



DESIGN OF HORIZONTAL AXIS WIND TURBINE NACA4412 BLADE

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ABSTRACT

Wind energy is the rotary engine in which the kinetic energy of a moving fluid is converted in to mechanical energy and generate electrical energy. Small horizontal axis wind turbines need to be affordable, reliable and maintenance free for the average person to consider installing one. In this paper the work was carried out to the aerodynamics design of a 500W horizontal axis wind turbine (HAWT) by using blade element momentum theory (BEM) Wind energy is a very popular renewable energy resource. In order to increase the use of wind energy, it is important to develop wind turbine rotor with high rotations rates and power coefficient. In this work was carried out to the society for the domestic purpose and the design of a 500W horizontal axis wind turbine by using Blade Element Momentum theory (BEM). The generated design was scaled and built for testing purposes in the discharge of an axial flow fan of 1400 mm in diameter. This work will focus on review of Design and Simulation of Horizontal Axis Wind Turbine rotor blades through General Public Licensed Software Q Blade. Q Blade utilizes the Blade Element Momentum (BEM) method for the simulation of horizontal axis wind turbine performance. For the design of custom air foils and the computation of air foil lift and drag coefficient popular's the viscous-in viscid coupled panel method code XFOIL is integrated within the graphical user interface of Q Blade. Blade is designed using Catia V5R20 Software using NACA 4412 air foil by calculated value by using tip speed ratio of 4 , wind speed and angle of attack. This paper briefly elaborate the design of such a horizontal axis wind turbine (HAWT) for domestic application and utility purpose.

KEYWORDS: BEM; Tip Speed Ratio; HAWT; Air foil; Design.

INTRODUCTION

Nowadays electricity plays the major demand problem in this world and majorly in Tamil Nadu, India [1]. In the present condition of steadily rising of fuel costs and wind energy is becoming an increasingly attractive component of future energy source systems [2]. The wind potential of India is very high [4]. Taking in to consideration that a large portion of the Indian land will not be viable for the use of traditional windmills due to low wind speeds, a generator which would produce the energy even at low

wind speed is required [5]. The wind turbines have been installed and wind energy is being harvested, predominantly in the high wind velocity areas near by sea shore and high velocity region [6]. The wind potential of India is very high. In order to ensure the extraction of maximum wind potential even at lower wind speeds, the turbine blades have to be designed and analysed to suit the low wind regions. At present India stands fifth in the world of wind power generation of installed capacity of 22465MW. Also the transmission losses in India are very high. Hence, to reduce the transmission losses the turbine could be placed near the place of energy consumption. In state wise energy scenario TamilNadu plays a 1st place of cumulative installation of 6987.6 MW of annual installation of 1083.5 MW [11]. TamilNadu plays a major role in utilising wind energy resources while comparing other states. This paper elaborates the design and development of such a wind turbine blade National Advisory Committee for Aeronautics NACA 4412 profile for domestic application by comparison with various profiles. This research work is for generating electricity at low wind speeds and that can be used to power the lighting requirements of a domestic house hold requirements.

DESIGN AND SIMULATION

Horizontal Axis Wind Turbine (HWAT) has a 3 blade and with a length of the blade up to 1400mm and In this process the basic structure of an air foil is chosen and the coordinates where marked. In this design process NACA 4412 profile has been taken for the wind condition. For a Horizontal Axis Wind Turbine Blade the coordinates where marked to draw the profile of an Air foil the entire design of the wind turbine design using CATIA V5 software. In this turbine blade design 4412 air foil design is used to draw the air foil outer layer profile design using CATIA V5 as in Figure 1.1.

