A COMPARATIVE STUDY OF DIFFERENT FORMS OF SAVONIUS WIND TURBINE

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Abstract: ***This paper represents a comparative study of different forms of Savonius wind turbine. The Savonius turbine is one of the simplest vertical axis wind turbine. Savonius wind turbine is usable for wind power and tidal power belongs to vertical axis wind turbine (VAWT). Recently, more and more research is made on it for its advantages such as: being able to accept wind from any direction, long fatigue life of the blades, high starting torque, wide working wind speed range, easy to install, manufacture and maintain and low noise etc. The different forms of savonius wind turbine are Conventional, Helical, Modified Savonius wind turbine. Aerodynamically, savonius wind turbine is drag-type devices, consisting of two or three blades (vertical – half cylinders). Wind energy is one of the most promising sources of renewable energy. It is pollution free & abundantly available in the earth's atmosphere, can be locally converted and thus help in reducing the dependency on fossil fuels. This paper reviews various forms of Savonius wind turbine along with experimental and numerical study results.***

IndexTerms - Vertical axis wind turbine, Energy generation, Wind energy, Renewable energy, Savonius wind turbines, Numerical study.

I. INTRODUCTION

1.1 INTRODUCTION

The renewable energy is considered as a new technology and an alternating energy source to be used instead of fossil fuel, its continuous rising cost of it and due to growing concern to reduce the effects of climate change, such as global warming, generated by extensive and deliberate use of fossil fuels, mainly in the electric power generating plants and transport. Global warming will continue until we reduce use of fossil fuels, thus the Wind power is most important in reducing greenhouse gas emissions.

Wind is the secondary form of solar energy and is always being replenished by the sun energy. Wind energy is associated with the kinetic energy of flowing wind. It is formed from point where the sun's radiation, which in combination with other factors such as tilt and displacement of the Earth in Space or we can say that it is affected due to differential heating of the earth's surface by the sun. Wind energy is an useful and ecofriendly option over the falling reserves of fossil fuels resources throughout the world. However, VAWT research work endures in parallel on one relatively small. Scientists and engineers have established various Wind turbine structures and use different Methodologies for their analysis. The optimum conditions for working VAWTs were determined. The different forms of Savonius turbine & the major findings of the researchers on the vertical axis Wind turbines are reviewed in this paper.

A closer look at the concepts The fact that VAWTs are suitable for power leads Where the conditions are not overly traditional HAWTs Such as high wind velocity and turbulent due to capacity the wind blows. Another major advantage is that VAWTs Omni-directional wind from any direction, without any accepted Mechanism yawing.

1.2 OJECTIVES

- The main objective of this paper is comparative study of different forms of Savonius wind turbine with respect to their aerodynamic aspect, their advantages & disadvantages.
- The another objective is to study different forms of Savonius wind turbine with experimental and numerical study results like Coefficient of performance(Cp), Coefficient of torque(Ct), Coefficient of static torque(Cts).

II. DESCRIPTION OF SAVONIUS WIND TURBINE

The Savonius turbine is simplest type of VAWTs. Aerodynamically it is a drag type device, consisting of two or three scoops. It was invented by a Finnish engineer, S.J. Savonius.

The Drag based VAWTs have comparatively higher starting torque and low rotational speed than the aerodynamic lift based VAWTs. Various types of drag based VAWTs have been developed in the past which use plates, cups, buckets, oil drums, etc. as the drag device. Mostly the Savonius rotor is an S - shaped cross section rotor which is drag based, but also uses a certain amount of aerodynamic lift. Furthermore, their power output to weight ratio is also less. Due to the low rotating speed, these are generally considered unsuitable for producing electricity, although it is possible by selecting proper gear trains. Drag based windmills are useful for other applications such as grinding grain, pumping water and a small output of electricity. A major advantage of Savonius -type VAWTs lies in their self– starting capacity, unlike the Darrieus lift–based vertical axis wind turbines.

The savonius wind turbine works due to the difference in forces exert on each blade. At the lower blade the air wind and forces the blade to rotate around its central vertical shaft. Whereas, the upper blade hits the blade and causes the air wind to be deflected sideway around it. The differential drag forces causes the Savonius turbine to rotate. For this reason, Savonius turbines extract much less of the wind's power than other similarly sized lift type turbines because much of the power that might be captured has used up pushing the convex half, so savonius wind turbine has a less efficiency.

Its working principle is extremely simple. The turbine rotates because of the difference of the drag force acting on the concave and convex parts of its blades.

