Experimental Comparison of Savonius Wind Turbine, Extended Blade Wind Turbine and Helical Wind Turbine

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Abstract- *One of the particular fields of interest is the use of wind energy to generate electricity. But there are limitations in the process of harnessing this wind energy. But if the wind turbine has been utilized in cases where the air velocity is generated while performing some work, then there is a scope for harnessing this wind speed by wind turbine and converting it in energy which can then be further supplied to grid or utilized for certain applications. The idea is to design a wind turbine that can be installed between the sleepers on a track, and as the train passes overhead, the wind drives a turbine to generate electricity. This paper aims at studying three different wind turbine designs which can be efficient for the said purpose. It involves design and manufacturing of these turbines and experimentally verifying their performance. This project will essentially be a demonstration of the proof of concept for the selected design.*

Keywords- Renewable energy sources, Wind energy, Wind turbine, Blade profile

I. INTRODUCTION

In this modern age more and more energy is required for daily consumption in all walks of life. Sources and quantum of fossil energy are dwindling day by day and getting exhausted at a very fast rate. Hence conservation, tapping new sources of energy and harnessing of the same from the various non-conventional sources, is an important aspect of energy production/conservation and utilization all over the world. Wind energy is a clean and inexhaustible energy source widely used as a working fluid for wind farms for centuries. 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. Wind power devices are now used to produce Electricity, and are commonly termed wind turbines.

As anyone living near railway tracks will tell you, speeding trains generate quite a bit of wind as they whoosh past. The idea is to design a wind turbine that can be installed between the sleepers on a track, and as the train passes overhead, the wind drives a turbine to generate electricity [1]. This device could be placed along railway or subway lines, and make good use of an otherwise wasted resource. This wind turbine generator device is installed between railroad ties and buried half-underground so as to not interfere with normal train operation. But to harness the wind energy, a number of wind turbine designs exist. The type of wind turbine that should be used so that it can generate sufficient power is one concern that should be thought upon.

This study aims to investigate and analyse some of the prominent wind turbines. These wind turbines have to be proven to meet the power requirements in a wide variety of environmental conditions After considering the literature review of major wind turbine designs, it has been decided to design and fabricate Savonius wind turbine [2], Extended blade wind turbine as well as Helical wind turbine and to experimentally investigate their performances. The purpose of the present study is to investigate the performances of these three wind turbine designs and to compare their performance under the same test conditions.

II. DESIGN

The design and construction of the wind turbines was focused solely on turbine performance. Through modelling varying blade designs within Solid Works, the optimal blade profile was developed. The designs of the blades were executed into a sketch. The blade structure of the Savonius wind turbine and the Extended blade wind turbine is based on semi circles of 150 mm diameter which are along intervals of 180º [3]. The thickness of each blade is 3 mm. Once the sketch was prepared, it was extruded to the length of the blade which is 500 mm.

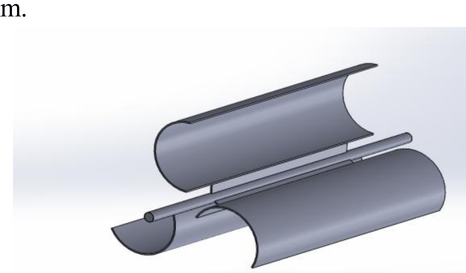

Figure 1. Savonius Wind Turbine

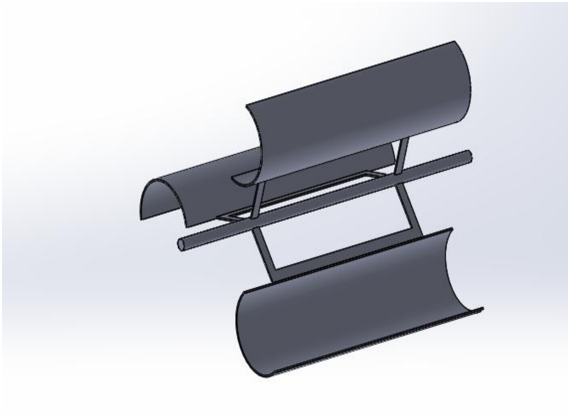

Figure 2. Extended Blade Wind Turbine

The Helical blade has been designed based on changing the angle of twist and blade shape. For the helical blade, the sketch was divided into five parts, each part having a different twist angle from top to the base reaching 180º along the length. The length of the helical blade is 500 mm longitudinally. The structure is symmetrical from the centre 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. The section of the helical blade is of width 100 mm and thickness 1mm. The turbine has three such helical blades having identical twist subtended at 180º from each other. The diameter of the shaft is 20 mm on which the blades would assemble. The blades, used for converting the power of the wind into torque on a rotating shaft, are uniquely designed to catch the wind from all directions, while the skewed leading edges reduce resistance to rotation [5].

