OPTIMIZATION OF SAVONIUS ROTOR FOR WIND TURBINE

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ABSTRACT

Increasing demand in energy facilitated the need of clean energy such as wind energy. This study was done to investigate the design and development of a micro Vertical Axis Wind Turbine (VAWT)-Savonius Type. In regions where wind speed is limited Horizontal Axis Wind Turbines (HAWT) do not have a practical application due to high wind speed requirement. VAWT provide operational abilities at lower speeds and do not require an alignment mechanism. Through an exhaustive bibliographical research, it is possible to identify the influence parameters, and to show that the aerodynamic efficiency of the Savonius rotor can be notably improved via a judicious choice of its geometrical parameters. Modified forms of the conventional Savonius rotors are being investigated in an effort to improve the power. The modification are made in the shape of the conventional Savonius rotor, and for different velocity ranging from 2m/s to 8m/s the effect on the torque generated is examined and compared with the conventional Savonius rotor, with small change in the shape of the conventional Savonius rotor we observe the drastic change in the power generation by theoretical calculation and analysis by software.

KEYWORDS: *Savonius rotor, Solidworks, CFD.*

I. INTRODUCTION

1.Wind Power:

Wind energy is the most potential alternative source for renewable energy. This is mostly Pollution free and abundantly available in the earth's atmosphere. The interest in wind energy has been growing and many researchers have to introduce and develop cost effective and reliable wind energy conversion systems. In practice, however there are many difficulties to introduce wind turbines into the community because of lesser wind energy source, noise pollution etc. There are two types of wind machines, namely, horizontal axis machines and vertical axis wind machines. [3]

Horizontal axis wind turbines have their shaft and electric generator at the top of a tower and must be pointed into the direction of the wind. Larger horizontal axis turbines use wind sensors that are coupled to a servo motor. They include a gear box which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electric generator. These machines in general have a higher efficiency when compared to vertical axis machines. Axis can be adjusted Vertical axis wind turbines have the main rotor shaft arranged vertically. The main advantage offered by this type of arrangement is that the turbine does not need to be pointed in the direction of the wind to be effective. This is useful in a site where the wind direction is highly variable. Since the shaft is vertical, the gear box and the generator can be placed near the ground so that the tower does not need to support it and is hence, more accessible for maintenance. They are difficult to mount on towers and hence, they are installed near the base, like a building rooftop. Since they are located closer to the ground than horizontal wind machines, the arrangement can take an advantage of the natural constructions and surrounding buildings to funnel the air and increase the wind velocity.

1.1 Savonius Rotor:

Savonius wind rotor is a vertical axis wind machine. It is a drag type rotor and its basic configuration consists of an ‘S’ shape formed by two semicircular blades with a small overlap between them. This structure has the ability to accept wind from any direction. Savonius rotor is not popular for large power production because of its low aerodynamic efficiency compared to other wind machines and hence, its performance is lower than other rotors. It has very high starting torques. [1] They are suitable for pumping water and for small scale power generation. They act as efficient starters for other wind machines due to their high starting torque characteristics. Various blade shapes and designs like semi circular type, lebost type etc. have been studied by researchers over the years in order to improve the efficiency of the Savonius rotor. The Savonius rotor is a drag type rotor, i.e., the main driving force on the rotor is the drag force acting on its blade.[2]

Figure1 shows the structure of a conventional Savonius rotor. The semicircular plates are held in place with the help of two flanges as shown in the figure.

1.2 Literature Review:

Widodo et al. In their paper presents the design and analysis of the Savonius rotor blade to generate 5 kW power output. The relevant design parameters and theories were studied in this paper and used to determine related design geometry and requirements of the Savonius rotor blade. The Savonius rotor was designed with the rotor diameter of 3.5 m and the rotor height of 7 m. The 3D model of Savonius rotor blade was created by using SolidWorks software. Computational Fluid Dynamics (CFD) analysis and structural Finite Element Analysis (FEA) are presented in this paper. CFD analysis was performed to obtain the pressure difference between concave and convex region of the blade while FEA was done to obtain the structural response of the blade due to the wind load applied in term of stresses and its displacements.[6]

