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Computational Flow Field Analysis of Combined Axis Wind Turbine

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ABSTRACT: Wind energy is one of the major forms of renewable energy resources found abundantly which is widely used as an alternative energy. Wind power is sustainable and the production of electricity using wind energy is increasing day by day due to lack of availability of fossil fuels. The energy can be converted into electricity by using vertical axis wind turbine (VAWT) and Horizontal axis wind turbine (HAWT). The vertical axis wind turbine is highly used for domestic applications where the volume of production is low and efficiency is optimal while the horizontal axis wind turbine is widely for larger volume of production requires huge investment and the efficiency is high. This can be done by combining the vertical axis wind turbine (VAWT) and horizontal axis wind turbine (HAWT) in a same tower using create 3d model in CAD software and analyzing CFD flow simulation software.It achieve maximum speed than the VAWT.

Keywords: VAWT, CFD and HAWT

1 Introduction

With the constantly increasing energy needs, it is important to find means of energy production to meet these needs. Wind power is quickly becoming a very popular option due to the recent change in the public opinion towards protecting the environment. It is also viewed as a safe energy source that does not rely on limited natural resources.

1.1 Introduction to Wind Power

Wind power is a form of power that is renewable as well as a clean alternative to traditional electricity generation. Wind power is harnessed when wind forces turbine blades to rotate. The spinning of the blades rotates the rotor of the motor, which generates electricity through the permanent magnet motor. This motion is then converted into electrical power delivered to households, commercial buildings, or power companies.

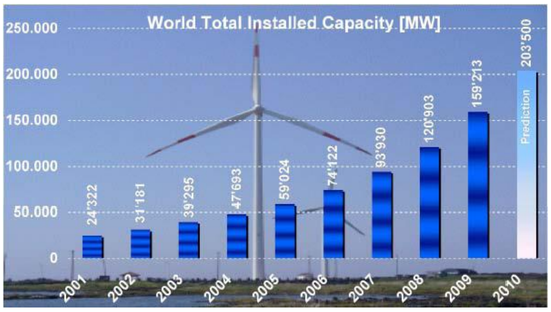

Fig 1.1 Strategy of Wind Power

Wind turbines can be separated into two types based by the axis in which the turbine rotates. Turbines that rotate around a horizontal axis are more common. A wind turbine applicable for urban settings was also studied. All three types of wind turbines have varying designs, and different advantages and disadvantages.

- Horizontal Axis Wind Turbine
- Vertical Axis Wind Turbine

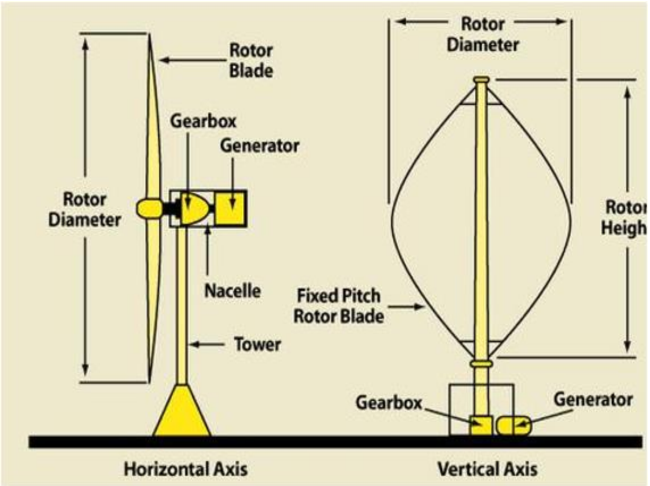

Fig1.2 Horizontal axis and vertical axis wind turbine

1.3 Horizontal Axis Wind Turbine

Horizontal axis wind turbines, also shortened to HAWT are the most common type used. A HAWT has a similar design to a windmill; it has blades that look like a propeller that spin on the horizontal axis. All of the components (blades, shaft and generator) are on top of a tall tower, and the blades face into the wind. The shaft is horizontal to the ground.

