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Performance Analysis of Small Scale Wind Turbine at Various Angles of Attack With Different Velocities

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Abstract-For applications of an effective energy resource in future, the limitations of fossil fuels are clear and the security of alternate energy sources is an important subject. Among others, wind energy technologies have been developed and are about to play a major role on new energy field. It is observed even in many villages power cut off for entire night. Here an attempt is made to develop the cost economical and effective wind turbine which can fulfil the basic needs such as lightening of village houses. In the present work a small scale wind turbine with five blades coupled to PMMG motor is developed. Experimentation is conducted on turbine at various angles of attacks with different wind velocities and the results are tabulated. It is observed that maximum power is developed at 90^0 angle of attack and velocity of 6m/s. Lightening of 12V DC bulb 3watts is achieved with this work.

Keywords—wind turbine, permanent magnet motor generator(PMMG) (key words)

1. INTRODUCTION

Wind energy is one of the most abundant renewable energy resource on the earth and has been targeted for centuries. It's predicted that human beings have been using wind energy in their daily work from many decades. earlier wind energy was used to irrigation purposes .Wind was also used to grind grain and that's the reason why we still speak of "windmills", even though they are now hardly used for grinding grains [1]. The horizontal axis wind mills are a relatively newer invention than the vertical axis windmills. Though the first documentation of the horizontal axis windmills dates back to the 12th century, the theoretical descriptions regarding the driving power of horizontal axis devices, i.e. lift forces on the blades, was investigated only during the beginning of the 20th century. One of the most popular early horizontal axis wind turbine was the tower mills, shown in Figure 1, which existed in southern Europe. The first written evidence of such windmills dates back to the 13th century [1]. There were some other types of horizontal axis windmills which existed in different parts of the world (mainly in the Occident) during different periods of time: *Post windmill* (1100s), *Wipmolen Dutch* (1400s), *Dutch smock mill* (1500s), *Paltrock mill* (1600s) and *Gallery smock mill* (1700s). Brief description about these windmills can be found [1] . Large Scale Wind Turbines (LSWTs) have been extensively examined for decades but very few studies have been conducted on the small scale wind turbines (SSWTs) especially for the applications near ground level where wind speed is of order of few meters per second. This study provides the systematic effort towards design and development of SSWTs (rotor diameter<50 cm) targeted to operate at low wind speeds (<6 m/s).

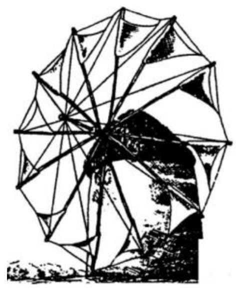

Figure: 1 Tower mills

2. OBJECTIVES AND METHODOLOGY

The following are the primary objectives of the present investigation,

- To develop effective Small Scale wind Turbine to operate at low wind speed.

- To generate the power to fulfill the basic lightening application.
- To investigate the performance of wind turbine at various angles of attacks with different velocities.

The following are the steps carried out in the present investigation

- Objectives of the problem are defined.
- Wind blades are developed by preparing die and by impression on steel with high impact.
- A suitable PMMG motor is selected based on the available wind potential.
- Experimental setup details such as instrumentation and experimental procedure is discussed
- Experiment is conducted on wind turbine at various angles of attacks with different velocities.
- Optimization and suitable conclusion from the present investigation is done

3. EXPERIMENTATION AND ANALYSIS

The major components of wind turbine and experimental set up of the present work are shown in the figure 2, Figure 3 and Figure 4. With the concept that power output of wind turbine is proportional to cube of wind velocity, higher the wind velocity increases the wind power by its cube.

A. blades

Blades are developed by preparing the die of the blade profile and then through impression by higher impactive force. The ends of blades are drilled with two holes of 3mm diameter for fastening to the hub. The length of blade is 20 cm.

Figure 2. wind blades

B. Hub

Hub is the centre portion of wind turbine provide with internal threads for fastening the blades and center circular hole for connecting to the shaft of PMMG motor. Once the blades are manufactured it will be fastened to hub by bolt system. Then the hub along with the blades is fixed to the rotating shaft of PMMG

Figure 3. Hub

C. Experimental Setup

The expermintal setup of the small scale wind turbine(SSWT) is shown in the figure 4. Blades are coupled to the hub through bolts provided at hub Fig 3. The hub along with blades is fastened to the PMMG using bolt of 2mm. the assembly will be supported by stand mounted on 12mm plywood.