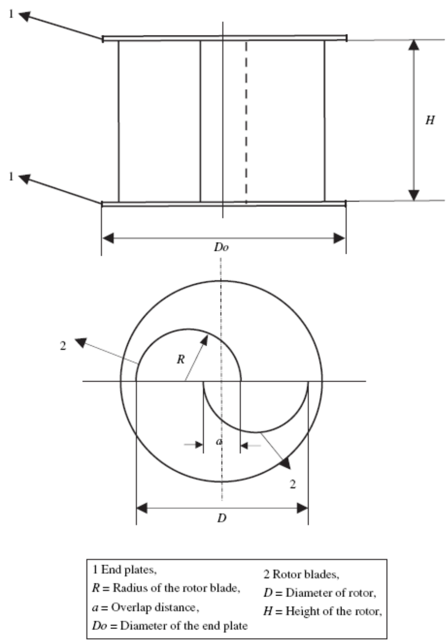

Figure 1: Basic Structure of a Conventional Savonius Rotor[1]

R. Gupta, et al done the CFD analysis of a rotating two-bucket Savonius rotor with 0 rotor angle for five overlaps, namely 16.2%, 20%, 25%, 30% & 35% was carried out using Fluent 6.3.26 software. Velocity and static pressure contours were generated for each overlap condition and then these were analyzed Static pressure decreases from upstream to downstream side of the rotor. The maximum pressure drop is found in case of 16.2% overlap (18.41e+02 Pa) and minimum in case of 35% overlap (9.27e+02 Pa) meaning maximum power extraction from wind by the rotor at 16.2% overlap condition. The net pressure on the advancing and returning buckets comes out to be almost equal in case of 16.2% overlap (about 1.02e+03 Pa), which would ensure stability of the rotor at 16.2% overlap by minimizing vibration during rotation[5]

II. COMPUTATION OF ROTOR PERFORMANCE

The optimal values of rotor dimensions are described in exhaustive literature survey, it is found that the conventional rotor and the modified Savonius rotor have higher coefficient of power in comparison to other modifications on the rotor. In the present chapter, the dimensions of the rotor are computed for two cases, one for conventional and other for modified rotor shown in Figure 1. The final section states the conclusions drawn on the basis of result obtained. Power output (p) 21.24 watt from the calculation the power generated theoretical by the conventional Savonius rotor is 21. 24 watt, which is less some modifications in the shape of Savonius rotor helps to improve the power generation capacity of the turbine. In this work the suggested change in the shape of the Savonius rotor is as shown in figure

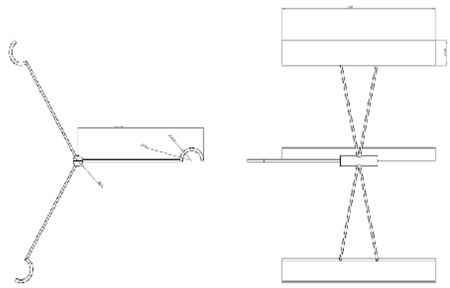

Figure 2.The modified shape

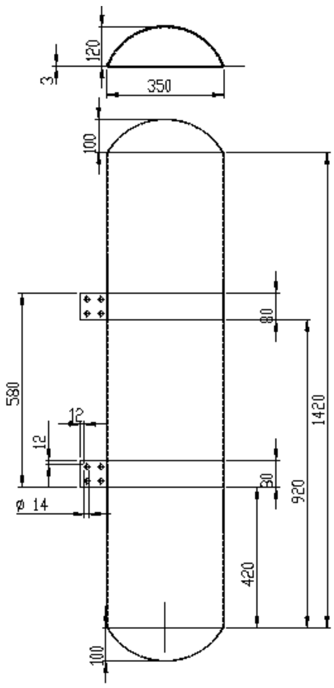

Figure 3. Modified shape of Savonius rotor of Savonius turbine

Calculations are done for the modified Savonius rotor and for air velocity 6 m/s the Theoretical power generation is (P) 97.26 watt.It is observe that the power generated by modified Savonius rotor is much greater than the theoretical power generated by the conventional Savonius rotor.