Figure 1 illustrates this principle:

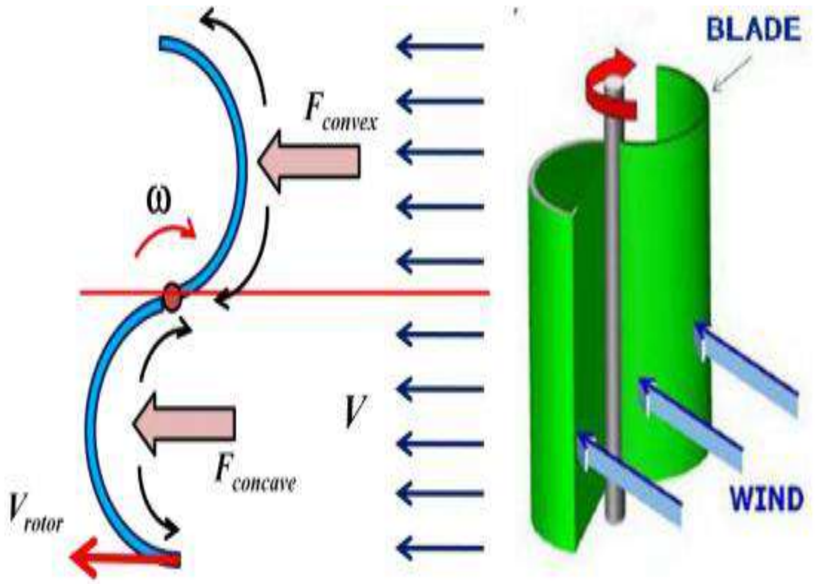

Fig -1: Working principle of a Savonius rotor

Accordingly, more blades can be added to the S shape design, and the same principle causes to rotate the turbine as shown in Figure 2. The three blade savonius wind turbine are constructed from three half cylinders, which are arranged at (120^0) relative to each other.

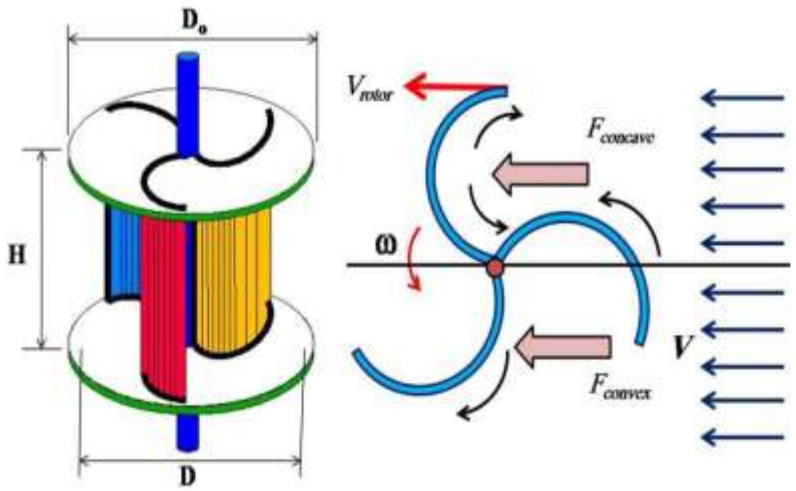

Fig -2: Three blades Savonius turbine

III. DIFFERENT FORMS OF SAVONIUS WIND TURBINE

3.1) Conventional Savonius wind turbine
3.2) Helical Savonius wind turbine
3.3) Modified Savonius wind turbine

3.1 Conventional Savonius wind turbine

Convectional form of Savonius wind turbine is the old type of Savonius turbine consisting of two or three scoops. They consist of two or three vertical – half cylinder mounded on vertical shaft. A two blades savonius wind turbine would look like an "S" letter shape in cross section as shown in fig 1.

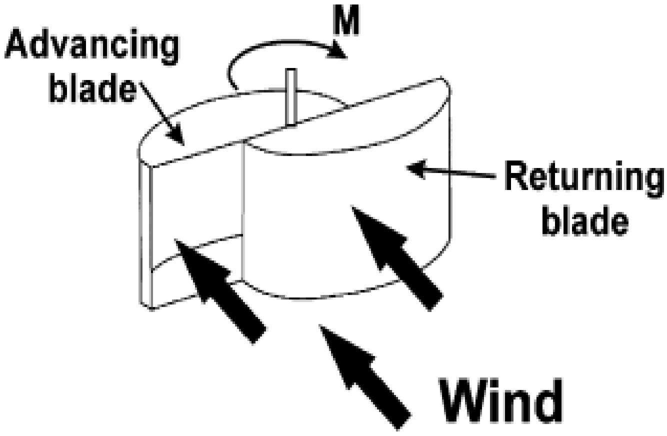

Fig -3: Conventional Savonius rotor

The fig 3 shows conventional Savonius rotor with two scoops, one is advancing and another is returning blade. Since one of the major advantages of the Savonius turbine is its simplicity and corresponding compactness, robustness and low cost. Wind from any direction can be accepted due to vertical axis. The device is quiet, easy to build, and relatively small. Due to the turbine is close to the ground, maintenance is easy. The limitation is that the scoop system used to capture the wind energy is half as efficient as a conventional turbine, resulting in less power generation**.** In fact, in the case of conventional turbine, the torque developed by the rotor is alternative and sometimes takes positive values and sometimes negative values.

