Design of Savonius Wind Turbine with Magnetic Levitation

Ashik Gaoture[1], Shubham Deoke[2], Trishala Kokate[3], Ajay Mahawadiwar[4]

[1]*Student, Department Mechanical Engineering,*
[2]*Student, Department Mechanical Engineering,*
[3]*Student, Department Mechanical Engineering,*
[4]*Professor, Department Mechanical Engineering,*
[1,2,3,4]*Abha Gaikwad-Patil College of Engineering, Nagpur, Maharashtra, India*

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Abstract - *Savonius wind turbine is the vertical axis wind turbine. Savonius has the two cu shaped structures. Savonius wind turbine is one of the turbines which are operated in the low speed wind. This produce the high operating torque at the low speed, it is the self-starting turbine. Savonius would use with the magnetic levitation for obtaining the high speed rotation of the generator. Magnetic Levitation is the phenomenon which is anybody is freely suspended in the air without any support with the opposed of gravitational energy. This magnetic levitation occurred due to the repulsion between the two symmetrical poles. The strong levitation is occurred with the used of permanent magnets.*

Key Words: **Savonius Turbine, Magnetic Levitation, Rotor, Generator.**

1. INTRODUCTION

Now a day, the electricity is generated from conventional energy sources. These sources will be at the end of the scale. For save this sources, we will be must use the renewable energy sources. The wind energy is the one of the big energy source of renewable energy sources. The wind mill are used the wind power for produce the electricity.

Wind is the form of solar energy. Wind is created from the atmosphere of the sun causing areas of uneven heating. In conjunction with the uneven heating of the sun, rotation of the earth and the rockiness of the earth's surface winds are formed. This wind energy strikes on the blade of turbine which rotate the turbine. This rotation of turbine shaft rotates the shaft of generator which is coupled together. The mechanical energy of wind is converted into the electrical energy. The wind mill gas the various bearing, gear mechanism, which absorbs the energy in friction form.

For reducing the friction between the bearing and shaft we are use the magnetic levitation. Magnetic Levitation are suspended the shaft in air without contact with steady side part of wind mill. This totally neglects the Friction between the shaft of rotor and the stator assembly. Due to this, speed of wind power is not reduced and it passes to the generator shaft.

Vertical axis wind turbine is the best option for the acquired the wind energy from all the direction. Vertical axis wind turbine has not required any yaw mechanism. It is simple in construction. The Savonius turbine is to be used for this vertical axis wind turbine. The Savonius wind turbine is rotated at the low speed wind turbine is rotated at the low speed wind, due to the minimization of friction between shaft and stator the total wind speed of turbine observed passes to the generator. This causes the Savonius wind mill are rotated at high speed within the low wind speed [1].

Savonius turbine wind turbine is used with the magnetic levitation for reducing the friction between the rotor and stator. This turbine is worked at the low wind speed. This turbine gives the maximum power than any other wind mill. We are created the design of Savonius turbine with levitation.

1.1 Savonius turbine

The Savonius wind turbine was invited by Finnish Engineer Sigurd Johnson Savonius in 1922.The Savonius turbine is one of the simplest turbines. Aerodynamically, it is a drag-type device, consisting of two or three scoops. When we look from top side it will be appeared as the "S" shape cross section. The drag force turns the Savonius wind turbine. It has the maximum torque at the starting.

The horizontal axis wind turbine will not be used at household applications. It is difficult to construct. Savonius turbine is the best option for household power generation in the load shading region.[2] This constructed also on the roof floor.

2. THEORY AND DESIGN

Power of Wind Turbine

Wind energy is attacked on the blade area with the mass of air flow with kinetic energy. The wind power is defined as the multiplication of mass flow rate and kinetic energy per unit mass.[3] The wind power is given by,

$$P_w = \frac{1}{2} \times \mathrm{m}V^2 \quad Watt$$

Where, $m = \rho AV$ mass flow rate kg/s

V= velocity of wind

$$P_w = \frac{1}{2} \times \rho \times A \times V^3$$

Where, ρ= Density of air, 1.25 kg/m³

A= swept area of blade, (D*H)

D= Diameter of Rotor

H= Height of rotor

Therefore,

$$P_w = \frac{1}{2} \times \rho \times D \times H \times V^3 \quad Watt$$

The wind power increases as, the function of the cube of the velocity of the wind.