The wind hits the blades of the turbine that are connected to a shaft causing rotation. The shaft has a gear on the end which turns a generator. The generator produces electricity and sends the electricity into the power grid. The wind turbine also has some key elements that add to efficiency. Inside the Nacelle (or head) are an anemometer, wind vane, and controller that read the speed and direction of the wind.

As the wind changes direction, a motor (yaw motor) turns the nacelle so the blades are always facing the wind. The power source also comes with a safety feature. In case of extreme winds the turbine has a break that can slow the shaft speed.

This is to inhibit any damage to the turbine in extreme conditions. These are identified by the fact that the axis of rotation of the blades are in a fixed horizontal position therefore the unit must be placed in the direction of the wind, these are most popular in rural areas.

Downwind machines have been built, despite the problem of turbulence, because they don't need an additional mechanism for keeping them in line with the wind, and because in high winds, the blades can be allowed to bend which reduces their swept area and thus their wind resistance. Since turbulence leads to fatigue failures, and reliability is so important, most HAWTs are upwind machines.

Currently Horizontal Axis Wind Turbines (HAWT or propellers) cover more than 90% of wind turbine World Park. About 100 companies produce these machines.

1.4 Vertical Axis Wind Turbine

Vertical-axis wind turbines (or VAWTs) have the main rotor shaft arranged vertically. Key advantages of this arrangement are that the turbine does not need to be pointed into the wind to be effective. This is an advantage on sites where the wind direction is highly variable. VAWTs can utilize winds from varying directions.

It is difficult to mount vertical-axis turbines on towers, meaning they are often installed nearer to the base on which they rest, such as the ground or a building rooftop. This can provide the advantage of easy accessibility to mechanical components. However, wind speed is slower at a lower altitude, so less wind energy is available for a given size turbine. Air flow near the ground and other objects can create turbulent flow, which can introduce issues of vibration, including noise and bearing wear which may increase the maintenance or shorten the service life. In designs that do not have helical rotors significant torque variation will occur.

1.5 Methodology Followed in this Project

A comparison between the results obtained based on existing material and the results obtained from the ANSYS. Work bench has been carried out.

In conventional approach conception ideas are converted into sketches or engineering drawing. With the help of this drawings the prototypes i.e. product which looks same as that of final product are made. It is launched in the market after testing of prototype which gives acceptable results. The thing is, product is launched after doing many practical testing and many trial and error procedures which consumes more time and cost too. In CAE approach some steps are same as that of conventional method.

Here also ideas, concepts are converted into engineering drawing, but it is then modeled on computer. Geometric model of product is made using solid work software like CAD which enables better visualization of simple as well as complex models. These models then further used for computerized analysis by using different CAE tools (FEA/CFD software's) depending upon the application before the prototype is been made to check whether the components are going to work according to its intended function. After that once appropriate results are obtained the final practical testing is carried out.

1.6 Objective

This paper focused on increasing the efficiency of using wind energy by producing large amount of electricity and reduces the space for installation and the cost of development of individual turbine.

2. MODELING

2.1 Introduction To CAD/CAM

CAD/CAM is a term which means computer-aided design and computer-aided manufacturing. It is the technology concerned with the use of digital computers to perform certain functions in design and production. This technology is moving in the direction of greater integration of design and manufacturing, two activities which have traditionally been treated as district and separate functions in a production firm. Ultimately, CAD/CAM will provide the technology base for the computer-integrated factory of the future.

Computer – aided design (CAD) can be defined as the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. The computer systems consist of the hardware and software to perform the specialized design functions required by the user firm. The CAD hardware typically includes the computer, one or more graphics display terminals, keyboards, and other peripheral equipment. The CAD software consists of the computer programs to implement computer graphics on the system plus application programs to facilitate the engineering functions of the user company. Examples of these application programs include stress-strain analysis of components, dynamic response of mechanisms, heat-transfer calculations, and numerical control part programming. Computer-aided manufacturing (CAM) can be defined as the use of computer systems to plan, manage, and control the operations of manufacturing plant through either direct or indirect computer interface with the plant's production resources.