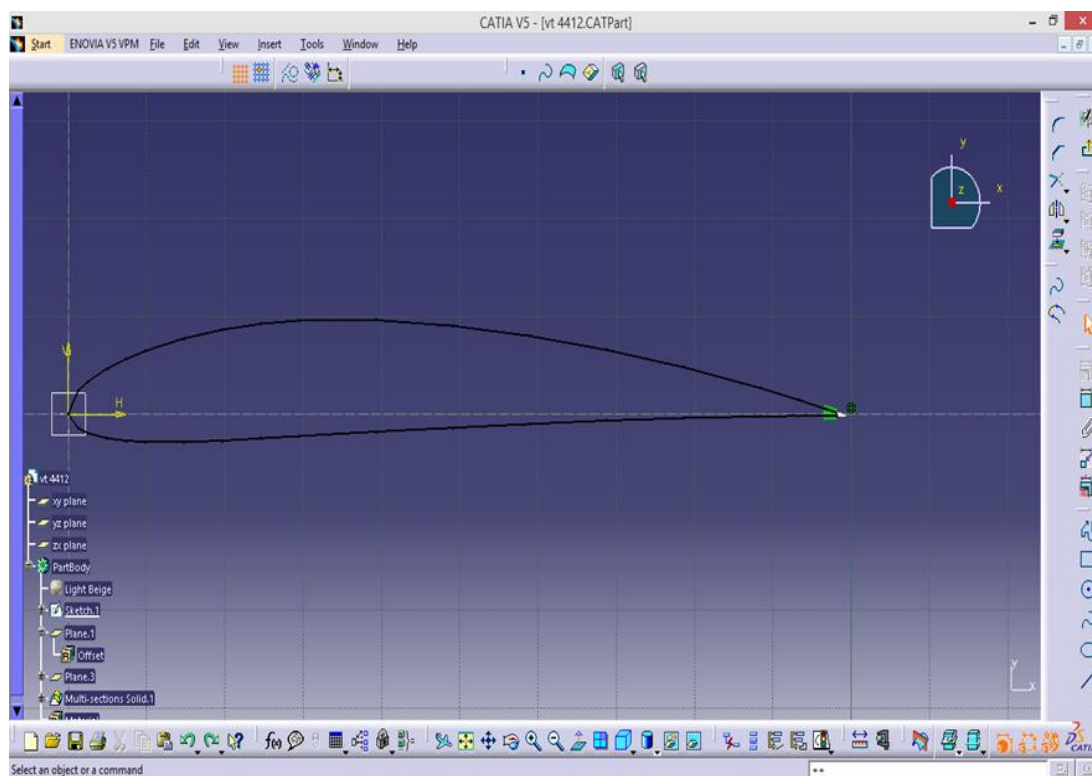


Figure 1.1 NACA4412 Coordinate

From that NACA4412 profile the coordinate's data are coded to the CatiaV5 and they are joined in the system coordinates to make a complete structure of the Horizontal Axis Wind Turbine blade (HWAT) of NACA4412 series profile in Figure 1.2.

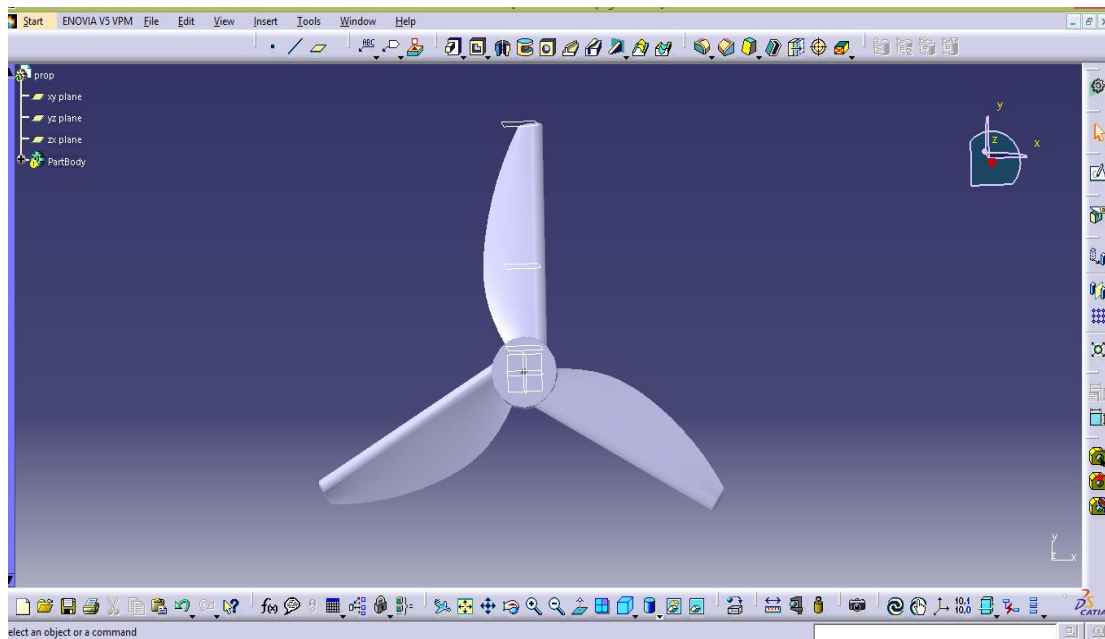


Figure 1.2 Blade Design

The designed profile is simulated using Qblade software the basic structure of an airfoil is drawn and as shown in the Figure 1.3.

