DESIGN ANALYSIS OF VERTICAL BLADE WIND TURBINE

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ABSTRACT

In this Research a vertical bladed ultra low speed wind turbine has been designed, fabricated and tested at the site. Wind as a source of energy is being used for a long time. It has gained more significance in the current age of energy crisis. Multi blade wind turbine with increase in number of blades runs successfully with proper adjustment of swept area and the angle of attack. The blade can be propelled even by low wind speed. The material used for fabricating the blades in Wind Turbine is Glass Fibre Reinforced Plastics with the diameter 500mm, length of the blade is 600mm with chord length 100mm and the blade profile is NA CCA 0015. It may be utilized in the houses for power generation to reduce cost for being economical. It also plays a vital role in reducing utilization of conventional energy and mobility to utilize the power.

Introduction

A wind turbine is a machine for converting the kinetic energy in wind into mechanical energy. Wind power has been growing dramatically since the beginning of the 21st century. The global installed capacity at the end of 2013 was around 318 GW, up from 18 GW at the end of the 2000. Around 35 GW of new wind capacity were added in 2013, the lowest growth since 2008, after 44 GW in 2012. Over the last couple of years, wind's centre of growth has been moving from Europe and North America to Asia, which emerged as the global leader. In fact China became the first market in terms of total installed capacity in a very short time, overtaking the United States in 2010.

A number of recent important policy measures and programs have emerged in support of the expansion of the wind market, and many of the new policy developments concern offshore wind. The contribution of wind power to the energy supply has reached a substantial share even on the global level. By the end of 2013 all wind turbines installed around the globe could Manuscript received September 30, 2014; revised January 29, 2015. Marco Casini is with the Department of Planning, Design, and Technology of Architecture (PDTA), Sapienza University of Rome, Italy have potentially saved a total of 640 terawatt hours to the worldwide electricity supply, more than 4% of the global electricity demand. In the year 2013, around 103 countries used wind energy for electricity generation. In 2013 Europe reached 117 GW of wind power capacity, meeting the power needs of 66 million households, equivalent to the output of 45 nuclear power plants – with more than 11 GW added in the last year, a decrease of 8% compared to 2012 installations caused by market, regulatory and political uncertainty in a number of key markets.

The total installed wind power capacity in Europe at the end of 2013 covers 13% of the EU-27's electricity demand. 18 By 2020, European Wind Energy Association (EWEA) estimates that 192 GW (including 23 GW offshore) of wind power capacity will be installed in the EU, producing 442TWh of power, meeting 15% of the EU's electricity demand (2.9% from offshore). Wind provides 34% of electricity in Denmark, while Portugal and Spain get around 20% of electricity from wind power, followed by Ireland (16%), Germany (9%) and Italy (5%).

Ten European countries have agreed to develop an offshore electricity grid in the North Sea to enable offshore wind developments. The turnover of the wind sector around the world has already reached 60 billion € (75 billion US$) in the year 2011. According to World Wind Energy Association (WWEA), based on the current growth rates, in 2016, the global capacity is expected to increase up to 450`000 MW. By the end of 2020, at least 700'000 MW are expected to be installed globally. Recently, thanks to the development of small wind turbine quiet and specified for urban use, it is possible to harness wind power for on-site energy generation or domestic production or agricultural districts.

These turbines, reaching a maximum of 20 kW of power, can also find space on rooftops or in garden they have relatively little visual impact and are able to produce energy even from modest wind flows. Moreover, in contrast to large wind turbines, such plants do not require major infrastructures for electricity transmission from utilities and lend themselves to distributed generation of electricity. Small wind systems can be used both as standalone systems or as grid connected systems, and both can be paired with other energy conversion systems, such as photovoltaic. As of the end of 2012, a cumulative total of 806.000 small wind turbines were installed all over the world (excluding two major markets as India and Italy), 76'000 of which were newly erected that year. During 2012, the number of installed small wind turbines grew by 10%.

