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CFD ANALYSIS OF SAVONIOUS TYPE VERTICAL AXIS WIND TURBINE

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ABSTRACT

The main aim of this paper is to produce electricity for street lights through savonius wind turbine which is a type of VAWT (Vertical Axis Wind Turbine). The performance of the savonius rotor depends on the design of aerodynamic structure of the blades which facilitates easy air flow over the blades without any restriction. The performance of the savonius type of wind mill can be increased by reducing the drag with some modifications. Drag is caused because of the resistance offered to the rotor blades by the wind flow. This can be overcome by designing the leading and tailing edges of the blade by considering the aerodynamic flow of wind. The rotor of the savonius turbine produces high torque, and it can able to rotate in low wind speeds hence it does not need any starter mechanism for the initial rotation. The modelling and analysis process of rotor blade is done by the Computational Fluid Dynamics (CFD). The replacement of normal blades by newly designed an aerodynamic blade which is made up of aluminium sheet having high density and less weight, results in increasing efficiency of savonius type of wind mills. The generated power is stored in the battery for future use. Thus the aerodynamic structure of blades results in more power production.

Key words: Savonius wind turbine, Vertical axis wind turbine, computational fluid dynamics, Kinetic energy, swept area, blade profile.

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1. INTRODUCTION

Since 1973 after all the oil crisis issues, Wind energy become wider with the development of renewable energies. In future, the price for oil would be raised and one of the best alternative renewable energy source would be wind energy. The wind turbine is generally a device that generate electrical or mechanical power by utilizing the wind energy. The wind turbines are generally classifies as Vertical Axis Wind Turbine (VAWT) and Horizontal Axis Wind Turbine (HAWT). The most commonly one and known type of wind turbine is HAWT, that generally operates parallel to the direction of the wind whereas the modern one, which is been developed in recent years is VAWT, that has a rotor which is operated perpendicular to the direction of wind. The two most common design principle of VAWT is Savonius type and Darrieus type. The lift driven and drag driven wind turbine are the two main classes of Wind turbine. The Aerodynamic lift provides the rotational force in the former case and where ass the aerodynamic drag force make the turbine to spin in the latter case. Savonius wind turbine is one of the type of Vertical Axis Wind Turbine (VAWT), where its rotor blade in the wind turbine operates based on drag concept. The working principle of Savonius wind turbine rotor is resembled to a cup anemometer. They are drag type devices which produces more torque and can be placed in ground level. It produces less noise when compared to other types of wind turbines. It construction is simple hence it can be used for household application. The Savonius rotor is a drag type VAWT where improves the drag force for its operation. D'Alessandro et al., (2010) highlighted that the aerodynamic concepts developed for lift type wind turbine (HAWT and Darrieus wind turbine) cannot be applied for Savonius rotor. This paper aims at improving moreoutput power of the Savonius turbine as well as the static torque, which measures the self-starting capability of the turbine.. The most specious improvement of VAWT is it can run in all wind direction and thus are built without using any yaw mechanism (Halsey, 2011). Other benefits built in low noise and simplicity. The performance of the savonius rotor depends on the design of aerodynamic structure of the blades which facilitates easy air flow over the blades without any restriction. The performance of the savonius type of wind mill can be increased by reducing the drag with some modifications. Drag is caused because of the resistance offered to the rotor blades by the wind flow. This can be overcome by designing the leading and tailing edges of the blade by considering the aerodynamic flow of wind.The modelling and analysis process of rotor blade is done by the Computational Fluid Dynamics (CFD). The boundaty condition and the CEL language is derived from the several literatures [16-29]. The replacement of normal blades by newly designed aerodynamic blades which is made up of aluminium sheet (a type of metal) having high density and less weight, results in increasing efficiency of savonius type of wind mills.

2. DESIGN OF ROTOR BLADES

The rotor blades of the savonius wind turbine are designed using the solid works software which is user friendly. At first the length and diameter of the blades and shaft are determined. Then the angle between the blade ends is determined. The rotor is made of composite fiber, the property and the importance is explained in notable studies [7-15]. The rotor blades are connected with the frame which is mounted along with the rotating shaft. Then the whole setup is assembled on the base plate. The blades are assembled in a manner which is facing opposite to each other. A gap is present in between the blades and the shaft which provides necessary path for air to pass through.

Table 1 Specification of the savonius wind turbine

Parameter	Value
Diameter of blade, D	3000mm
Height of blade, H	6000mm
Thickness of blade, t	0.15mm
Diameter of shaft, d	250mm
Length of the shaft, L	7500mm
Density of aluminium, ρ	2.7g/cm^3
No. of blades	2

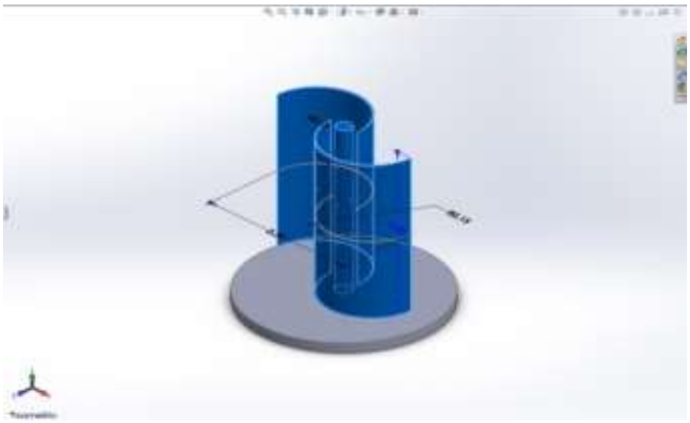

Figure 1 Blade design of savonius wind turbine

3. CFD ANALYSIS

Computational Fluid Dynamics is the most common method to create a simulation over the constructed experiment model that represents the real world flow. This reduces the cost and time for the practical setup which has to be done. The aim of this simulation is to predict the pressure and velocity over the sides of the concave and convex blades surfaces. At first the primary goals of theexperiment has to be set. Then the flow rate has to be given. The boundary layer has to be created around the testing specimen. The flow is regulated within the boundary layer. The pressure flow indicates the distribution of pressure rate over the surface of the rotating blades.