Figure 4. Experimental Setup

4. RESULTS AND DISCUSSION

A. Power Calculations

Power Pa=V*I/Motor efficiency

For the trial with velocity 6 m/s from table 1,
V=2.66 volts, I=22.8 mAmps
Assuming the motor efficiency of 60%
Pa=2.66*22.8*0.001/0.60=0.101Watts

Table 1: Power Developed at 90^0 angle of attack for different wind velocities

sl. No.	Velocity v in m/s	Voltage V in Volts	Current I in milliamps	Actual power Pa in Watts
1	2	2.51	3.8	0.016
2	3	2.55	6.8	0.029
3	4	2.58	12.1	0.052
4	5	2.61	16.3	0.071
5	6	2.66	22.8	0.101

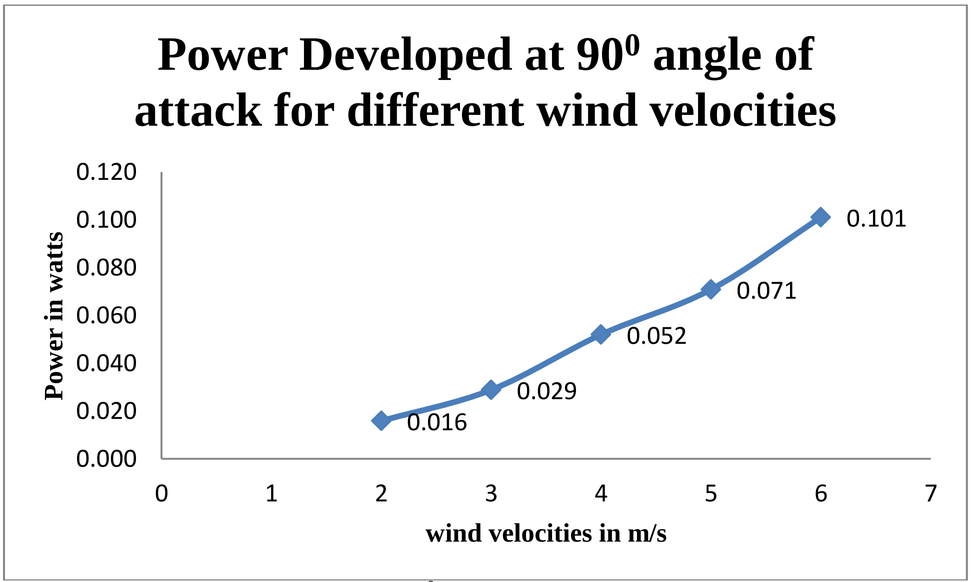

Figure 5. Power Developed at 90^0 angle of attack for different wind velocities

Table 2: Power Developed at 60^0 angle of attack for different wind velocities

sl. No.	Velocity v in m/s	Voltage V in Volts	Current I in milliamps	Actual power Pa in Watts
1	2	2.5	1.4	0.006
2	3	2.53	4.4	0.019
3	4	2.58	9.2	0.040
4	5	2.61	14.6	0.064
5	6	2.7	21.1	0.095