3.2 Helical Savonius wind turbine

In the present review, a helical Savonius rotor has been manufactured to improve the low aerodynamic performance of Savonius wind rotor. To overcome demerits of conventional type the helical Savonius rotor were constructed to improve the coefficient of torque, but slightly lowered the coefficient of performance. It should be noted that the blade with a twist of a $\alpha = 0^0$ corresponds a semi-circular blade. The helical rotor consists of two parts, each part can be defined as a curve generated by a marker moving vertically at a constant velocity on a rotating cylinder (at a constant angular velocity). Fig. 4 shows a single helical rotor with two blades. The blade retains its semi-circular cross-section from the bottom (0^0) to the top (180^0). Fig. 4 shows the top view of the twisted Savonius rotor which is exactly the top view of conventional Savonius rotor.

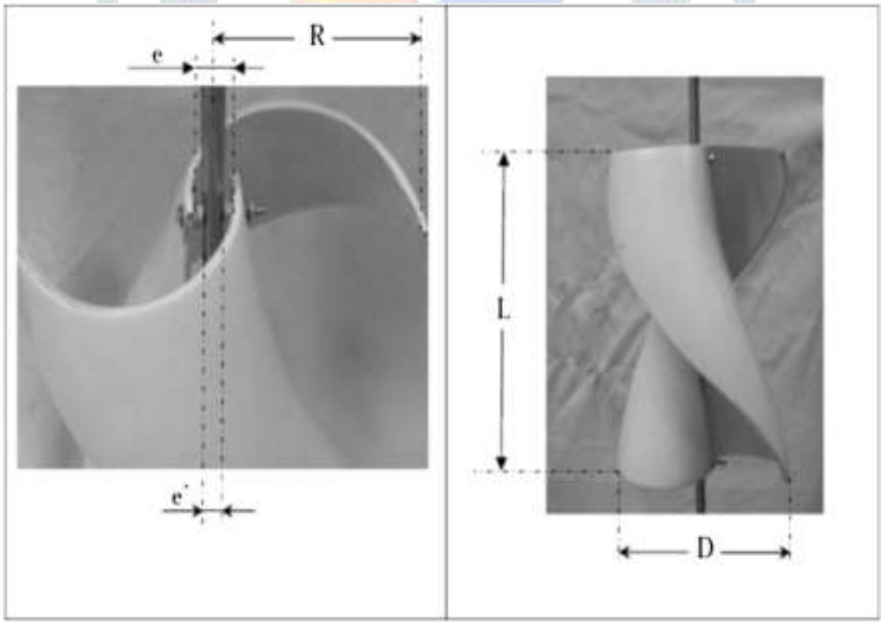

Fig -4: Helical Savonius rotor

In contrast, in the case of helical turbine, the torque is also alternative but always positive. Consequently, the average torque developed by the helical rotor is greater than that developed by the conventional rotor. The coefficient of power increases with increase in Reynolds number. So, the performance increases of the helical Savonius.

3.3 Modified or bach type Savonius wind turbine

Fig 5 shows the basic modified Savonius rotor without shaft & fig 6 shows geometrical parameters of optimized modified Savonius rotor with shaft. Modified Savonius rotors are manufactured from aluminium sheet whose thickness is 2 mm. Rotors are covered from top and bottom by an acrylic plate of 10 mm thickness. There are two types of Modified Savonius rotor, without shaft is not having any shaft in between the two end acrylic plates and rotor with shaft between the two endplates. Stainless steel flanges housing the two end shafts are bolted to the two acrylic sheets.

The conventional S-shaped Savonius rotors were used as these wind turbines are capable of producing power at very low wind speeds, but face difficulties with power efficiency and structural integrity during storms. These demerits of Conventional and Helical Savonius rotor have been overcome in Modified Savonius rotors. Such as lower efficiency, high starting torque required in conventional Savonius rotors.