2.2 The Design Process

The process of designing is characterized by six identifiable steps or phase

1. Recognition of need
2. Definition of problem
3. Analysis and optimization
4. Evaluation
5. Presentation
6. Synthesis

2.3 Application of Computers For Design:

The various design-related tasks which are performed by a modern computer-aided design system can be grouped into four functional areas:

1. Geometric modeling
2. Engineering analysis
3. Design review and evaluation
4. Automated drafting

2.4 Geometric Modeling

In computer-aided design, geometric modeling is concerned with the computer-compatible mathematical description of the geometry of an object. The mathematical description allows the image of the object to be displayed and manipulated on a graphics terminal through signals from the CPU of the CAD system. The software that provides geometric modeling capabilities must be designed for efficient use both by the computer and the human designer.

There are several different methods of representing the object in geometric modeling. The basic form uses wire frames to represent the object. Wire frame geometric modeling is classified into three types, depending on the capabilities of the interactive computer graphics system.

2.5 Engineering Analysis

CAD/CAM systems often include or can be interfaced to engineering analysis software which can be called to operate on the current design model. Examples of this type are

1. Analysis of mass properties
2. Finite element analysis

The analysis may involve stress –strain calculations, heat-transfer computations, or the use of differential equations to describe the dynamic behavior of the system being designed.

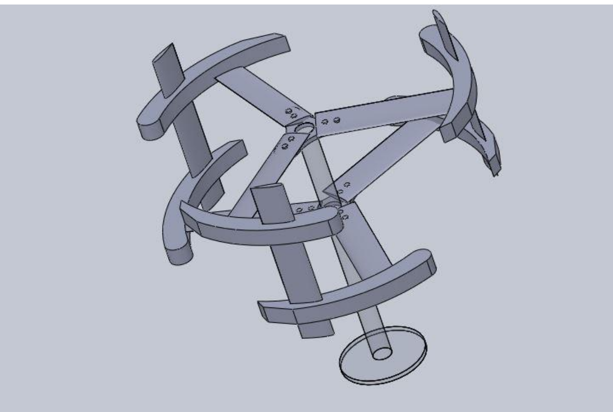

Fig 2.1 3D Model in Combined Axis Wind Turbine

3. ANALYSIS

3.1 Introduction to FEM

In mathematics, the finite element method (FEM) is a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. It uses variation methods (the calculus of variations) to minimize an error function and produce a stable solution. Analogous to the idea that connecting many tiny straight lines can approximate a larger circle, FEM encompasses all the methods for connecting many simple element equations over many small sub domains, named finite elements, to approximate a more complex equation over a larger domain.

The subdivision of a whole domain into simpler parts has several advantages:

- Accurate representation of complex geometry
- Inclusion of dissimilar material properties
- Easy representation of the total solution
- Capture of local effects.

FEM is best understood from its practical application, known as finite element analysis (FEA). FEA as applied in engineering is a computational tool for performing engineering analysis. It includes the use of mesh generation techniques for dividing a complex problem into small elements, as well as the use of software program coded with FEM algorithm. In applying FEA, the complex problem is usually a physical system with the underlying physics such as the Euler-Bernoulli beam equation, the heat equation, or the Navier-Stokes equations expressed in either PDE or integral equations, while the divided small elements of the complex problem represent different areas in the physical system.

FEA is a good choice for analyzing problems over complicated domains (like cars and oil pipelines), when the domain changes (as during a solid state reaction with a moving boundary), when the desired precision varies over the entire domain, or when the solution lacks smoothness. For instance, in a frontal crash simulation it is possible to increase prediction accuracy in "important" areas like the front of the car and reduce it in its rear (thus reducing cost of the simulation.