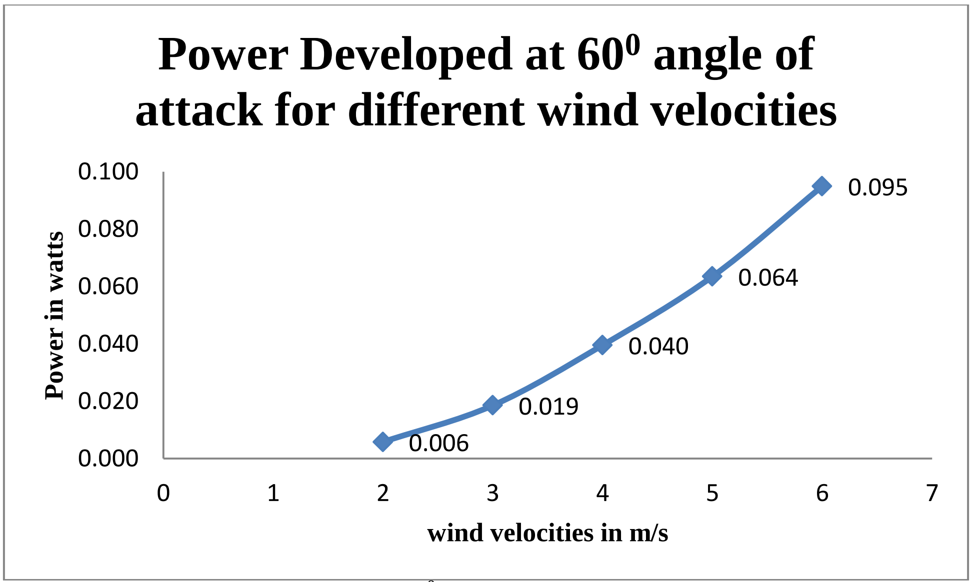

Figure 6. Power Developed at 60^0 angle of attack for different wind velocities

Table 3: Power Developed at 30^0 angle of attack for different wind velocities

sl. No.	Velocity v in m/s	Voltage V in Volts	Current I in milliamps	Actual power Pa in Watts
1	2	0.02	0	0.000
2	3	0.5	0	0.000
3	4	2.45	0.05	0.000
4	5	2.5	2.4	0.010
5	6	2.58	8.9	0.038

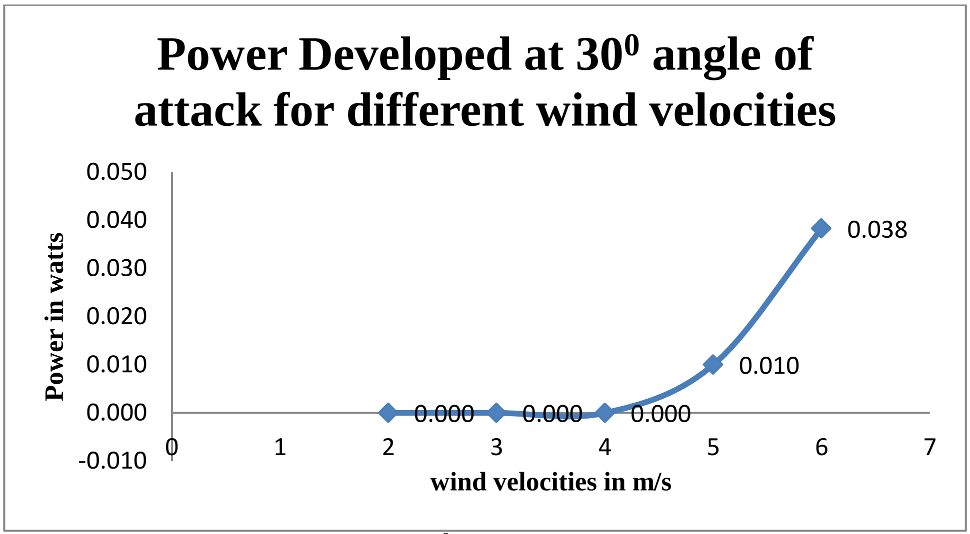

Figure 7 Power Developed at 30^0 angle of attack for different wind velocities

Table 4: Power Developed at various angle of attacks for different wind velocities

sl. No.	Velocity v in m/s	30 degree angle of attack	60 degree angle of attack	90 degree angle of attack
1	2	0.016	0.006	0.000
2	3	0.029	0.019	0.000
3	4	0.052	0.040	0.000
4	5	0.071	0.064	0.010
5	6	0.101	0.095	0.038