Literature Review

In design consideration, selection of blade material is very important parameter; the material should have low cost and high operating life. The smaller wind turbine blades are usually made of aluminium, or laminated wood [1]. Metals were initially a popular material because they yield a lowcost blade and can be manufactured with a high degree of reliability, however most metallic blades (like steel) proved to be relatively heavy which limits their application in commercial turbines
[2]. In the past, laminated wood was also tried on early machines in 1977

[3]. There are many materials used for design of SB-VAWT, such as wood, Al and fibre glass composites. Wood, a naturally occurring composite material, is readily available as an inexpensive blade material with good fatigue properties
[4]. Aluminium blades fabricated by extrusion and bending are the most common type of VAWT materials. The early blades of Darrieus type VAWTs were made from stretches and formed steel sheets or from helicopter like combinations of aluminium alloy extrusions and fibre glass. It has been reported by Parashivoiu [5] that the former were difficult to shape into smooth air foil, while the latter were expensive. The major problem that aluminium alloy for wind turbine application is its poor fatigue properties and its allowable stress levels in dynamic application decreases quite markedly at increasing numbers of or approximately twice the strength of low carbon steel [7].

The performance or output of SB-VAWT depends upon the thickness of blades, blade arrangements in one or two stages, number of blades and the setting angle of blades. VAWT developed torque at low speeds is greater when the setting angle of blades is greater but the VAWT developed torque at higher speeds is greater when the setting angles of blades is less [8]. The SB-VAWT has a relatively low cut-in velocity as compared to curved-bladed VAWT irrespective the number of blades. The CB-VAWT with two and three blades has a cut-in velocity of about 7 m/s and 4 m/s respectively. The three blades

VAWT has lower cut-in velocity as compared to the one with two blades. This observation can be explained as follows; the additional blade have larger wetted surface and hence giver higher torque, which finally results in a lower cut-in velocity. However, both cut-in velocities are quite high to be compared to the average wind velocity [9].

DESIGN SPECIFICATION:

Blade material – Glass Fibre Reinforced Plastic Blade Profile-NACA 0015 Blade Chord Length-

100 mm Blade Thickness- 20mm 34 Bearing type – Plummer Block Bearing inner diameter = 40 mm Shaft diameter =20 mm Diameter of the turbine (D) = 500mm Length of the turbine= 600mm Angle of rotation ϴ=120o Wind speed=4m/s Density of air= 1 kg/m^3

The standard NACA profile generator software is available where the coordinates for NACA 0015 is generated and they are imported to mat lab where the continuous curved aerofoil profile is generated.

- ✓ The curve is then imported to

CAD MODELLING software (solid works) where the curve is smoothened by giving spline option.

- ✓ The 2-D curve is then extruded

up to 600mm and then by giving flex command and twisting it to 120° we get single helical blade.

- ✓ The circular base at the two ends

is provided whose diameter is 500

mm and thickness 20mm which holds the blades. The blade is then offset by 250 mm from the centre so that it is been hold at corner of the circular base.

- ✓ Then circular pattern command is used about the centre for generating 3 blades equally oriented mutually. Circular shaft of diameter 40mm is then modelled within the setup

ANALYSIS OF SINGLE NACA 0015 BLADE PROFILE The most challenging work in the turbine design is the analysis part where the results may vary according to the given input of the analysis parameters (i.e.) mesh size, number of iterations and residuals. The analysis part is again classified into 2-D and 3-D analysis which further each is classified with/without rotating mesh.

ANSYS 2015 FLUENT software has been used for analysis purpose.

The aerofoil model is imported into Ansys and counter wall is created around it for applying the boundary conditions. Then it is fully developed for the 3 blades across the circular plate and the flow is studied.

MESH PARAMETERS

Inflation at boundary

- ✓ With 59 edges
- ✓ 10 layers
- ✓ growth rate
- ✓ Total thickness Fine mesh

- ➢5360 Nodes
- ➢ 2564 Elements Although these

mesh sizes are very much low for the analysis of aerofoil hence it produce approximate results up to certain degree of accuracy.

