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ANALYSIS, FABRICATION AND TESTING OF VERTICAL AXIS WIND TURBINE

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Abstract— **Wind energy is an indirect form of solar energy since wind is introduced chiefly by the uneven heating of the earth's crust by the sun. The conversion of this wind energy into electrical energy can reduce the power deficit to large extent. Vertical axis wind turbines (VAWTs), which may be as efficient as current horizontal axis systems, might be practical, simpler and significantly cheaper to build maintain than horizontal axis wind turbines (HAWTs). In this project we attempt to design and fabricate a Savonius Vertical Axis Wind Turbine.**

Keyword- **Savonius; Overlap Ratio; VAWT; CFD**

I. NOMENCLATURE

P= Power to be generated
C_P= Power coefficient
ρ= Density of air
A= Swept area
V= Wind velocity
D= Diameter of rotor
H= Height of rotor
C_L= Coefficient of lift
C_D= Coefficient of drag
F_L= Lift force
F_D= Drag force
F= Resultant force

II. INTRODUCTION

Carbon dioxide (CO_2) being the main culprit for global climate changes, the world is focusing on development and installation of wind energy farms. It is estimated that global wind power capacity is 74 GW and India has 2000 MW out of the total 45000 MW. India ranks fourth in the world with regard to the total wind power installation. So, wind turbines can be the best option for one of the renewable source of energy. As horizontal wind turbines are currently present though they require large infrastructure. So vertical axis wind turbine can be a better option for small power generation. In these paper we have discussed about savonius VAWT.

A. Types of VAWT:

1) Darrius wind turbine
2) Savonious wind turbine
   i) Semi circular blade
   ii) Semi elliptical blade

B. Advantages of VAWT over HAWT:

1) VAWT is simple to design and fabricate.
2) It is drag driven turbine.
3) It is wind direction independent turbine so that it is not necessary to mount turbine in front of wind direction.
4) It is small as compared to HAWT.

C. Disadvantages:

1) VAWT has low efficiency.
2) Due to its vertical shaft; mounting of alternator and gearbox may become a problem.
3) HAWT generates high power and has high capacity.

III. DESIGN THEORY

The Vane type rotor of S-shaped cross section is predominantly drag based, but also uses a certain amount of aerodynamic lift. Drag based vertical axis wind turbines have relatively higher starting torque and less rotational speed than their lift based counterparts. Furthermore, their power output to weight ratio is also less.

The power to be generated is assumed as 15 Watts.

$P=0.5*C_P*\rho*A*V^3$

Here wind velocity is assumed as 7 m/s and density of air is 1.223 kg/m^3.

Therefore swept area comes out to be 0.240 m/s.

So A= D*H

Here blade shape is taken as semi elliptical profile because semi elliptical profile has more concave area as compared to semi circular blade profile. So air will remain in contact with blade for more time and so less force required for rotation of blade.

Therefore Height of blade = 595 mm
Semi- Major axis of blade = 139 mm
Semi- Minor axis of blade =111 mm

Following are chosen design parameters for the fabrication of turbine:

1) Tip speed ratio: It is defined as ratio of tangential speed of tip of the blade to wind velocity. It is taken as 0.8.
2) Overlap ratio: It is ratio of overlap between two blades to the diameter of rotor. It is taken as 0.2.

3) Aspect Ratio: It is the ratio of height of blade to the radius of rotor. It is taken as 2.5. [1]

IV. ANALYSIS OF SAVONIUS WIND TURBINE

CFD analysis gives the detailed information about air flow over turbine blade and also gives the information about lift and drag coefficients. So from that we can calculate lift and drag force for turbine with the help of them. From that we can also get resultant force which is assumed to be point force acting at center of blade. So from that we will get required torque. [2]

Here CFD analysis is done on elliptical blade of dimensions mentioned in above design of turbine. For analysis wind speed is taken as 5.5 m/s.

From results of CFD analysis it is clear that VAWT is drag driven turbine as coefficient of drag is greater than coefficient of lift. But effect of lift force is also present in small percentage in savonius VAWT.

From graphs obtained from CFD analysis
We get $C_D = 2.7$
$C_L = 0.2$

Therefore drag force obtained is
$F_D = 0.5 * \rho * A * V^2 * C_D$
$= 0.5*1.223*0.238*5.5^2*2.7$
$= 11.88$ N

$F_L = 0.5 * \rho * A * V^2 * C_L$
$= 0.5*1.223*0.238*5.5^2*0.2$
$= 0.88$ N

Resultant force obtained is
$F = (F_D^2 + F_L^2)^{1/2} = 11.91$ N.

