Dimensional comparison of horizontal axis normal and micro wind turbine blades

Akarsh S[1], Dr. Hanumantharaju H G[2], Yashavantha K[3], Vinay K P[4], Keerthi Prasad C P[5], Madhusudhana C R[6]

[1]Dept. of Mechanical Engineering, UVCE, Bangalore-01,

[2]Professor, Dept. of Mechanical Engineering, UVCE, Bangalore-01,

[3]Dept. of Mechanical Engineering, UVCE, Bangalore-01

[4]Dept. of Mechanical Engineering, UVCE, Bangalore-01

[5]Dept. of Mechanical Engineering, UVCE, Bangalore-01

[6]Dept. of Mechanical Engineering, UVCE, Bangalore-01

Abstract: Micro wind turbines – an emerging technology, is a new approach for energy conversion. In this paper, a small comparison is made with respect to the dimensions of the normal wind turbine blade and a micro wind turbine blade considering the NACA (National Advisory Committee for Aeronautics) profile. NACA coordinates are used effectively in designing and analysis of various parameters of the aerofoil profile. Thus, for a better understanding of the term micro wind turbine blade, a comparison of the dimension length is conducted using the CAD models designed in CATIA software obtaining the coordinates for the aerofoil profile from NACA.

Keywords: Horizontal axis wind turbines, Vertical axis wind turbines, Micro wind turbines, NACA.

Introduction

One of the major challenges in this new century is the production of energy as well as its efficient use from renewable sources. Researchers around the world have shown that global warming has been caused in part by the greenhouse effect which is largely due to the use of fossil fuels for transportation and electricity. So, the use of renewable energy sources such as geothermal, solar, wind and hydroelectric power needs to be increased to protect the environment. As a renewable energy, wind energy has taken an increasingly important place in energy policies at the national and international level as a response to climate change. Wind power usage in India is growing and research in the field of wind energy will further improve the current situation [1].

In recent years, the importance of renewable sources of energy in power generation has been growing day by day around the world. Also, due to the lack of fossil fuel resources, utilization of renewable sources of energy has become even more important. Large wind farms, either in the countryside, offshore, in the mountains or at the seaside have already been invested by many countries around the world. Since wind speed and direction are well known and there are only a few factors that will influence them, the energy gathered from these wind farms can easily be predicted and calculated. However, in cities, where there are a crowded population and the land being used to a maximum extent, the availability of such huge area for setting up a wind farm is difficult. Also in the urban environment, the wind speed required for harnessing higher power is less. For these reasons, small wind turbines which can be installed on rooftops are suitable for use in urban areas, as well as rural areas that are not connected to any electricity network. Apart from all the renewable energy resources, cleaner energy systems such as micro wind turbines played a key role in the renewable electricity generation. In wind turbines, some mechanical and electrical aspects of the turbines are necessary to study in details so that the turbine can achieve its electrical output efficiency.

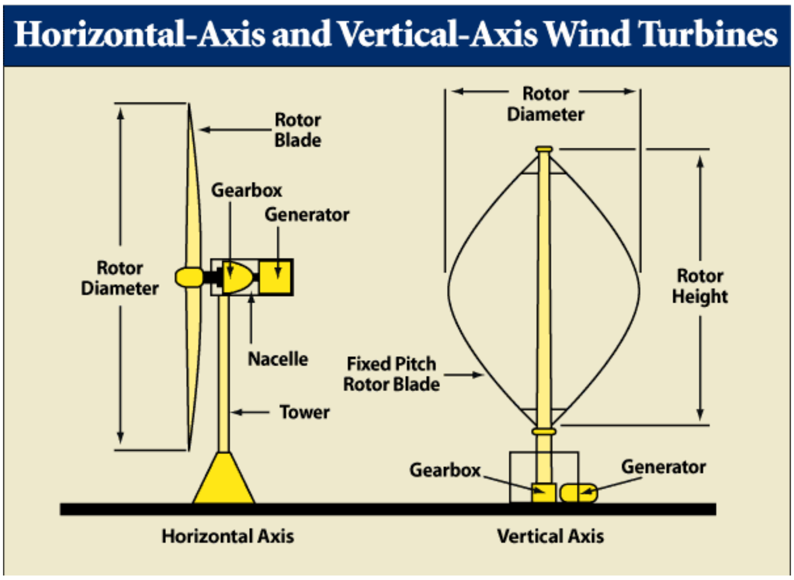

Figure 1: HAWT and VAWT

Wind turbines convert wind energy into electricity via mechanical energy. There are two primary types of wind turbines, namely horizontal axis (HAWT) and vertical axis (VAWT) wind turbines, and the efficiency of each wind turbine type varies by its design and fabrication. Similarly, these two main groups of a wind turbine are classified depending on their axis in which the turbine rotates. Because the horizontal axis has the ability to collect the maximum amount of wind energy for the time of the day and can adjust their blades pitch angle to avoid high windstorms, they are considered more familiar and more common than the vertical axis. HAWTs are most commonly used in wind farms.