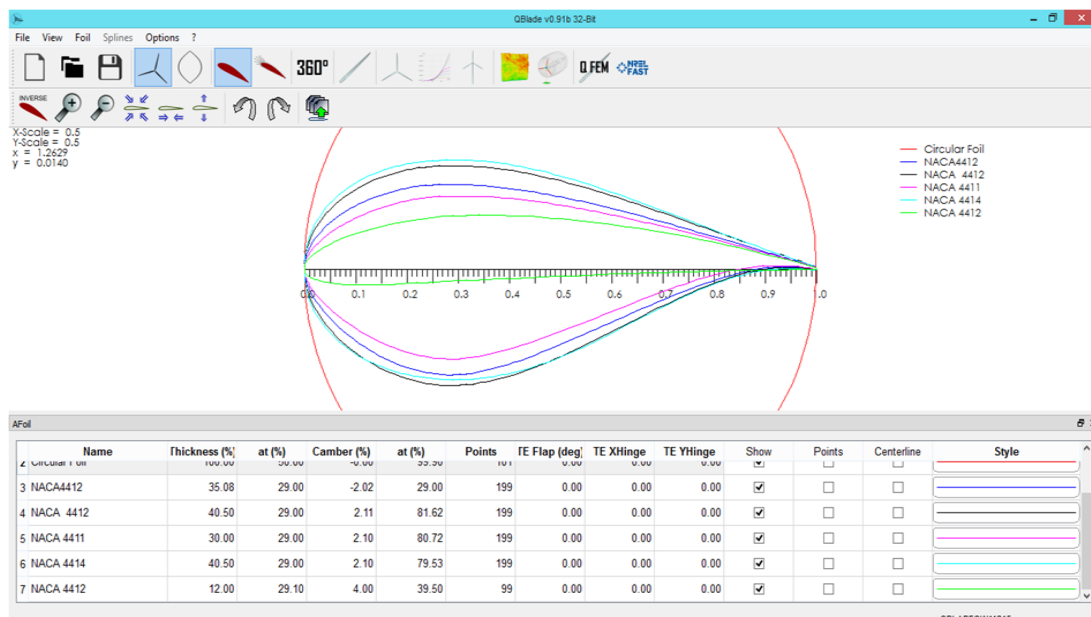


Figure 1.3 Qblade Coordinates

For designing of the wind blade National Advisory Committee for Aeronautics (NACA) profiles has been taken. According to the wind condition the NACA profiles has been chosen and there are 9

profiles are used to design the wind blade as shown in the figure. The blade consists of 1400mm of diameter of the profile. The simulated design as follows in Figure 1.4.