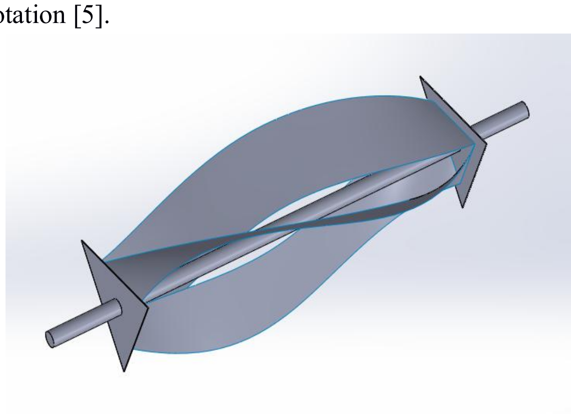

Figure 3. Helical Wind Turbine

III. MANUFACTURING

The physical models of the three turbines were fabricated in a workshop. The blades of the Savonius and Extended blade wind turbine were made from Poly Vinyl Chloride material. The semi-circular blades were then welded to a mild steel shaft. For the Extended blade turbine the semi - circular blades were extended radially away from the shaft by mild steel arms of length 100mm [4]. For the helical blades, metal strips were cut using a cutter. The length of the strips was taken as 520 mm to take into account the twisting in the lateral direction. The original material considered was aluminium but the final blades were manufactured on galvanized steel sheets 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 end plates where the extreme of each blade were introduced and welded. The other side of each blade was turned around the shaft and then welded on the other end plate giving the rotor the final twist. To increase stability and reduce vibrations, certain weights were welded along the length of the blades. Although these weights offered a little resistance to the flow of air, these provided better balancing and optimized performance of the turbine.

To mount the wind turbines, a frame was constructed. Pedestal bearings with inner diameter of 20 mm were bolted on each side of the frame structure. The wind turbine shaft was then assembled on the bearings. The frame was designed such that it facilitated easy removal and swapping of the three blade designs for testing purposes .

IV. TESTING

Experiments were then conducted on the manufactured wind turbines. The following components were used for testing the performance of the turbines:

A. Air Blower

A variable speed electric air blower was used to generate winds for testing the three turbines.

B. Digital Tachometer

The digital tachometer was used to measure the rotation speed of a shaft while the turbine was rotating in revolutions per minute (RPM). This was a manual process and was done during all phases of testing and recorded for analysis

C. Handheld Anemometer

The anemometer was used to measure and record the wind speed adjacent to the turbine during testing. As the wind flowed past the anemometer, the wind speed was acquired using the handheld anemometer.

D. Alternator

The alternator converted the mechanical energy of the shaft into electrical energy.

E. Multimeter

The multimeter was use to indicate the voltage and current generated from the alternator.

Upon final installation of the blade and instrumentation, the experimentation was realized by running the blower against the wind turbines. The speed of the blower was varied to get different air velocities which were measured by the anemometer. The wind speeds were from 5 m/s to 15m/s. Data was then acquired throughout the testing phase to generate data that could be later analysed. The testing data involved acquiring power data from the multimeter, wind speeds from the anemometer and manual measurement of the rotational speed of the turbine shaft.

V. EXPERIMENTAL RESULTS

The results obtained are tabulated as follows

Table 1. Savonius wind turbine output

Wind velocity, m/s	Turbine speed, rpm	Power output, W	Power Output kW/hr.
5	26	2.40	0.0240
6	30	4.63	0.0463
7	35	7.34	0.0734
8	41	9.95	0.0995
9	46	14.96	0.1496
10	53	19.44	0.1944
11	64	27.60	0.2760
12	76	39.12	0.3912
13	96	49.70	0.4970
14	115	61.36	0.6136
15	120	75.63	0.7563

Table 2. Extended blade wind turbine output

Wind velocity, m/s	Turbine speed, rpm	Power output, W	Power Output kW/hr.
5	40	3.42	0.0342
6	49	6.98	0.0698
7	58	11.76	0.1176
8	70	17.56	0.1756
9	81	21.3	0.213
10	94	33.2	0.332
11	114	41.6	0.416
12	128	53.10	0.5310
13	143	70.35	0.7035
14	163	82.00	0.82
15	178	98.3	0.983

Table 3. Helical wind turbine output

Wind velocity, m/s	Turbine speed, rpm	Power output, W	Power Output kW/hr.
5	43	7.33	0.0733
6	56	13.40	0.134
7	76	19.21	0.1921
8	98	25.23	0.2523
9	128	39.23	0.392
10	156	49.40	0.4940
11	173	62.24	0.6224
12	201	79.80	0.7980
13	215	89.34	0.8934
14	235	103.65	1.0365
15	256	115.20	1.1520

VI. DISCUSSION

The experiment's procedure was carried out and tested and the required measurements were obtained to study the performance of the Savonius wind turbine, Extended blade wind turbine and Helical wind turbine and make the comparison between them to see which one is better in performance than the other. It is seen that the Savonius wind turbine develops the lowest wind power among the three turbines for the same speed. The Helical wind turbine seemed the most efficient as it developed good power even at moderate wind speeds. Power outputs ranged from 7.33 watts (at 5 m/s) to 115.20 watts (at 15m/s). The maximum power output for this design is relatively good based on the size of the tested model. The three blade designs enabled a self-start under no load at a wind speed as low as 5m/s. The starting wind speed may, in fact, be lower but this could not be measured as the minimum wind speed available by the blower was only 5m/s.

VII. CONCLUSION

The purpose of the current study was to compare the three types of turbines i.e., Savonius turbine, Extended blade turbine and helical turbine. These turbines are comparatively easy to build and the investment is also well affordable. After analysing and comparing the results, it was determined that the helical wind turbine could be a viable alternative option for its use to generate cost-competitive energy. 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. The noise it produces is very low compared to common wind turbines, especially the other two turbines. The results of this experiment met all established performance goals. The turbine also proved to be self-starting under low wind speeds. The data from testing allowed for some general conclusions and provided insight into areas for future improvement. The maximum measured power output from the blade was just over 12W. Additional testing would be required to make a definitive conclusion

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