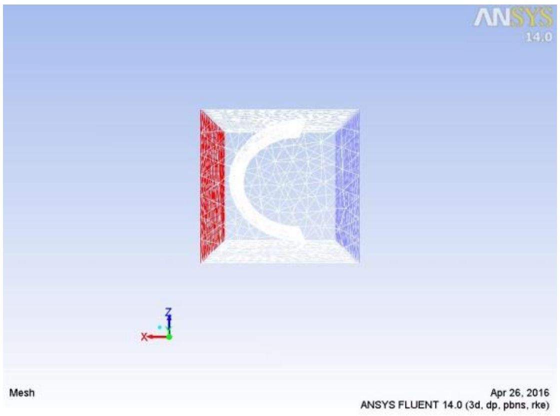

Fig. 1. Meshed profile of blade

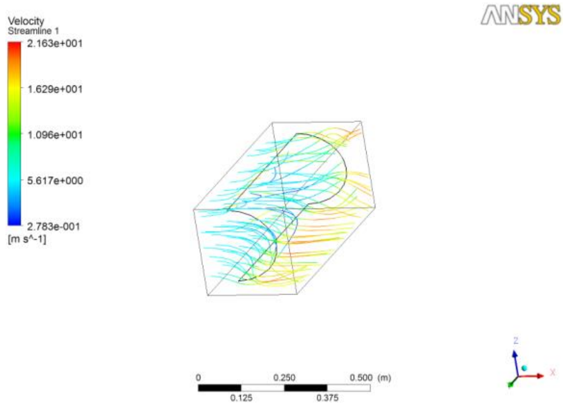

Fig. 2. Air flow on blade profile

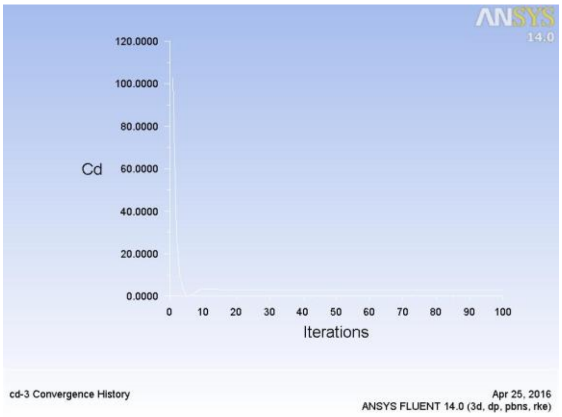

Fig. 3. Graph of C_D Vs. No. of iterations

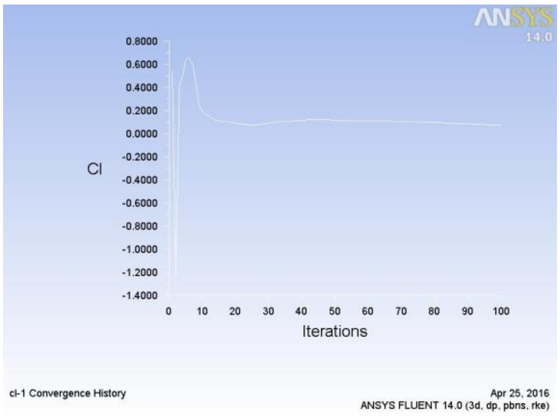

Fig. 4. Graph of C_L Vs. No. of iterations

V. FABRICATION OF SAVONIUS VAWT

In this project we have manufactured 3 bladed semi elliptical profile savonius VAWT. PVC pipes as used as a structure for turbine. Alternator is coupled to turbine with the help of coupling. Wooden planks are used as a supporting structure for bearings. We have used material for blades as aluminium and also material for shaft is aluminum as it has less density.

3 blades of turbine are arranged at 120^0 to each other having overlap in between them. Blades are attached to circular aluminum plates with the help of welding or joints.

On the upper part of shaft radial ball bearing is mounted while on lower part axial thrust bearing is used. In fabrication alignment of vertical shaft, rotor and bearings should be carefully checked so that shaft is perfectly perpendicular to ground. [3]

Fig. 5. Fabricated model of VAWT

VI. TESTING OF VAWT

Here turbine is tested with wind speed of 5.5 m/s using fan as a input source. With no load conditions turbine was first rotated. We get rpm of 150 with no conditions. While when alternator is mounted on turbine above the shaft we get 60 rpm.

VII. CONCLUSION

As testing is conducted for turbine with wind speed of 5.5 m/s satisfactory results are not getting. Minimum wind speed for turbine to rotate is between 3 to 4 m/s. VAWT is very useful in regions having continuous wind supply or at the sea shore. VAWT can also be used for pumping of water.

As from testing it is clear that due to axial load of alternator turbine rotates at lower speed. It can be only used for small power generation.

High wind speeds are necessary for VAWT

VIII. SCOPE FOR FUTURE WORK IN VAWT

1) Aerofoil profile blade can be used.

2) Lighter material can be used as blade material such as fiber.

3) Hybrid power plants can be a good option.

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