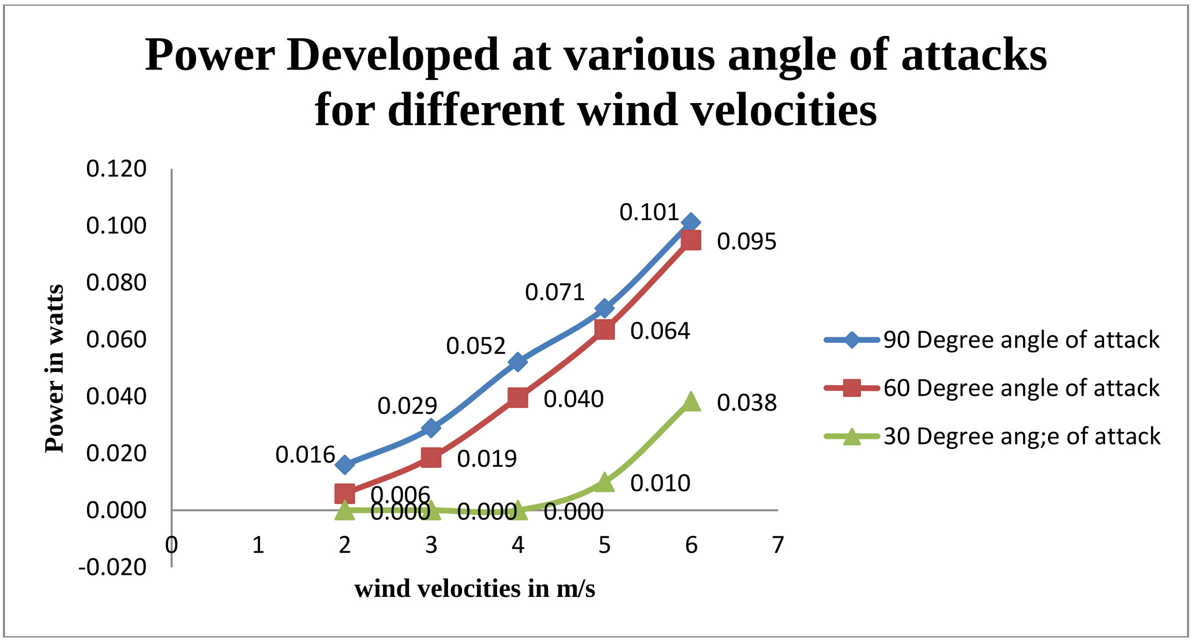

Figure 8 Power Developed at various angle of attacks for different wind velocities

Table 5: Power Developed at various angle of attacks for wind velocity of 2m/s

sl. No.	Andle of attack	Voltage V in Volts	Current I in milliamps	Actual power Pa in Watts
1	30	0.02	0	0.000
2	60	2.5	1.4	0.006
3	90	2.51	3.8	0.016

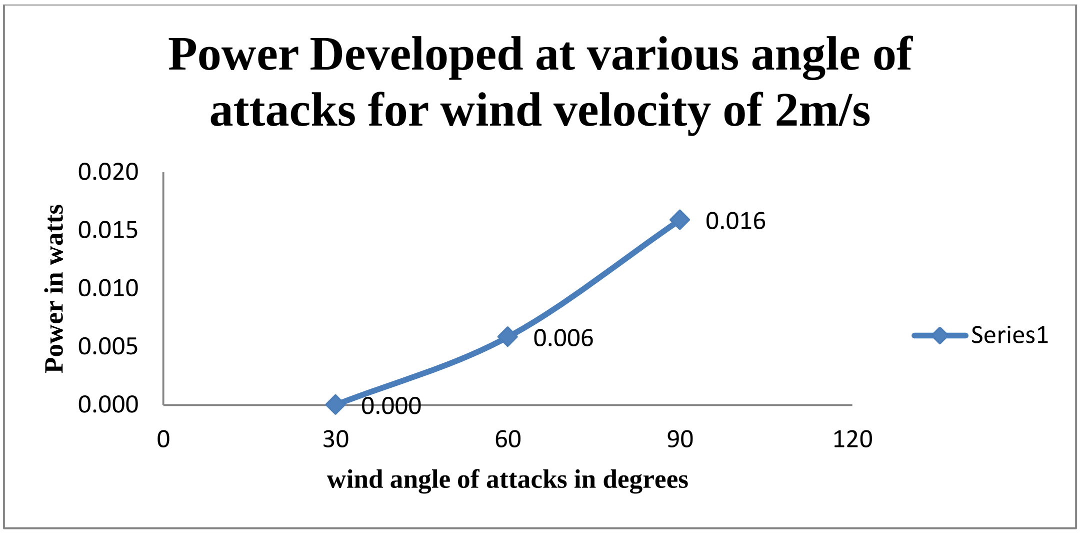

Figure 9 Power Developed at various angle of attacks for wind velocity of 2m/s

Table 6: Power Developed at various angle of attacks for wind velocity of 3m/s

sl. No.	Andle of attack	Voltage V in Volts	Current I in milliamps	Actual power Pa in Watts
1	30	0.5	0	0.000
2	60	2.53	4.4	0.019
3	90	2.55	6.8	0.029