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BASIC GEOMETRY

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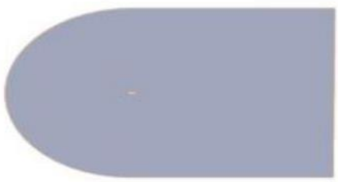
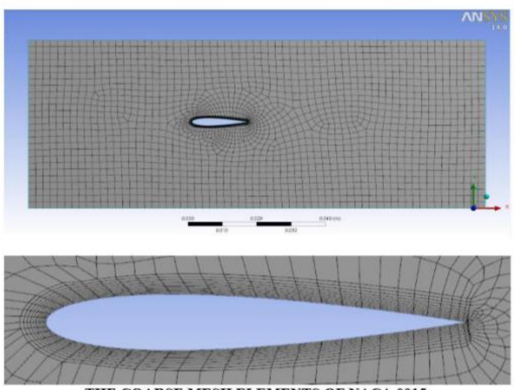


ADVANCED



THE COARSE MESH ELEMENTS OF NACA 0015

CONCLUSION

The Blade arrangements in one or two stages, number of blades and setting angle of blades. The vertical blades

Darrieus turbine has selfstarting Capabilities both at low Reynolds numbers and to moderate values of the solidity. The blade pitch angle has a great influence on the self-starting behaviour of the turbine: higher values of the blade pitch angle are Favourable for a low speed wind starting. The VAWT developed torque at low speeds is greater when the setting angle of blades is greater but the VAWT developed torque at higher speeds is greater when the setting angles of blades is less. The vertical axis wind turbine (VAWT) is either of curved- bladed (CB) or vertical -bladed (SB) type VAWT according to design configuration but the SB-VAWT is mostly used because of its simplicity, Whereas CBVAWT is rarely used due to its manufacturing difficulties. It is concluded that, to efficiently and economically change the wind energy to electrical energy, the SB-VAWT is mostly used.

REFERENCES

[1] The Encyclopedia of Alternative Energy and Sustainable Living. 2008.
Wind Turbine Blades. URL:http://www.daviddarling.info/encycl opedia/B/AE_blades.html (cited January 1,2008)

[2] Sutherland, H.J. 2000. A Summary of the Fatigue Properties of Wind Turbine Materials. Wind Energy. Vol 3, pp 1-34.

[3] Butler, B.L. and Blackwell, B.F. 1977. The Application of Laminated Wooden Blades to a 2-Meter Darrieus type Vertical Axis Wind Turbine. SAMPE Quarterly, Vol 8, No 2, January.

[4] CANMET Energy Technology Centre (CETC). 2001. Investigation of Alternative Materials for Use in Mid-Size Vertical Axis Wind Turbine Blades: Materials Assessment. Ontario, Canada.

[5] Paraschivoiu, I. 2002. Wind Turbine Design: With Emphasis on Darrieus Concept. Polytechnic International Press. Montreal, Canada.

[6] National Research Council (NRC), Committee on Assessment of ResearchNeeds for Wind Turbine Rotor Materials Technology, 1991. Assessment of Research Needs for Wind Turbine Rotor Materials Technology. URL:http://www.nap.edu/openbook.php?record_id=1824&page=R1 (citedDecember 22, 2007). Bergey. 2007.

[7]Bergey wind turbine URL:http://www.islandearthsolar.com/bergey_wind_power.htm (cited January 1,2008)

[8] Islam, M. 2008. Analysis of Fixed Pitch vertical-Bladed VAWT with Asymmetric Airfoils. Doctoral Dissertation, University of Windsor, Canada. 43

[9] H. Dumitrescu1, A. Dumitrache1, C. L. Popescu2, M. O. Popescu2, F. Frunzulică2 and A. Crăciunescu2 Wind Tunnel Experiments on VerticalAxis Wind Turbines with vertical Blades.