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Experimentation on Design and Development of Mini Wind Turbine

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Abstract*: Wind energy systems are energized by the naturally flowing wind, therefore it can be considered as a fresh source of energy. In addition, the wind energy is accessible as a domestic source of power in many countries worldwide and not bound to just a couple of nations, as on account of oil. However, the output of a wind turbine relies on upon the turbine's size and the wind's speed through the rotor. The amount of power created by the horizontal axis wind turbine is proportional to rotor area and power of wind velocity. In present paper the experimental and analytical study with finite element analysis has been carried out with considering dependent factors like wind speed, number of blades, size of blades to evaluate maximum output power. It is observed that, the eight numbers of blades with 1200mm diameter is more effective in terms of power output.

Keywords: Wind energy; Wind velocity; Finite element analysis; Wind turbine.

I. INTRODUCTION

Wind available in the nature is not uniform throughout the year. It is not uniform even during a day time and nor does it always blow when power is required. Thus, supply of energy from conventional wind turbines provides intermittent energy to the grid circuit which causes fluctuations in energy flow. Even mini wind turbine systems with battery backup give uneven intermittent supply due to fluctuation of wind velocity. However, traffic of vehicles on highways gives cyclic blow of wind constantly. The idea of capturing energy from such blown wind emerged when a researcher observed bowing of bushes and climbers at the sideways of highway, while passing of the heavy vehicles like buses and trucks.

The detailed study of behavior of small wind turbine at slow speed has been carried out by Write et al. (2004). However, this study was limited to find different starting conditions of small wind turbine and minimum speed required to start the turbine. The wind power generator developed by Bilgen and Crinion (2003) were useful for wind power generating system for electricity from wind created by moving vehicles. In this generator the generating assembly is operationally coupled to a substation whereby electricity formed by the generating assembly is shifted to the substation for distribution. Wagh et al. (2012) explained the design of small wind turbine, which completes the requirements of a single family. According to investigator, in India the average per capita electricity utilization for domestic utilities is from 1- 1.5kW, which means a small wind mill of 1 kW power, is logically enough to cope up with every day requirement of a family. In addition, the power curves obtained by testing wind machine methods illustrate improved performance over market similar capacity wind machines. Aerodynamic performance of three-bladed small horizontal axis wind turbine (HAWT) with rotor of 2.2m in diameter was investigated [1] At low wind speeds ranges from 5 m/s < U < 9 m/s, the BEM power prediction enhances to a maximum error of appr.17% for U =6 m/s whereas high wind speed U > 9 m/s expected the appox.45% error in the measured power output. The normal wind speed of 7.5 m/s then 616 W and 76 Hz power produced by the alternator [2]. The 20 percent increase in power is observed when wind speed is more than 10m/s[3]. Performance was investigated using the computational fluid dynamics (CFD). A model for electricity generation by fast moving vehicle studied by Wankhede and Khedkar (2016) for voltage generation [4]. The maximum voltage generated 10.8 volts at the speed of 90 km/hr.

Kulkarni and Birajdar (2010) carried out study on vertical axis wind turbine for highway application [5]. The efficiency was checked by changing size and shape of blades. This study concludes, the power generated is 28W at the wind speed of 6.1 m/s. On the same ground Mashyal et al. (2012) performed design and analysis of highway windmill electric generation [6]. This study recommended that, if the average speed of 70 km/hr for 100 vehicles at the average wind speed of 4.5 m/s for 2 hours then electric power generated 200W approximately. The idea of small wind turbine with diameter 800mm inside the concrete blocks set in both sides as a center or sides in the highways and to create the power by passing the vehicles in the roadway [7]. This concept does not require large area like nuclear or different types of power plant, it is feasible to be built in any highway around the globe and produce electricity. The wind speed approaches at turbine are directly proportional to square root of vehicle mass and velocity of the vehicle [8]. Malave and Bhosale (2013) suggested that, the wind is produced both sides of the highway by the vehicles [9]. Therefore, the wind turbine is placed middle in the highway to generate the major electricity and to supply the power for streetlight. Chandramouli et al. 2014 proposed the concept of hybrid based automatic highway lighting system with day/night sensor [10]. It was observed that, constructing hybrid solar wind system for the production of maximum

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energy and this energy is saved in a 12volts rechargeable battery. The wind can flow from both the direction using divider hence, higher force can be achieved in the center than the side of the street. Vehicle Mounted Wind Turbine (VMWT) possesses more smart features counting better rpm and torque compared to conventional mounted wind turbines. In addition, VMWT are found to be light weight, small size, convenient and portable design [11]. All in all, the extensive research has been carried out for generating power from mini wind turbine for highway. This method implemented properly then need not depend upon any other country for electricity whereas energy can produce, transform and transport by itself [12]. However, the parameters like diameter of blade, shapes of blade and number of blades are found to be ignored. Hence, attempt has been made to propose appropriate diameter of blade and number of blades for more output power with the help of experimental study.