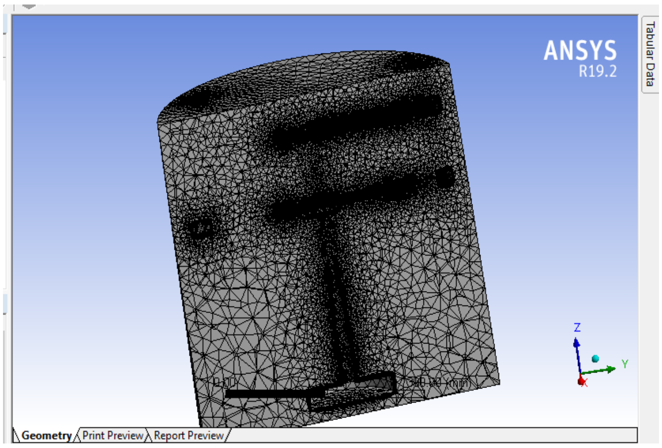

Fig 3.1 Meshing of CAWT

4. RESULT AND ANALYSIS

4.1 Comparison of VAWT and CAWT

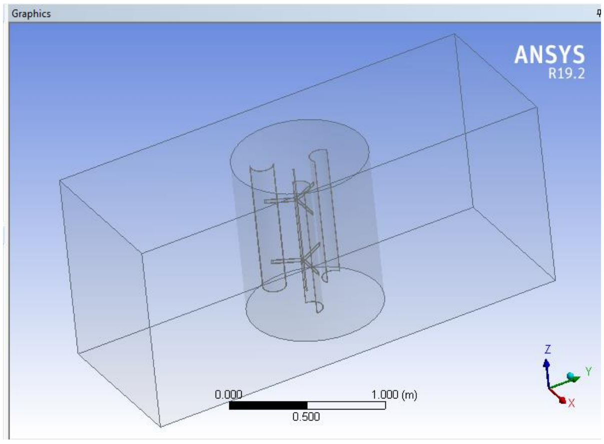

Fig 4.1 Meshing of VAWT

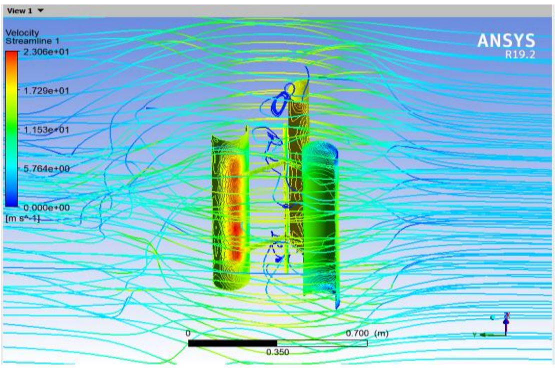

Fig 4.2 Velocity analysing of VAWT

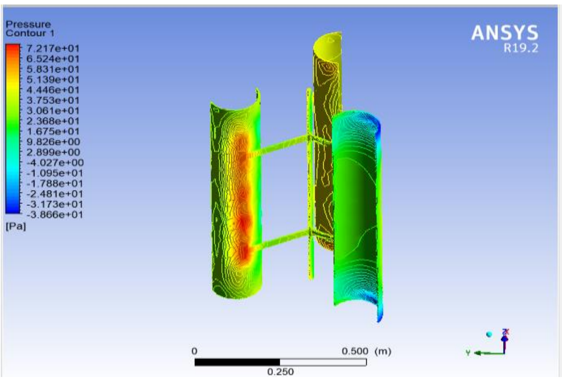

Fig 4.3 Pressure analysing of VAWT

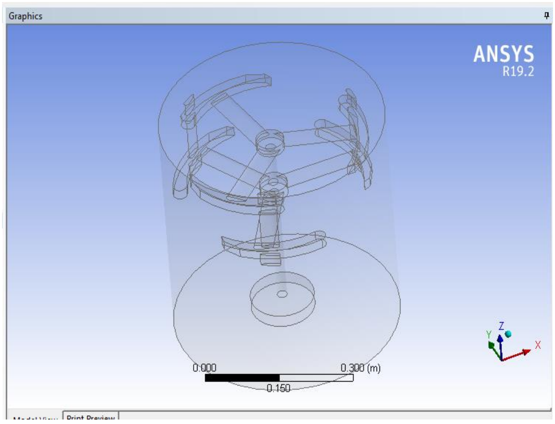

Fig 4.4 Meshing of CAWT

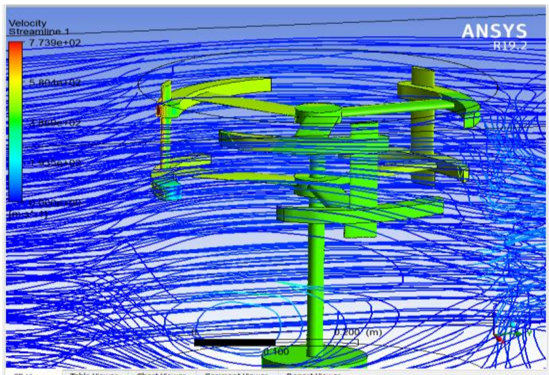

Fig 4.5 Velocity analysing of CAWT

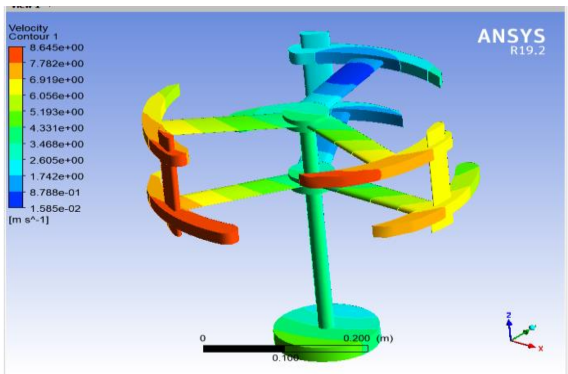

Fig 4.6 Pressure analysing of CAWT

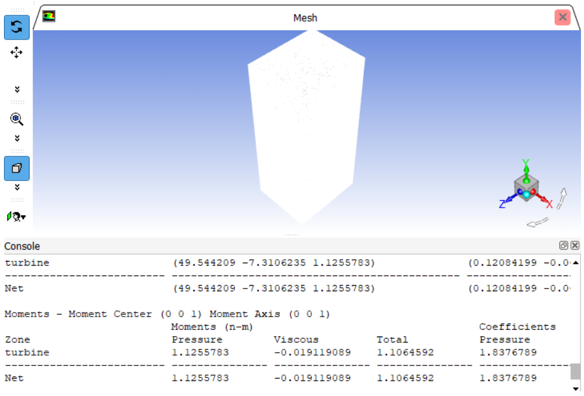