III. SIMULATION AND ANALYSIS OF MODIFIED SAVONIUS ROTOR

In this work, one kinds of simulation and analysis were done i.e. Computational Fluid Dynamics and using Solid Works Flow Simulation/cosmo.

4.1 Computational Fluid Dynamics (CFD) Analysis

The purpose of this simulation is to obtain the torque at the rotor surfaces for modified Savonius rotor induced. The pressure difference between concave and convex blade surfaces induces force that turns the blade. The torque induced was obtained by implementing Computational Fluid Dynamics (CFD) analysis on SolidWorks Flow simulation. The flow types in this work are internal flow analysis. The analysis was static analysis. The engineering goals for the internal flow analysis and external analysis are two surface goals and four global goals are dealing with total pressure for both concave and convex surface. The four global goals are dealing with total pressure, for both concave and convex surface. The four global goals are deal with total pressure, velocity, normal force and force.

In this work the flow analysis was done for the different inlet velocities on the rotor blade and the torque generated for the different velocities are use to calculation of the power to find out the improvement in power transmission capacity of modified Savonius rotor as compare to the conventional Savonius rotor.

IV. RESULT AND DISCUSSION

The flow analysis for the modified Savonius rotor is done for the range of wind velocity from 2 m/s to 8 m/s, and the computational domain is 5m x 5m x 15m for the internal flow analysis. Flow through the Savonius rotor blade, and then exit through the outlet that is set to environmental conditions. The Savonius rotor blade is placed in the middle of wind tunnel. In internal analysis, the computational Domain is automatically enveloped the model wall, which is the wind tunnel size for this work. The lids are used to apply boundary condition.
The lid thickness for an internal analysis is usually not important. However, the lid should not be so thick until the flow pattern is affected downstream in some way. If the lid is created to be too thin, this will make the number of cells to be very high. For most cases the lid thickness could be the same thickness used to create the neighboring wall the figure shows the flow pattern for the inlet velocity from 2m/s to 8 m/s. Input Parameters for the CFD analysis of the Savonius rotor for velocity 6 m/s are as given in the following table

