well at higher temperatures as well as lower temperatures and they can handle at high speed winds and these blades give best results at Single Nozzle.
- Aluminium blades are tested at different parameters and are best at higher temperature when compared to other blades in Multi nozzle.
- Coming to overall efficiency Wooden blades are best compared to the other steel and aluminium blades at high and low temperatures and also Aluminium blades attain good power co-efficient at high velocities of air inlet.

REFERENCES

1. N.N. Sørensen, and M.O.L. Hansen. Rotor performance predictions using a Navier-Stokes method. AIAA Paper.1998, 98 -0025.
2. J. Johansen, N.N. Sørensen, J.A. Michelsen, and S. Schreck. Detached-eddy simulation of flow around the NREL phase VI blade. Wind Energy. 2002, **5**: 185–197.
3. H.A. Madsen, N.N. Sørensen, and S. Schreck. Yaw aerodynamics analyzed with three codes in comparison with experiment. AIAA Paper. 2003, 003-0519.
4. Sanderse, B., *Aerodynamics of wind turbine wakes*, 2009, ECN Wind Energy.
5. Bartl, J., F. Pierella, and L. Sætran, *Wake measurements behind an array of two model wind turbines.* Energy Procedia, 2012. 24: p. 305-312.
6. S. V. Patankar, “Numerical Heat Transfer and Fluid Flow,” McGraw-Hill, New York, 1980.
7. G.D.Rai from the text book of “RENEWABLE ENERGY SOURCES”.
8. Griffin, DA. Blade system design studies volume II: Preliminary blade designs and recommended test matrix, Kirkland: SAND2004-0073; 2004.
9. Spera D. A. 1994. Wind Turbine Technology. New York: ASME Press.
10. Lanzafame R., M. Messina 2007. Fluid dynamics wind turbine design: Critical analysis, optimization and application of BEM theory. *J. Renewable Energy*. Vol. 32, pp. 2291-2305.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

11. Nagai B.M., Ameku K. and Roy J.N., 2009. Performance of a 3 kW wind turbine generator with variable pitch control system, *Applied Energy*, Vol. 86, No. 9, pp. 1774–1782.
12. Liu X., Yan C., Zhiquan. Y. 2007. Optimization model for rotor blades of horizontal axis wind turbine.Front. Mech. Eng. China. Vol. 2, No. 4, pp. 483-488.
13. Abbott I.H. and Vonoenhoff 1958. AET. In: Theory of wing sections. Ince NY: Dover.
14. Glauert, H. (1935) *Airplane propellers*. From Div. L, Aerodynamic Theory, ed. W.F. Durand. Berlin: Springer Verlag, 1935.
15. Wilson, R.E. & Lissaman, P.B.S. (1974) *Applied aerodynamics and wind power machines*. PB 238595, Report No. NSF-RA-N-74-113, NTIS, Springfield, Virginia.
16. C. J. Bai, F. B. Hsiao, , M. H. Li, G. Y. Huang, Y. J. Chen, “Design of 10 kW Horizontal-Axis Wind Turbine (HAWT) Blade and Aerodynamic Investigation Using Numerical Simulation”, Procedia Engineering 67, 2013, pp 279 – 287.