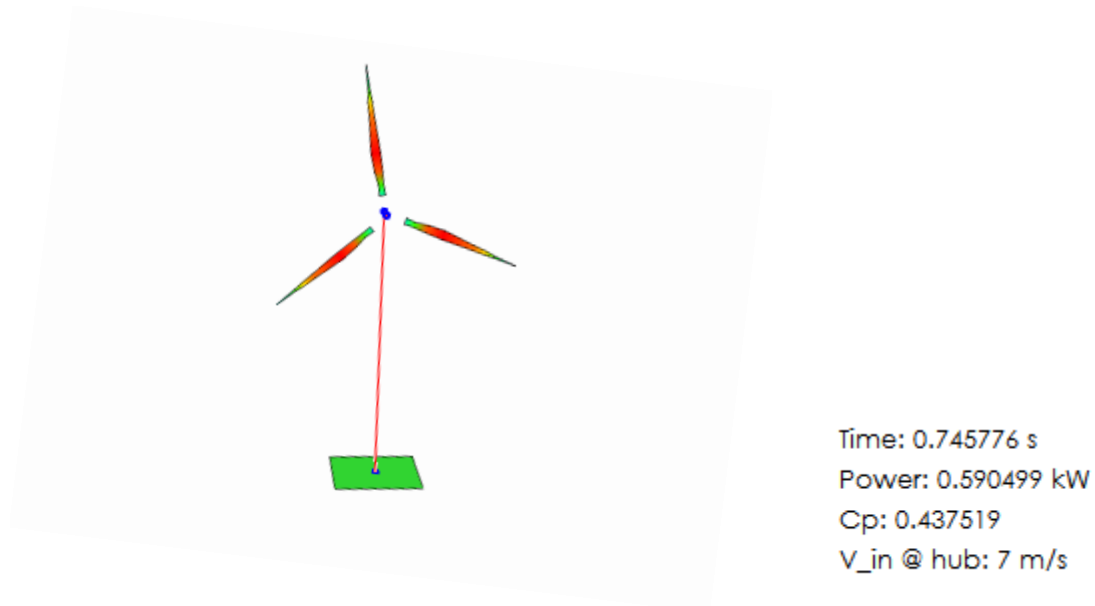


Figure 1.4 Simulated model

The simulated design runs at the designed specification and produce the output of 590W of power and used for household domestic purpose. The Power Vs. Wind speed ratio is calculated for wind blade design as follows,

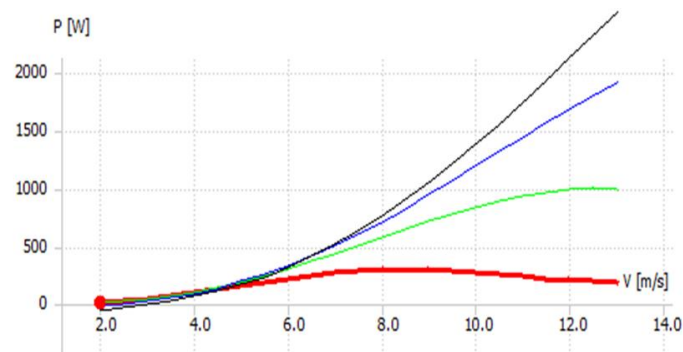


Figure 1.5 Power Vs. Wind speed

In this for 2m/s of wind the power produced by the wind blade is approximately 50W as shown by the graph and by increase in wind speed the power production also increases and at 7m/s of wind velocity the power achieved approximately equals to the 560W as in the Figure 1.5.

RESULT AND DISCUSSION

The mechanical power is defined as the product of torque and angular speed and it can be easily calculated for a wind turbine if we can accurately determine the torque and rpm of the rotor when wind

turbine is running without any external load. The blade of the wind turbine was held stationary until wind speed in the wind tunnel was stabilized and then it was allowed to rotate and accelerate freely to its maximum constant speed. The rpm of the turbine blade, while it was accelerating, was recorded at the time interval of 20 m/s using the optical tachometer.

S. No	Wind speed (m/s)	Power (W)	Density(ρ) (kg/m ³)	Velocity(V ³) (m ³ /s)	Coefficient of Power (Cp)	Area (m ²)
1	3	500	1.2754	27	0.5	58.07909211
2	4	500	1.2754	64	0.5	24.50211698
3	5	500	1.2754	125	0.5	12.5450839
4	6	500	1.2754	216	0.5	7.259886513
5	7	500	1.2754	343	0.5	4.571823577
6	8	500	1.2754	512	0.5	3.062764623
7	9	500	1.2754	729	0.5	2.151077485
8	10	500	1.2754	1000	0.5	1.568135487
9	11	500	1.2754	1331	0.5	1.178163401
10	12	500	1.2754	1728	0.5	0.907485814
11	13	500	1.2754	2197	0.5	0.71376217

Table 3.1 Calculated value of HWAT

The Table 3.1 shows the calculation for the various wind speed condition of a horizontal axis wind turbine (HAWT) of coefficient of power 0.5 with varying wind speed from 3m/s to 13m/s as calculated.

CONCLUSION

The design and simulation of a Horizontal Axis Wind Turbine Blade has been done. The horizontal Axis Wind Turbine Blade (HWAT) which operates at wind speeds between 3 m/s to 13 m/s. The major outcome of the study can be summarised. The wind turbine blade design shows that HWAT has maximum coefficient of performance of at the optimal tip speed ratio of 4.1. HWAT has very low cut-in wind speed of 3 m/s and it is found to generate mechanical power of 560W for the economic utility power supply to the domestic appliances. The renewable energy found abundant in nature and the energy can be utilized by using Wind Turbines.

Nomenclature

HWAT	Horizontal Axis Wind Turbine Blade
BEM	Blade Element Momentum theory
NACA	National Advisory Committee for Aeronautics

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