II. EXPERIMENTAL STUDY

The selection material is one of the critical assignment for experimentation purpose. For the selection of material, the parameters like availability of material, cost of material and property of material must be considered.

A. *Selection of Material*

Wind vitality is caught by the revolution of the rotor blade. For the most rotors have verifiably been made of wood, but since of their affectability to dampness and handling costs current materials, for example, Glass Fiber Reinforced Plastic (GFRP), Carbon Fiber Reinforced Plastic (CFRP), steel and aluminum are supplanting the conventional wooden units. Aluminum can be extremely disfigured without disappointment. This enables aluminum to be shaped by rolling, expelling, drawing, machining and other mechanical process. It can likewise be thrown for high resistance. Aluminum is a brilliant white metal with a thickness around three times than steel. Aluminum was just executed in testing circumstances in light of the fact that later it was found to have a lower exhaustion level than steel. Aluminum is malleable and great warmth conductor. Aluminum is a low value metal however it has great unwavering quality and has a low rigidity. Aluminum is lightweight, yet weaker and less solid than steel. So, Aluminum sheet is chosen as blade material for examination. The experimental study was carried out with variation of diameter of blades and number of blades. The diameter of bladed are varied as 450mm, 900mm and 1200mm whereas number of blades are varied as 4, 5 and 8. Figure 1 shows number of blades considered for the study.

B. *Generator details*

The generator used is a 3-phase permanent magnet directly coupled with low voltage-low RPM type generator. It is designed and manufactured by Tachometric Controls, Pune for an output power of 20 watts and is manufactured primarily for applications like wind application, other low voltage and battery operated applications. Table 1 presented details of generator.

Table 1 Details of the Generator

Sr. No	Model No (Mounting)	Weight (Kg)	Power (watt)	Rated Speed (RPM)	Output Volt AC (3Phase) or DC (Rectified)
1	Model 36 F-3	4.1	70	0-500	28 V, DC

After manufacturing blades and supporting structure, the generator and blades are directly coupled and mounted on supporting structure as shown in Fig. 2. The structure has the facility to adjust height.

a. Four Blades

b. Five Blades

c. Eight Blades

Fig. 1 Number of blades considered for study

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Fig. 2 Assembled model

For the preliminary study, in house testing was carried out. Wind speed regulated from 0 to 10 m/s and loading done with the help of 12V/20W bulb which is shown in Fig.3. The figure clearly shows lightning of 20w bulb at 10m/s wind speed.

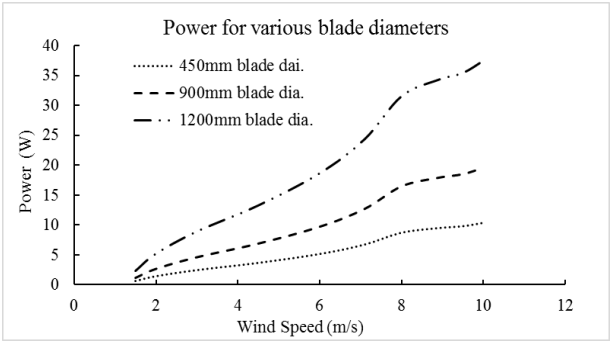
Fig. 3 In house testing

The results of in house testing are presented in Table 2. It is found that, as the wind speed increases the voltage, power and current increases. As the matter of fact, the increases in wind speed cause increase in RPM. Hence, it can be concluded that, to get more power the wind speed should be more as observed in experimental study. In addition, the difference in current, voltage and torque is decreases as the wind speed increases.

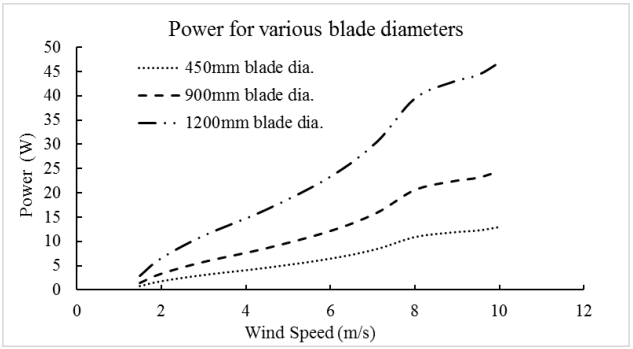
Table 2 Results of in house testing for 450mm blade diameter

Sr. No	Wind speed (m/s)	RPM	Voltage (Volts)	Current (Amps.)	Power (Watt)	Torque (Nm)
1	1.5	60	5	0.25	1.25	0.20
2	2	80	7	0.40	2.80	0.33
3	3	110	10	0.48	4.80	0.42
4	4.5	155	13	0.55	7.15	0.44
5	6	200	15	0.67	10.05	0.48
6	7.1	250	17.5	0.75	13.13	0.50
7	8.0	300	20	0.85	17.00	0.54
8	8.9	325	21	0.88	18.48	0.54
9	9.5	380	24	0.93	19.1	0.54
10	10	420	25	0.95	20.2	0.54