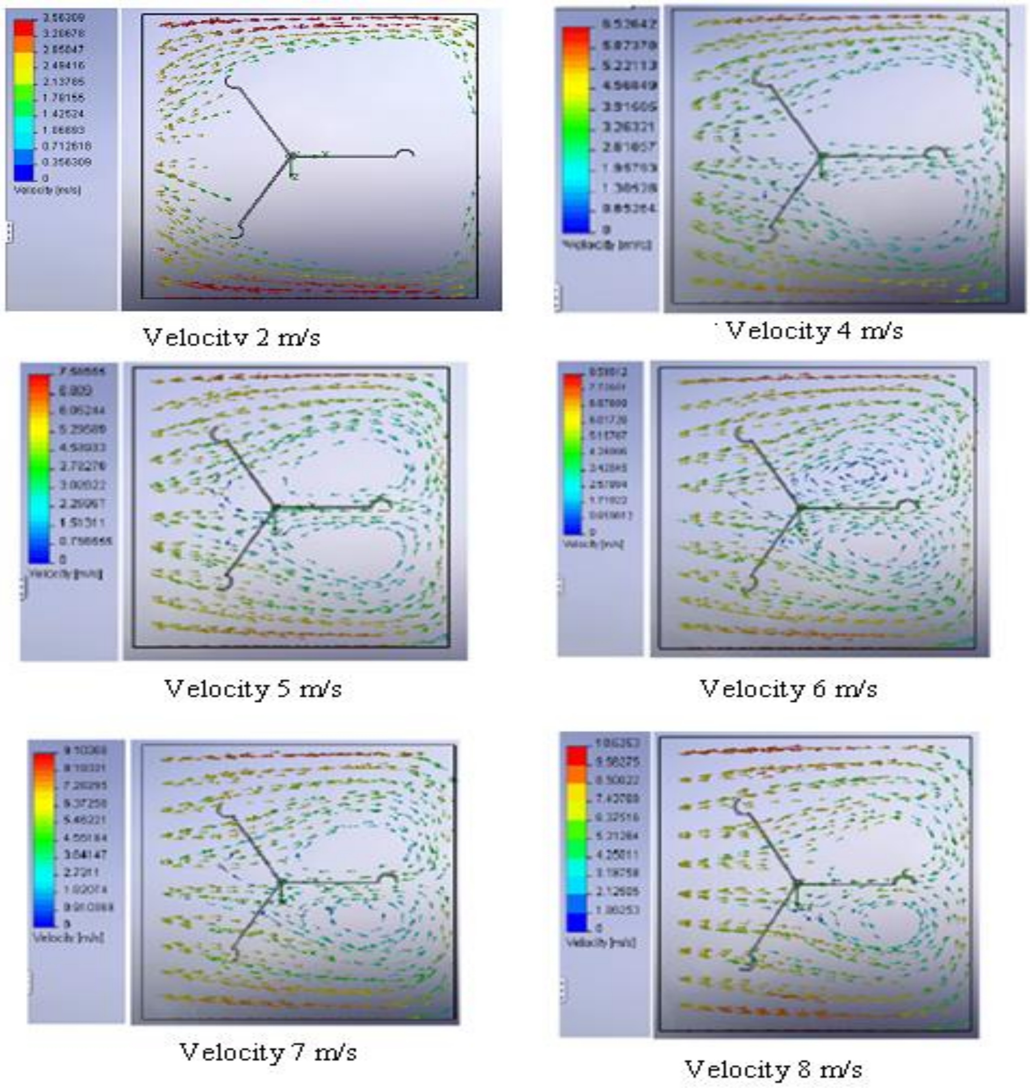

Figure 4. Flow pattern for velocity V= 2 m/s to 8 m/s

Table1.Input parameters for CFD analysis at velocity v = 6 m/s.

Local parameters				
Parameter	**Minimum**	**Maximum**	**Average**	**Surface area [m^2]**
Pressure [Pa]	101295	101357	101346	0.503087
Temperature [K]	293.216	293.219	293.219	0.503087
Density [kg/m^3]	1.19499	1.19554	1.19548	0.503087
Shear Stress [Pa]	1.6934E-09	0.423496	0.0411891	0.503637
Fluid Temperature [K]	293.216	293.219	293.219	0.503087

Output parameters from the analysis at V= 6 m/s are given in table below

Table 2. Out parameters at V= 6 m/s

Parameter	**Value**	**X-component**	**Y-component**	**Z-component**	**Surface area [m^2]**
Normal Force [N]	7.32404	6.35504	0.0277127	3.64064	0.503637
Shear Force [N]	0.006787	0.00373995	-0.000430454	-0.00564838	0.503637
Force [N]	7.32448	6.35878	0.0272823	3.63499	0.503637
Torque [N*m]	9.02615	-0.456129	8.98424	0.739427	0.503637
Surface Area [m^2]	0.503637	-0.297528	-3.73079E-05	-0.167707	0.503637
Torque of Normal Force [N*m]	9.02499	-0.45663	8.98306	0.73929	0.503637
Torque of Shear Force [N*m]	0.001288	0.000501344	0.00117918	0.000137376	0.503637

P = 2 x 3.14 x N x T / 60

P = 2 x 3.14 x 33 x 9.026 / 60

P = 31.75 watt

V. CONCLUSIONS

In this paper from the calculations and analysis we can see that the power generation capacity of modified Savonius rotor is more as compare to conventional Savonius rotor.
The theoretical power generated by the conventional Savonius rotor is 21.24 watt. And for the modified Savonius rotor the theoretical power generated is 97.26 watt power generation calculated by analysis of modified Savonius rotor is 31.75 watt which is much greater than the power generated by conventional Savonius rotor.

VI. FUTURE SCOPE

In this paper we have made the changes in the shape of conventional Savonius rotor and done the analysis using Solidworks flow simulation the same analysis can be done by using Ansys fluent and result of both analyses can be compared.
In future by further doing the modification in the Savonius rotor its power generation capacity can be enhance and better results can be obtain with less cost

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