Abstract
The performances of a VAWM with Savonius rotor under low and unsteady wind speed is investigated in this paper. One of the classical applications of wind energy is water pumping. Water pumping windmill pumps water from bore well, ponds etc. used for drinking and domestic purpose. Vertical axis wind mills are more suited in urban areas due to their low noise level.

1. Introduction
In the development of any economy, use of natural resources is very important. In India only 10% wind energy of total natural resources energy is used to produce power.
Various types (horizontal & vertical axis) of Windmills are used for same purpose. Generally, in the past horizontal axis wind mills were used. But due to less height, less available space creates obstacles due to buildings and trees; these are replaced by Vertical Axis Wind Mills. To implement a wind mill, careful and extensive investigation is required since different environments or geographical locations call for different wind speed. Taking into consideration the geographical attributes of our region, the Vertical Axis Wind Mill will be efficient for Pumping the Water. The
performance of VAWM is under low & unsteady wind speed is investigated, analyzed & modeled in this paper.

A wind mill is a rotary device that extracts energy from the wind. The wind mill converts kinetic energy from the wind, also called wind energy, into mechanical energy. If the mechanical energy is used to pump the water, the device may be called water pumping wind mill.

A two bladed Savonius rotor is used in wind mills. It has wide significance due to its ability to capture wind energy from any direction & it can operate at low wind speed also. It also called S-rotor, was originally invented and patented by Finnish Engineer Sigurd J. Savonius in 1931. The concept of Savonius rotor is based on the principle of Flatter rotor, which is formed by cutting a cylinder into two halves along the central axis and then bending it into the two semi-cylindrical surfaces sideways along the cutting axis to resemble the letter `S`. Although Savonius rotor has less efficiency in the range of 15% to 21%, it is widely used due to its advantages including Self-starting, Omni-directional, less noisy & most important suitable for pumping water, grinding grains, sailing etc. Savonius calculated a maximum power coefficient (Cp) of 0.31. And the highest measured efficiency was 24%. Between Sixties, many researchers [3-16] had investigated experimentally the performances of different designs of Savonius rotor and obtained their Cp in the range of 0.15-0.38.

Water pumping is done by Centrifugal pump. The centrifugal pump is generally the most economical followed by rotary and reciprocating pumps. Although, positive displacement pumps are generally more efficient than centrifugal pumps, the benefit of higher efficiency tends to be offset by increased maintenance costs.

2. Material And Methodology

Material used - Acrylic plastic  
Density (ρ) - 1200 kg/m³  
Thickness of blade - 1 mm

Savonius rotor efficiency is 60%  
\[ C_p = 0.3 \]  
For Power \( P = 75 \text{ watt} \)  
\[ P = C_p \frac{1}{2} \rho A V^3 \]  
T.S.R= 1 \((C_p=0.3)\)  
Density of air = 1.2 kg/m³ at 300 K  
Velocity of air = 10 m/s  
\[ P = C_p \frac{1}{2} \rho A V^3 \]  
75 = 0.3 \( \frac{1}{2} \) 1.2 x A x 10³  
\[ A = 0.4166m^2 \]  
Aspect Ratio = \( \frac{H}{D} \) = 2  
Area= H x D  
A = H x \( \frac{1}{2} \)H  
H²= 2A  
H= 0.9128 m  
D = 0.456m  
d = 0.22m  
r = 0.11m
Circumference = $2 \pi r$
= $2 \pi \times 115$
= 722 mm

T.S.R = $\frac{v_{rotor}}{v_{wind}}$
= $\frac{\omega d}{v}$

$N = \frac{2 \pi N}{60} \times \frac{d}{v}$

Torque = $\frac{P}{60}$
= $\frac{P}{2 \pi N}$

$T = 3.30$ N.m.

3. Parameters Of VAWM

<table>
<thead>
<tr>
<th>Numbers of blade</th>
<th>Two</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material of Blade</td>
<td>Acrylic plastic</td>
</tr>
<tr>
<td>Diameter of Wind Rotor</td>
<td>460 mm</td>
</tr>
<tr>
<td>Wind Speed</td>
<td>10 m/s</td>
</tr>
<tr>
<td>Wind Rotor Height</td>
<td>900 mm</td>
</tr>
<tr>
<td>Max output Power</td>
<td>75 watt</td>
</tr>
<tr>
<td>Swept Area</td>
<td>1.50 mm²</td>
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<tr>
<td>Aspect Ratio</td>
<td>2</td>
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<tr>
<td>T.S.R.</td>
<td>1</td>
</tr>
<tr>
<td>Blade Thickness</td>
<td>1 mm</td>
</tr>
</tbody>
</table>

4. Block Diagram

Figure 1: Block Diagram
Description of Block Diagram:

The block diagram consists of Frame, Blades of VAWM, Main shaft, Bevel Gear and Output shaft, on which the pump is mounted for water pumping.

- **Frame**: Frame is made from hollow rectangular channels. In which blades of vertical axis windmill are mounted and the main shaft is attached to the frame with two bearings for the proper operation.
- **Blade**: Blades of the vertical axis windmill are made up of Acrylic plastic of 1 mm thickness. Blades are light in weight. Diameter of blade is 460mm and height of rotor is 900mm.
- **Main Shaft**: Blades of VAWM are mounted on the main shaft. The motion of the blade is transferred to the output shaft for the pumping system.
- **Bevel Gear**: To transfer the vertical motion into the horizontal motion, bevel gear is used. Another end of the shaft bevel pinion is connected.
- **Output Shaft**: On this output shaft, the pumping system is attached for water lifting purpose.

5. Conclusion

The electrical connectivity of rural India is not very good and also distribution losses are significant. An effort has been made to pump the water by hand pump and by other instruments. As air is easily available, in maximum quantity can be used for pumping the water. No electricity is needed & maintenance cost is low.

References

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