The Modified Savonius rotor without shaft is having the highest coefficient of power followed by conventional Savonius rotor (without shaft between the end plates) and modified Savonius rotor with shaft. Maximum coefficient of power at a Reynolds number of 150,000 is as follows:

Cp_{max} of modified Savonius (without shaft) = 0.21;
Cp_{max} of conventional Savonius = 0.175;
Cp_{max} of modified Savonius (with shaft) = 0.143;

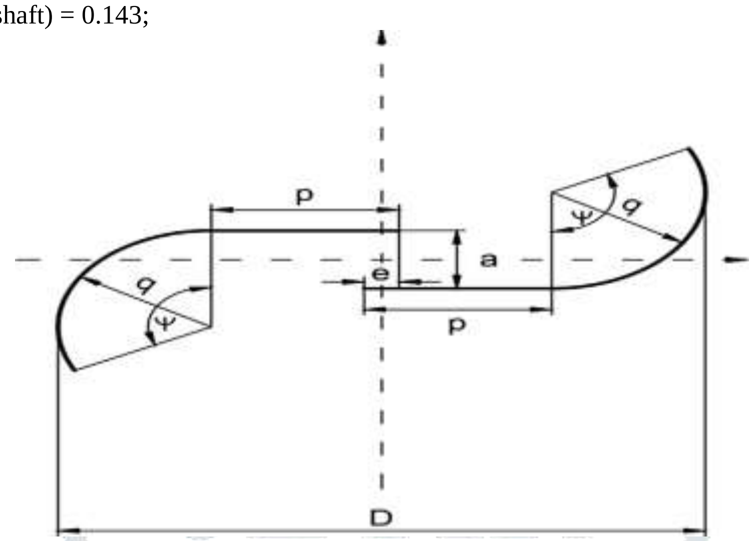

Fig -5: Basic modified –type Savonius rotor without shaft.

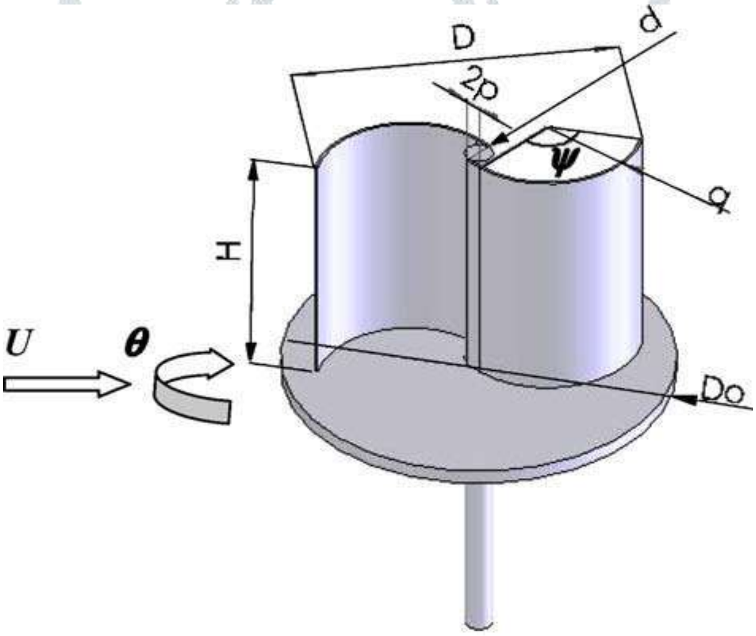

Fig -6: Geometrical parameters of optimized modified Savonius rotor with shaft.

IV. EXPERIMENTAL AND NUMERICAL STUDY OF DIFFERENT FORMS OF SAVONIUS WIND TURBINE

Table -1: Experimental and numerical study results.

Experimental study results				Numerical study results
Sr. No.	Conventional Savonius wind turbine	Helical Savonius wind turbine	Modified Savonius wind turbine	Modified Savonius wind turbine
Cp	0.18	0.17	0.21	0.34
Ct	0.28	0.3	0.33	0.44
Cts	0.31	0.32	0.357	0.43

In the table 1 it observed that Modified Savonius turbine has highest Cp, Ct, Cts as compared to Conventional and Helical Savonius wind turbine. The numerical study results are slightly high in comparison with experimental study results.

V. CONCLUSIONS

In this paper we studied different forms of Savonius wind turbine i.e Conventional, helical, modified or bach -type Savonius wind turbine.

It is observed from the experimental and numerical study results, that modified or bach –type Savonius wind turbine is having highest Cp, Ct, and Cts as compared to Conventional & Helical Savonius turbines.

In the present work it has been proved that Modified Savonius wind turbine is more beneficial with respect to maximum Cp, Ct & Cts values.

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