Studies on the Design of a Wind Turbine with Vertical Axis and with a Helical Rotor Shape

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Abstract: - The paper presents a new wind turbine type with vertical axis and a helical rotor shape. The tests that was made with this type of wind turbine conducted in experimental conditions, has demonstrated outstanding qualities of performance and energy even in low wind speeds.

Key-Words: - renewable energy, wind turbine, vertical axis.

1 Introduction

The ever increasing global demand for electricity and the effect the generation of such has on the ecosystem, in concert with the lack of natural resources to keep up with growing demand has provided new impetus to look toward the development of alternative and renewable energy sources.

The policy objectives of research on sustainable energy systems (energy efficiency with new and renewable energy sources) include increasing the security of energy supplies, reducing greenhouse gases and pollutant emissions (Kyoto), as well as enhancing the competitiveness of European industry and improving quality of life both within the EU and globally by improving energy efficiency and increasing the use of renewable energy.

The environmental pollution, greenhouses effect, intensification due to the wide-ranging of organic fuel, as well as care of energy supply to the future generations caused the accelerator development of technologies oriented to the realization of renewable energy sources (RES).

Environmental concerns are growing, interest in environmental issues is increasing and the idea of generating electricity with less pollution is becoming more and more attractive.

Wind power is today the fastest growing electricity generation technology. Impressive annual growth rates of more than 35% between 1996 and 2001 have made Europe into the frontrunner in wind energy technology development. During the last years, annual installations of wind power in the EU have been increasing at an average rate of almost 40 %. The European Commission’s “White Paper for a Community Strategy” sets out a strategy to double the share of renewable energies in gross domestic energy consumption in the European Union by 2010 from the present 6 % to 12 %) [2].

All around the world there is a number of small isolated communities, like island and rural villages without access to a large electricity grid. Further, in many places, due to remoteness and cost, it is unlikely that a main grid connection will be established, as telecommunications stations, inquiring centers, etc. As it has been proved by a lot of researches and energy engineers, it will be a very positive and economic solution the replacement of bigger part of diesel generators with stand alone HES, especially in medium and high wind and solar potential locations. Power systems which can generate and supply electricity to such remote locations are variously termed “remote decentralized, autonomous, or stand alone”.

2 Wind turbine with vertical axis and helical rotor shape

Vertical axis wind turbines have the inherent advantages of stability due to gyroscopic action of the rotor, simplicity of design due to the avoidance of yaw mechanism and blade controls, and strength of construction.

The support structure is an H beam structure, a lattice frame structure, a tripod shape which minimizes the wind blockage.

The blades are spun by the force of wind which in turn spins a generator to produce electricity. The blades are generally helical. Because of its vertical configuration, the blades are capable of operating
at lower and higher wind speeds. Moreover, vertical configuration allows the rotor to be placed closer to the ground, which allows for easier access and lower maintenance costs.

In addition, the blades face the wind from all directions. The blades begin rotation without a starter motor. Blade configurations are chosen to maximize blade efficiency by increasing wind harness and decreasing drag [3].

The generator can operate in wind speeds as low as 8 to 12 mph and as high as 35-75 mph. The ability to operate at lower and higher wind speeds allows the wind generator to produce energy more often and in a greater variety of locations because it can handle a greater range of wind speeds.

The present wind turbine has been designed to accommodate different methods of assembly, either in the factory, when practicable, or at the installation site when shipping and handling costs make this advisable.

In remote areas, out of connection with electric network, or if you are connected, but wants the production and direct sending the electric energy to the network can be used successfully wind turbine with vertical axis. The single rotor type helical with three blades fiber glass, made by the company in Romania FINEX is made into a new concept, revolutionary patented, characterized by the following advantages compared to classical turbines with horizontal axis:

- Simplicity in construction that offers a great robustness;
- High reliability;
- Price less 20% compared with what similar turbines;
- High specific power on the active surface;
- Ensures big start torques;
- It is self breaking at higher speeds of the wind of 20m / s, without mechanical components due to the original geometric construction of the rotor, and that was patented;
- No guidance is needed by the wind;
- The turbine can stand up to wind speeds of 50 m / s;
- Wind turbine is only accepted by environmental agencies, because they don’t kill birds in flight;
- Doesn’t make noise during its work;

Rotor was mathematically modeled and tested in experimental conditions on a car adapted as a mobile laboratory where they measure the following parameters:

- Wind speed in [m / s]
- axis turbine speed [rpm]
- generator power flow [W]
- air temperature [°C]

The main components of this wind turbine are: rotor, low-speed shaft, gear box where the low speed of the shaft is increased of eight times, coupling, electrical generator PMG – 1800, inverter, and power electronics. The rotor typically has three blades that number provides the best balance of high rotation speed, load balancing, and simplicity.

In Fig.2 is shown the graph of power that was obtained with this type of wind turbine at different wind speeds.

The chart above can be used to estimate the energy output in W units for a small wind turbine on a 10 meter mast.