Power of turbine is not totally observed from the coefficient of power to calculate the power of turbine. By Belt'z theory the maximum coefficient of power is 0.59 and for Savonius Turbine is maximum 0.18

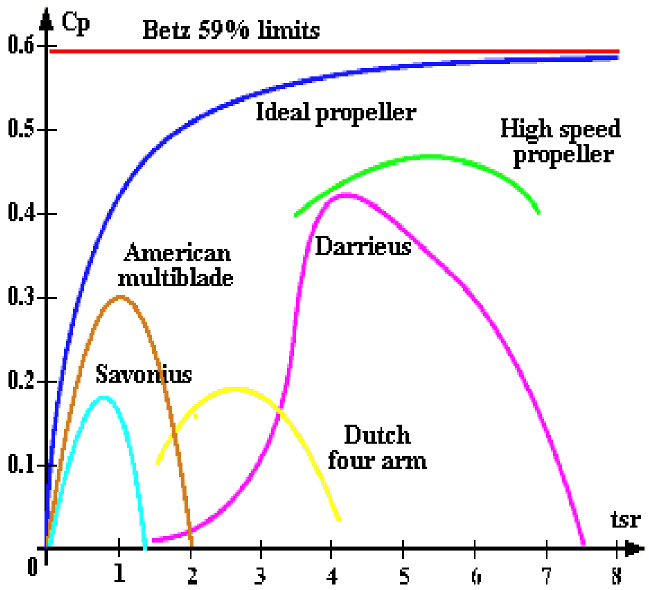

Fig01: C_p - λ Diagram for Different type of wind Turbine.[4]

Coefficient of power

Coefficient of power is the ratio of mechanical power developed by the turbine to power of wind.

$$C_p = \frac{P_T}{P_W}$$

Power of Turbine

From this coefficient of power, we calculated the power of wind turbine,

$$P_T = \frac{1}{2} \times \rho \times D \times H \times V^3 \times C_p \quad Watt$$

Aspect Ratio

Aspect ratio is the most important term to calculate the aerodynamic performance of Savonius rotor. The optimum aspect ratio for Savonius Turbine is 2.[5]

$$A.R. = \frac{H}{D}$$

Tip speed Ratio

It is defined as the, it is ratio of tangential speed of tip of blade to the untouched wind velocity. It is denoted by λ. T.S.R improves the performance of Savonius wind turbine and expanding the rotational rate of rotor.[6]

It has expressed,

$$\lambda = \frac{\omega R}{V}$$

Where, ω= Angular velocity of turbine.

R= Radius of Rotor

Overlap Ratio:

Overlap ratio is the ratio between overlap length and the length of the cord of blade. The overlap ratio improves the performance of turbine. This is increase the drag force. It is gives optimum performance for the value of 20-25%.[7]

$$\beta = \frac{e}{d}$$

Where, e= overlap distance

d = Diameter of one blade

Solidity

It is the ratio of blade area to the turbine rotor swept area. It is related to tip speed ratio.

$$\sigma = \frac{n \times d}{R}$$

Where, n= No. of Blade

d= Chord length (Diameter of each cylinder)