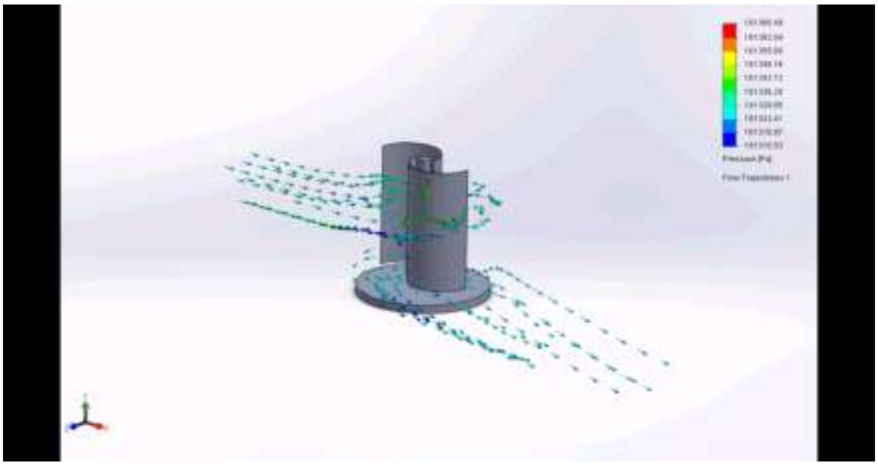

Figure 2 Pressure indication flow

The velocity flow represents the velocity of air that passes in and out of the 1concave and convex blade surfaces. The flow is represented by the series arrows, here the boundary is imaginary in order for better view. During this analysis process the velocity of air should be provided before the initiation of this process. This represents the velocity of air at various points such as in and out of the blades.

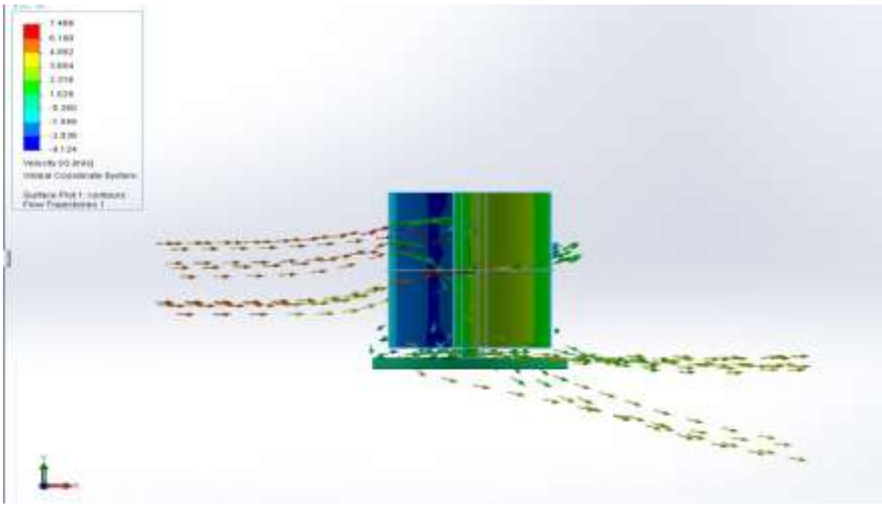

Figure 3 Velocity indication flow

4. RESULT AND DISCUSSION

As a result of the CFD analysis is performed in order to determine the pressure and velocity variations over the blades surfaces. From the pressure indication we concluded that the presence of gap between the concave and convex blade surfaces has results decrease in pressure over the blade surface which reduces the drag that restricts the rotational motion of the blades. When it passes through the gap in between the blades initiate the additional rotation of the motion and the torque. From the velocity indication we concluded that the air which passes in between the blade surfaces further induces the rotational motion of the rotor blades. The air enters the outer surface of the blade is 6 m/s and then the air leaves at the rate of 3m/s to 5m/s. This shows that the drag was reduce and increasing the efficiency.

Table 2 Property difference along wind turbine

Goal Name	Unit	Value	Averaged Value	Minimum Value	Maximum Value
SG Max Velocity (X) 1	[m/s]	3.061215714	3.061215714	3.061215714	3.061215714
SG Max Velocity (Y) 1	[m/s]	0	0	0	0
SG Max Velocity (Z) 1	[m/s]	5.167675848	5.167675848	5.167675848	5.167675848
SG Max Static Pressure 1	[Pa]	101341.513	101339.2628	101338.5132	101341.513
SG Max Total Pressure 1	[Pa]	101357.7154	101354.7071	101353.7876	101357.7154
SG Max Dynamic Pressure	[Pa]	16.50202607	16.50138102	16.50103521	16.50202607

5. CONCLUSIONS

Thus the performance of the newly designed savonius rotor is increased by reducing the drag. This is done with some modification from the already existing one. The average power output of the savonius rotor is 16 watts/hour. The power output of the savonius rotor is more than enough to recharge the battery. Hence the power output of the savonius rotor is stored in the battery for future use. The power which is stored in the battery can be used for the illumination of street lights.

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