However the wind speed at any site is highly dependent on local features which may cause shelter and turbulence.
To find the power of this wind turbine was used the next equation [2]:

\[ P = k \cdot A \cdot v^3 \]  \hspace{1cm} (1)

where:
- \( P \) – the output power [W];
- \( K \) – power coefficient;
- \( A \) – the rotor surface [m\(^2\)];
- \( V \) – wind speed [m/s];

After the tests the power coefficient \( k \) had the value of 0.28.
In Fig.3 is shown the graph of power variation according with the rotation speed of the turbine shaft.

Blade curvature is the amount of curvature of a given horizontal cross section of the blade. Blade curvature affects how much wind the blade takes in and pushes out. Generally, the more blade curvature emphasizes more wind intake. The more wind intake, the higher the rotational speed. More curvature is useful for lower wind speed conditions, and lower curvature is useful for higher wind speeds.

Wind swept volume is defined as the volume of air through the blades pass in their normal course of rotation. A vertical cross section of the wind swept volume would have an approximately trapezoidal shape [4].

The present wind turbine has been designed to accommodate different methods of assembly, either in the factory, when practicable, or at the installation site when shipping and handling costs make this advisable.

In Table 1 is shown the technical characteristics of the wind turbine with vertical axis.

<table>
<thead>
<tr>
<th>Power</th>
<th>2000 W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind speed</td>
<td>Cut-in speed: 2-3 m/s; Nominal wind speed: 12 m/s; Cut-out speed: 20 m/s.</td>
</tr>
<tr>
<td>Blade numbers</td>
<td>3 x 2</td>
</tr>
<tr>
<td>Rotor diameter</td>
<td>2.0 m</td>
</tr>
<tr>
<td>Rotor height</td>
<td>2.0 m</td>
</tr>
<tr>
<td>Current generator</td>
<td>GL – PMG 1800</td>
</tr>
<tr>
<td>Turbine weight</td>
<td>135 kg</td>
</tr>
</tbody>
</table>

Depending on the wind speed per year, Weibull distribution \( K \) according with the site of mounting, turbine height is possible to calculate approximately the output energy per day, month or
year. Also is possible to find the time of pay back of investment and the cost of energy obtained in $/kWh.

The major application for wind energy, in terms of potential for installed capacity, is the bulk power market.

Below are shown the inputs values and the results obtained after the tests with this wind turbine with vertical axis.

<table>
<thead>
<tr>
<th>Inputs:</th>
</tr>
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<tbody>
<tr>
<td>Average Wind (m/s) = 6</td>
</tr>
<tr>
<td>Weibull K = 2</td>
</tr>
<tr>
<td>Site Altitude (m) = 300</td>
</tr>
<tr>
<td>Wind Shear Exp. = 0.2</td>
</tr>
<tr>
<td>Anem. Height (m) = 10</td>
</tr>
<tr>
<td>Tower Height (m) = 19</td>
</tr>
<tr>
<td>Turbulence Factor = 0.0 %</td>
</tr>
<tr>
<td>Perf. Safety Margin = 0.0 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Results:</th>
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<tbody>
<tr>
<td>Hub Average Wind Speed (m/s) = 6.82</td>
</tr>
<tr>
<td>Air Density Factor = - 2.8 %</td>
</tr>
<tr>
<td>Average Output power (W) = 652</td>
</tr>
<tr>
<td>Daily Energy Output (kWh) = 15.7</td>
</tr>
<tr>
<td>Annual Energy output (kWh) = 5,712</td>
</tr>
<tr>
<td>Monthly Energy Output = 476</td>
</tr>
<tr>
<td>Percent Operating Time = 89.9 %</td>
</tr>
</tbody>
</table>

In Fig.5 is shown the energy obtained in kWh/year according with the average wind speed in the site of turbine mounting.

3 Conclusions

Depleting oil and gas reserves, combined with growing concerns of atmospheric pollution/degradation, have made the search for energy from renewable sources, such as solar and wind, inevitable.

After experimental tests have demonstrated the advantages of using this type of original wind turbine with vertical axis, compared to other completed and patented worldwide, and as a result of new tests conducted in laboratory conditions and aerodynamic tunnels to improve as much as these tools.

Once installed, wind energy enjoys the advantages of zero air, water and solid waste emissions. In addition, total fuel-cycle emissions, including emissions experienced during construction, fuel extraction (zero for wind) and operations, are very low in comparison to fossil fuel combustion and other types of generating technologies. These environmental advantages can help power companies meet environmental regulations and satisfy their customer's desire for clean power sources.

Wind energy may be uniquely positioned to add value in some instances, e.g., where coincidence of resource and load is high, or where the combination of economics and environmental impacts is the most favorable compared with the alternatives.

Wind turbines located in agricultural areas can enhance land values by boosting rents and prices, while leaving the majority of the land for continued agricultural use. Such values are highly dependent on specific utility systems and wind sites.

References:


