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HELICAL VERTICAL AXIS WIND TURBINE FOR HIGH POWER PRODUCTION

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***ABSTRACT*— This project describes about the wind power and its potential that can be harnessed in the future to meet the current energy demand. With detailed description of the wind turbine of the generators with the grid and the problems associated with it. The shape of the blades is changed to helical so that it can rotate continuously at any direction of wind. Hence the efficiency of the turbine is improved and also the stresses are minimized. Conclusions were made about the behaviour of the wind in urban location. Thereafter, the helix angle of the blade is changed and the best angle of operation is analyzed.**

Keywords— ***Energy demand, wind turbine, helical blade, helix angle.***

I. INTRODUCTION

Wind energy is a clean and inexhaustible energy source widely used as a working fluid for wind farms for centuries. However, its use as a means of electricity supply began modern era due to the rise of environmental concerns and fuel resources issues. The global demand for sustainable and renewable energy has created the necessity for research and the development of new technology. Hence, the wind energy has been the focus of the industry and has considerably grown its use but just in a large scale production. In recent years, significant increase of more efficient, larger and expensive horizontal axis wind turbines (HAWT) appeared to create onshore and offshore wind-turbine fields.

This study aims to produce electricity on a lower scale by using a small wind turbine in order to generate a house-hold electricity supply and build a cost-effective and accessible turbine for people who need an alternative option to cover their own electricity demand.

II. DESCRIPTION OF TURBINE SYSTEM

The maximum available *power* in the wind can be obtained if theoretically the wind speed after the rotor is reduced to zero

$$P_{max} = \tfrac{1}{2}\rho A V^3$$

Where, ρ is the air density, V is the wind speed and A is the area where the wind speed is reduced. In practice it is not possible to reduce the speed of the wind after the rotor to zero using a wind turbine, so a power coefficient Cp is added to the before mentioned theoretical equation [3]:

$$P_{max} = Cp\tfrac{1}{2}\rho A V^3$$

The performance coefficient, Cp is a function of tip-speed ratio (TSR) where

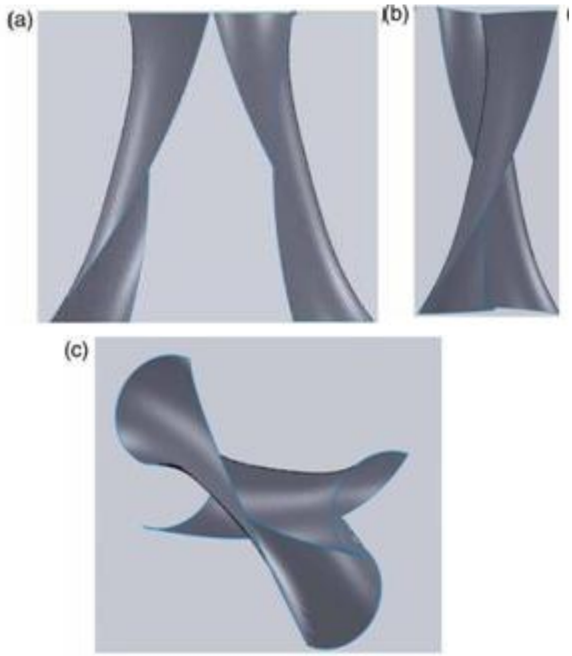
$$TSR = \frac{\omega_s R}{V}$$

R is the radius of the wind turbine rotor (m) and the TSR is used by wind turbine designers to properly match and optimize a blade set to a generator. Two blades having a blade radius of 100 mm, height of the blade is 2 feet and thickness of the sheet metal is 0.5mm . For the chosen turbine details with a wind speed of 9m/s, the estimated output power is 1000W with a speed of 440 rpm.

III. BLADE DESIGN

The design of blade was executed into a 3D sketch (Fig. 1-a). First, the sketch was divided into five parts, each part have a different twist angle from top to the base reaching 180°. The blade structure is based on semi-circles which give the diameter in each section (Fig. 1-b); such diameters change as are approximate to blade center. The structure is symmetrical from the center to the ends but with opposite direction. Once the structure was established, the blade surface was created by the lofted surface tool using splines to delineate the blade border (Fig. 1-c); the base has 0.4 m diameter and with 1 m height. The top and the base are 1 diameter separate each other respect the axis. The surface was elaborated with aluminum, a material that is light-weight, strong and easy work with.

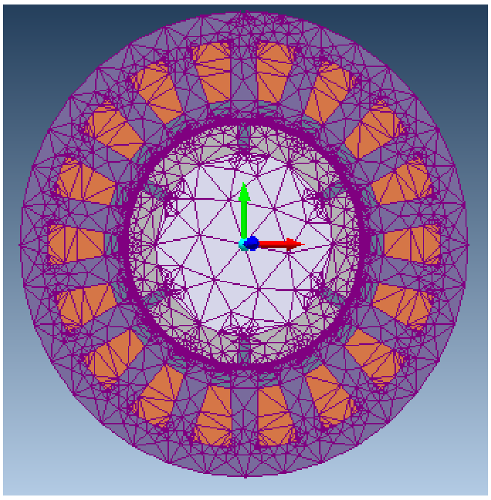
The turbine has two identical twist blades with a 180° torsion (Fig. 2-a). Both blades are placed facing away from each other to have 360° of sweep area (Fig. 2-b) to then be assembled on a 1.5 m steel shaft. The blades assemble was carried out by holding the ends of each blade on the shaft, base and top of each blade with the same extremes of the other but in opposite directions (Fig. 2-c) [4],[5].



(a).Twist blades (b).Blade assembly (c).second view of blade assembly

IV. GENERATOR

In permanent magnet based WECS the output voltage and current is proportional to electromagnetic torque and rotor speed. A diode rectifier with a dc link capacitor followed by inverter circuit is most widely used converter with Permanent Magnet based WECS as shown in the figure below. It has the benefit of being simple and there is no need of controlling at rectifier side. Advantages of this technology are that, it provides active and reactive power control and also increases power factor because of Pulse Width Modulation techniques. The mesh analysis view of permanent magnet generator is shown in figure.

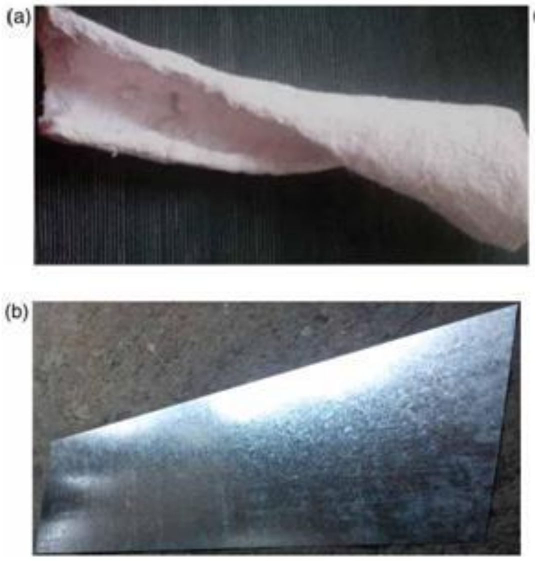


IV. MANUFACTURE

Based on the 3D sketches, a plaster mold for the blades was developed . The mold was used to cut sheets and make the blades. The original material considered was aluminum but the final blades were manufactured on galvanized steel gauge 18 to reduce costs.

When cutting the blades, both sheets were rolled to make twisting on the shaft easier. Then the blades were set on the shaft which has two arms where the extreme of each blade were introduced and welded . The other side of each blade was turned around the shaft and riveted on it giving it to the rotor the final twist.

Finally, the rotor was set on a tapered rolling bearing to reduce friction and bear high axial loads. The base was a 30 kg steel plaque in which the rotor was welded on a PTR structure to increase stability and reduce vibration.



(a).Plaster mold (b).Galvanized sheet steel

VI. EXPERIMENTATIONS AND RESULTS

The experimentation was realized in two centrifugal fans using a hot wire anemometer for the velocity flow mea-sure. The fans were installed one over the other in vertical position to cover all the rotor sweep area (Fig 5). To calculate the velocities profile, the air flow was measured along the pipeline diameter to assess the flow behavior and establish the rotor position.

The measurements of velocity test range from 5 m/s to 14 m/s and the turbine power curve was determined by obtaining the torque produced by the rotor in each velocity. The results shown at the Tab. 2 are for the 1 m^2 turbine. The 1500 kW/h per year are reached at the velocity of 10.2 m/s approximately, equivalent to 6.79 m/s in the 3.4 m^2 turbine. These results are similar at the analytical data shown before.

VII. CONCLUSION

A helical vertical axis wind turbine was built with the purpose of covering the electricity supply for a house-hold with an average consumption of approximately 1500 kW/h per year. The turbine was subjected under many tests to confirm its performance and operation ranges. After analyzing and comparing the results with the analytical data, it was determined that the helical wind turbine could be a viable alternative option for its use to generate cost-competitive energy. Wind power is a clean and inexhaustible source of renew-able energy, which has experienced dramatic growth in the last decade. Considering the featured benefits, such as the construction and maintenance costs, turbine size and operation requirements, this rotor mechanism could be a scalable solution, which has a significant expansion potential to address the current renewable energy demands.

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