Some of the basic parameters to describe the aerofoil geometry are:

1. Leading edge-the forward most point on the aerofoil (typically placed at the origin for convenience).

2. Trailing edge-the aft most point on the aerofoil (typically placed on the x axis for convenience).

3. Chord line-a straight line between the leading and trailing edges (the x axis for our convention).

4. Camber line-a line midway between the upper and lower surfaces at each chord-wise position.

5. Maximum camber-the largest value of the distance between the mean camber line and the chord line, which quantifies the camber of an aerofoil.

6. Maximum thickness-the largest value of the distance between the upper and lower surfaces, which quantifies the thickness of the aerofoil.

7. Angle of contact-it is the angle between the chord line and the average relative wind.

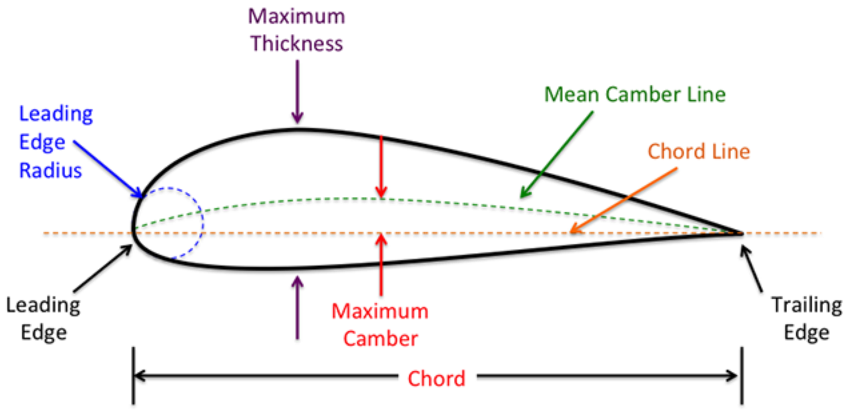

Figure 2: Parameters of the wind turbine blade profile

Advantages of horizontal axis wind turbines:

- **High power output**:- Horizontal axis wind turbines are generally built to have a capacity ranging between 2 to 8 MW, depending on the usage. While the output of a wind turbine depends on the turbine's size and the wind speed, an average onshore wind turbine with a capacity of 2.5–3.0 MW can produce more than 6 million kWh in a year, which is enough to supply 1,500 average EU households with electricity.
- **High efficiency**:- For any type of energy conversion, there is always energy lost. How to improve energy conversion efficiency is one of the biggest focuses of product development in the wind energy industry. Currently, horizontal axis wind turbines have the highest efficiency. They can transform 40 to 50 % of received wind power into electricity.
- **High reliability:-**Being the dominant wind turbine model for decades, research and development of horizontal axis wind turbines are already mature. Not only are existing products on the market reliable, the application and usage of horizontal axis wind turbines are also thoroughly explored.
- **High operational wind speed**:-Due to the height of the rotors, horizontal axis wind turbines are able to receive wind with greater speed. This means they are more likely to operate at higher wind speed which helps them provide optimal performance. Since the air flow at such height is relatively stable, horizontal axis wind turbines enjoy more consistency in wind and thus in power output.

Limitations of horizontal axis wind turbines:

Due to the massive size of horizontal axis wind turbines, transporting and installing them come with great logistic and technical challenges. With blades sometimes as long as 70 meters and as heavy as 20 tons, horizontal axis wind turbines might just not fit onto the narrow, curvy roads of mountainous areas, or even our day-to-day roads where houses, utility poles, and street lamps line up the sides. Once the turbines are delivered, the challenge of installation comes. From ground foundation to electronics, component placement and assembly, it takes a whole team of professional workers and even months to install a turbine safely and properly. Orient Energy System documented the installation of their 50 MW wind farm in timelapse in 2018.

Last but not least, maintaining a horizontal axis wind turbine is especially consuming because the key components such as the gearbox, generator, wind measuring systems, brake, yaw system, and rotor, all are located on the top of the tower. This means maintenance experts have to carry out maintenance tasks at the dizzying height over 80 to 100 meters in high wind speed.

Advantages of horizontal axis micro wind turbines:

Micro wind turbines can be designed using PVC blades as it can give better power capacity and less costly. It can be used in areas where the velocity of wind is low, that is, as low as 2 m/s, like a plateau or hilly region or in places where large wind turbine does not give a good result. Because of low cost and being of economical, it can be installed in residential areas over the houses for power generation. Moreover, utilization of small wind turbines for the household would result in fewer burdens on the grid and also plays a vital role in reducing utilization of conventional energy and mobility to utilize the power. These micro wind turbines can be used where wind velocity is low like hilly regions or especially rooftops of building and they are less costly, easier to install and can power electrical devices like the LED sign, Cell phones, lighting a lamp, etc.

Comparison of length of the turbine blade:

The NACA coordinates are obtained from their official website and are imported into the commercially available CAD software CATIA and the necessary dimensional comparison is conducted. NACA 63 series profiles are used for the dimensional comparison for effective results. Figure 3 shows the 14m blade which is derived from the NACA 63(4)-221 and the coordinates are imported and the blade is developed using CATIA V5 software. Table 1 shows the dimensions of the NACA 63(4)-221 blade profile.

Table 1: Parameters for CAD model of HAWT blade [2]

Length of blade	14 m
Chord length	1.36 m
Type of aerofoil	NACA 63(4)-221

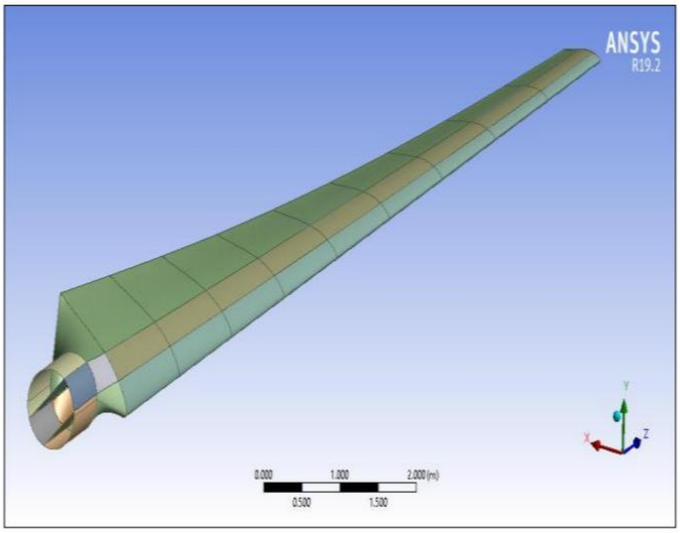

Figure 3: CAD model of HAWT blade [2]

For comparison with the micro wind turbine blade, a similar approach is considered wherein the NACA 63-614 profile is developed in CATIA V5 and the constraints are measured and compared with the normal blade of NACA 63(4)-221. Table 2 shows the details of the dimensions obtained from NACA 63-614 profile. Figure 4 shows the CAD model of the developed blade design of NACA 63-614 profile where the length is found to be 0.08m.

Table 2: Parameters for CAD model of HAMWT blade

Length of blade	0.08 m
Chord length	0.008 m
Type of aerofoil	NACA 63-614

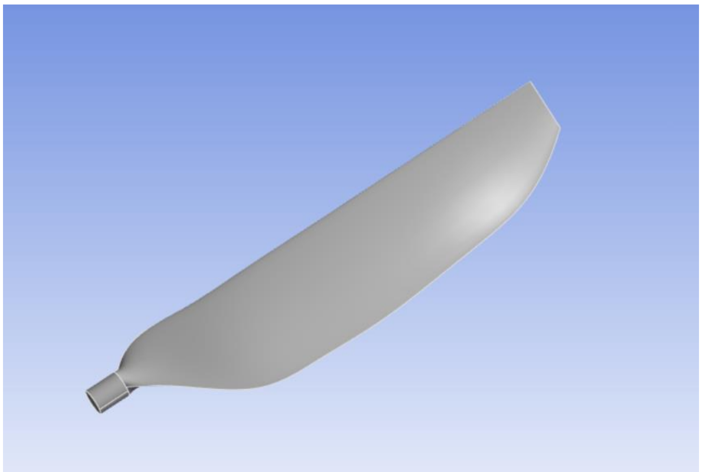

Figure 4: CAD model of micro wind turbine blade

Conclusion

After measuring the length of both the normal and micro wind turbine blades, it was found that the blade with NACA 63(4)-221 profile was found to be 14m and that of NACA 63-614 profile was found to be 0.08m. These small wind turbines also known as micro wind turbines can be developed as complete working models by confirming with various experimental analysis in order to withstand all the possible constraints.

References

[1] Deibanehbok Nonghar, et al., Design pf Horizontal Axis Micro Wind Turbine for Low Wind Speed Areas, ISSN:2582-0257, pp.39-47, Issue No.2, AJEEE.

[2] Praveen Kumar Nigam, et al., Sturctural Performance of 14m HWAT blade through CFD, Innovative Journal of Technology. An Exploring Engineering (IJITEE), ISSN:2278-3075(online), Volume-9 Issue-3.