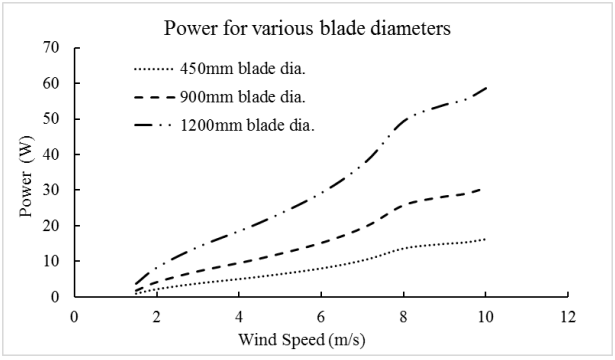
The main aim of this study is to suggest the diameter of blade which will produce more power with same wind speed. Hence, the variation in diameter were considered to observe power generated with variation of wind speed. Figure 4 shows power generated with various blade diameter against the wind speed. It is observed that, as the diameter of blade increases the generated output power increases for same wind speed. The 1200mm diameter of blade is found to be more efficient for lightning the 60w bulb in house. In addition, variation of number of blades were studied for power generation. It is also seen that, as the number of blades increases the power generated increases. This means, eight number of blades are significant to generate more power than three, four and five blades. However, with the three, four and five blades the power can be generated to lightning the bulb of 40W with wind speed of 10m/s. Whereas, five and eight number of blades are sufficient for lightning 60W bulb when wind speed is maintained at 10m/s.



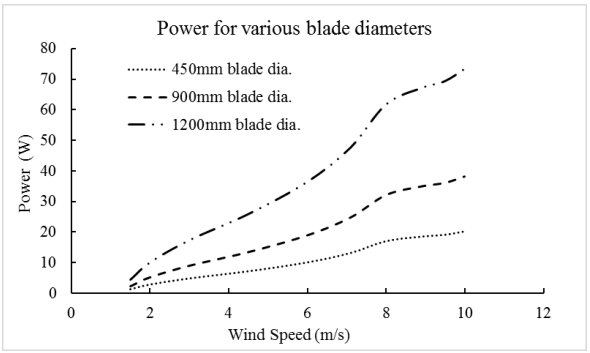
Three Blades



Four Blades



Five Blades



Eight Blades

Fig. 4 Power generated with variation of wind speed and blade diameter for in house

The in house testing is then carried out by varying distance of wind turbine and wind source. The results are tabulated as shown in Table 3.

Table 3 Variation of responses for various distance from source

Sr. No.	Distance from source (Feet)	Wind Speed (m/s)	RPM	Voltage (Volt)	Current (Amp)	Power (Watt)	Torque (Nm)
1	1	9.2	460	24	1.7	40.80	0.847
2	1.2	9	452	23.6	1.5	35.40	0.748
3	1.5	8.3	445	23.3	1.3	30.29	0.650
4	1.8	8.1	425	23	1.1	25.30	0.568
5	2	8	410	22.7	0.9	20.43	0.476
6	2.2	7.5	380	22.3	0.7	15.61	0.392
7	2.5	7.2	362	22	0.6	13.20	0.348
8	2.8	7	340	21.6	0.5	10.80	0.303
9	3.2	6.7	315	20	0.45	9.00	0.273
10	3.5	6.2	295	19.2	0.4	7.68	0.248
11	4	5.9	255	18.4	0.35	6.44	0.241
12	4.3	5.6	220	17.6	0.3	5.28	0.229

It is seen that, as the distance of wind turbine from source of wind increases the wind speed decreases resulted in decreases in power, voltage, current and torque. Therefore, to get more power the distance of source of wind and wind turbine should be kept as minimum as possible.

III. CONCLUSION

The experimental study was carried out for design and development of mini wind turbine. The variable parameters like diameter of blade and number of blades were considered. The main aim of this experimental study was to determine effective combination of blade diameter and number of blade for generation of more power form wind. The experimental study shows that, as the diameter of blade increases the power generated increases. Also, to get more output power eight blades with diameter of 1200mm is effective combination for more generation of power. In addition, power generated with this combination can be used to lightning of 60W bulb when it was used in house. The results clearly showed that, with five number of blades of 900mm blade diameter 40W power can be generated with a wind speed of 10m/s. However, with same wind speed the generate power can be increased up to 60W for eight number of blades of 1200mm diameter.

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He is assistant professor at Zeal college of engineering and research since 2011. He is having experience of almost more than 10 years of teaching. He has published more than five papers in national journals. In addition, he has registered two patents on his research work.

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