R= radius of wind turbine

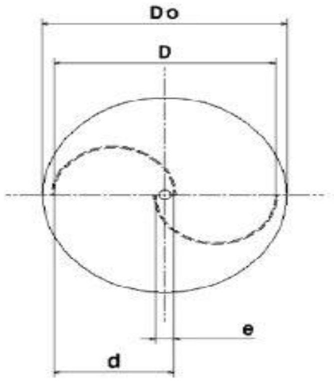

Fig02: Design Model for Savonius Rotor Blade

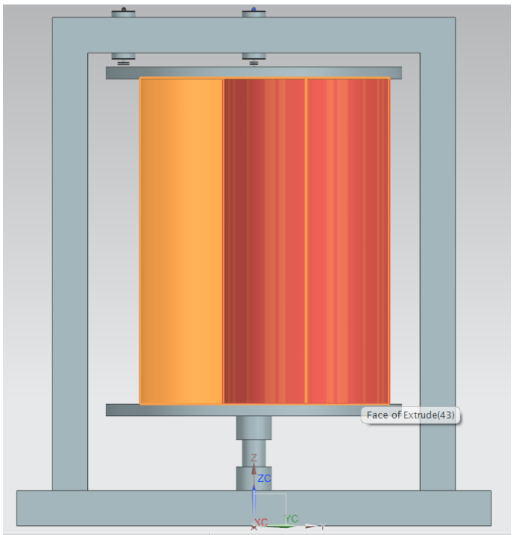

Fig03: Savonius Model

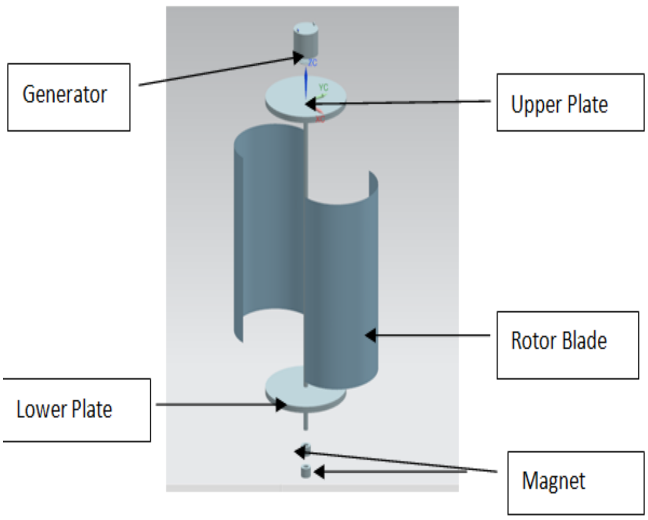

Fig 03: Assembly of Savonius Rotor at PG

Table I: Shows design parameter in this Paper

Parameter	Value
Power Generated	4.94 Watt
Swept Area	0.18 m^2
Rated Wind Speed	6.25 m/s
Aspect Ratio	2
Solidity	2.24
Rotor Diameter	300 mm
Rotor Height	600 mm
Chord Length	168 mm
Overlap Ratio	0.24
Blade Thickness	1 mm
Numbers Of Blade	2

3. MATERIAL OF WIND TURBINE

A wide range of materials available for used the blade of turbine. These materials are categorized with the application with the configuration of material characteristic.

In Savonius turbine major part of material to be used for the blade, because of the large area of blade is used in this turbine. The material of blade is selected on the basis of its weight, strength and corrosive resistant. For the blade material steel, copper, brass aluminum are the major option available, but from this group of metals, the aluminum has the low weight, therefore we select Aluminum metal for turbine blade [8].

Aluminum has the low specific weight other than above metal; therefore it is light in weight. It is the highly corrosive resistant property as well it is good reflector of visible light, heat that with low weight. Aluminum is the strong with a tensile strength of 70 to 700 MPa depending upon the alloy and manufacturing process.

Table II: Properties of Aluminum

Parameter	Value
Density	2712.00 kg/m^3
Thermal Conductivity	0.18 KW/ m °C
Specific Heat	920.00 J/ kg °C
Modulus of Elasticity	68947.57 MPa
Poisson's Ratio	0.330
Yield Strength	275.790 MPa
Ultimate Strength	310.264 MPa

4. GENERATOR

Generator has the basic function as the convert the mechanical energy into electrical energy. Generator is worked on the basis of Faraday's law of electromagnet induction. It states that, when the electricity is passed to the conductor then it produce magnetic field. In the Generator this principle are used in the opposite way. When armature is rotated in the magnetic field, then electromotive force are produce in the armature which produce current in it.

The magnets are set as opposite pole to each other with the air gap in the generator. The air gap present between magnet pole and the armature. The armature coupled with the turbine shaft. Magnetic flux lines are passes perpendicular to the axis of shaft. When the shaft is rotated, the magnetic flux lines are cut off. When the cut off this magnetic flux line, the emf are produce in the generator.

Faraday's law of electromagnet induction states that, the induced electromotive force equal to the change in magnetic flux over the change in time.

$$emf = \frac{Nd\emptyset}{dt} \quad volt$$

5. MAGNETIC LEVITATION

Magnetic Levitation accrued when the two similar pole are repelled without each other. Anybody will be suspended with any other support with this repulsion. This magnetic force is opposed to the gravitational force. The magnetic levitation is reducing friction between shaft and stator assembly. This replaces the bearing between the shaft and stator body.[9]

The vertical axis wind turbine as Savonius turbine shaft is fully supported with the magnetic levitation and rotor vertically with the wind. Magnetic Levitation are performed with the used of permanent magnet as like Alnico, Ceramic, Samarium Cobalt and Neodymium Iron Boron. Ne-Fe-B is the strongest magnet than any other above magnet. Ne-Fe-B has the attractive magnetic characteristic, which offers high flux density operation and the ability to resist demagnetization[10].

The ring shaped permanent magnets are used for the levitation. The shaft introduced in it and the like poles are faced to each other. The shaft is used which has non-magnetic property. The magnet has used which has configuration N52 with size inside diameter 20 mm, outside diameter 40 mm and thickness is 10 mm. This is suspended the Savonius blade with shaft.[10]

The force between this two like magnetic pole are to be calculated as,

$$F = \frac{\mu q_{m_1} q_{m_2}}{4\pi r^2}$$

Where, q_{m1} & q_{m2}= magnitudes of magnetic poles (Amp- mtr)
μ= permeability of intermediate medium as air, $4\pi*10^{-7}$ N/A^{-7}
r= Distance between two magnetic pole.

6. ADVANTAGES

Biggest advantage is that, it will free from consumable power sources of electricity. This windmill is run at low speed.
It is independent from yaw mechanism which is used for rotate the blade against the direction of wind flow.
It is simple in construction and maintenance is easy.
It is increase the generation of power than conventional wind mill.

7. RESULT AND DISCUSSION

Result of this paper investigates the components that add to the design. Rotor blade is designed by utilizing the Unigraphics 9.0. In this paper average wind speed is considered as 6.25 m/s. This turbine rotated in low wind speed. The output power for this paper with including parameter obtains as 4.94 watt.

3. CONCLUSIONS

The Savonius wind turbine with magnetic levitation is the successful model for electricity generation. The Savonius wind turbine give better performance with the magnetic levitation. The rotor base plate take as the higher mass than upper plate for providing better stability. The wind mill turbine rotates smoothly with the use of magnetic levitation with permanent magnet. This the best model for house hold applications.

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BIOGRAPHIES

Mr. Ashik K. Gaoture
Student Of Bachelor of engineering, Department of Mechanical Engineering, Abha Gaikwad-Patil College Of Engineering, Nagpur

Mr. Shubham S. Deoke
Student Of Bachelor of engineering, Department of Mechanical Engineering, Abha Gaikwad-Patil College Of Engineering, Nagpur

Miss. Trishala V. Kokate
Student Of Bachelor of engineering, Department of Mechanical Engineering, Abha Gaikwad-Patil College Of Engineering, Nagpur

Prof. Ajay Mahawadiwar
Head Of Department, Mechanical Engineering, Abha Gaikwad-Patil College Of Engineering, Nagpur