Fig 4.7 Final result of VAWT

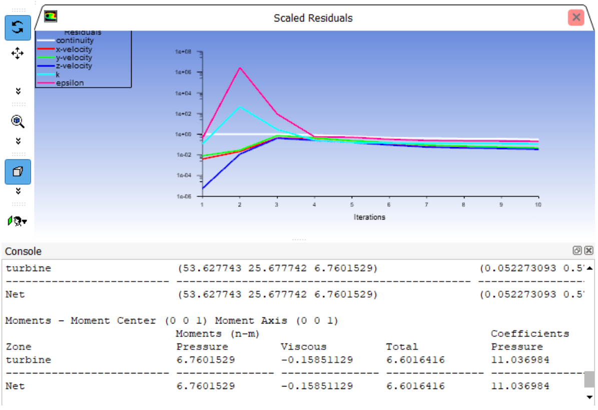

Fig 4.8 Final result of CAWT

	VAWT	**CAWT**
Velocity(m/s)	250	250
Torque(N-m)	1.1064592	6.6016416

Table . 4.1 Comparison of VAWT and CAWT

Thus the comparison of VAWT and CAWT indicates the CAWT torque is higher than the VAWT.

5. Conclusion

It is concluded that CAWT has better efficiency than VAWT .Then the speed of CAWT is higher than the VAWT.Torque produced by VAWT is (1.1064592) and torque produced by CAWT is (6.6016416).Thus the maximum speed is achieved by the CAWT.

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