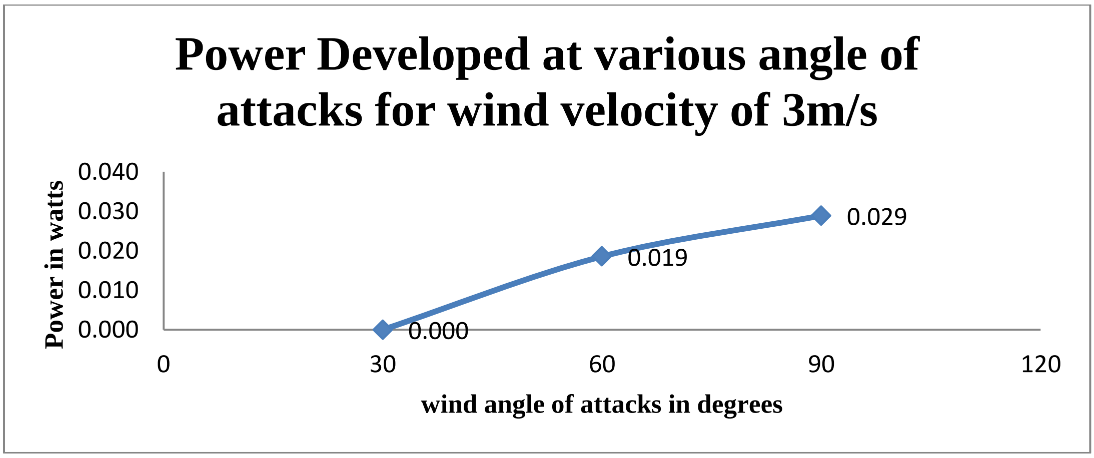

Figure 10 Power Developed at various angle of attacks for wind velocity of 3m/s

Table 7: Power Developed at various angle of attacks for wind velocity of 4m/s

sl. No.	Andle of attack	Voltage V in Volts	Current I in milliamps	Actual power Pa in Watts
1	30	2.45	0.05	0.000
2	60	2.58	9.2	0.040
3	90	2.58	12.1	0.052

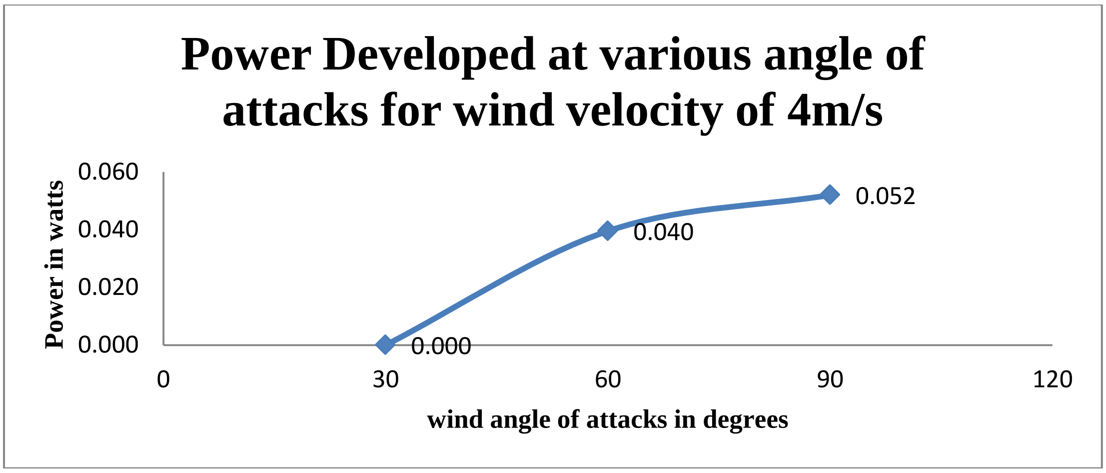

Figure 11 Power Developed at various angle of attacks for wind velocity of 4m/s

Table 8: Power Developed at various angle of attacks for wind velocity of 5m/s

sl. No.	Andle of attack	Voltage V in Volts	Current I in milliamps	Actual power Pa in Watts
1	30	2.5	2.4	0.010
2	60	2.61	14.6	0.064
3	90	2.61	16.3	0.071

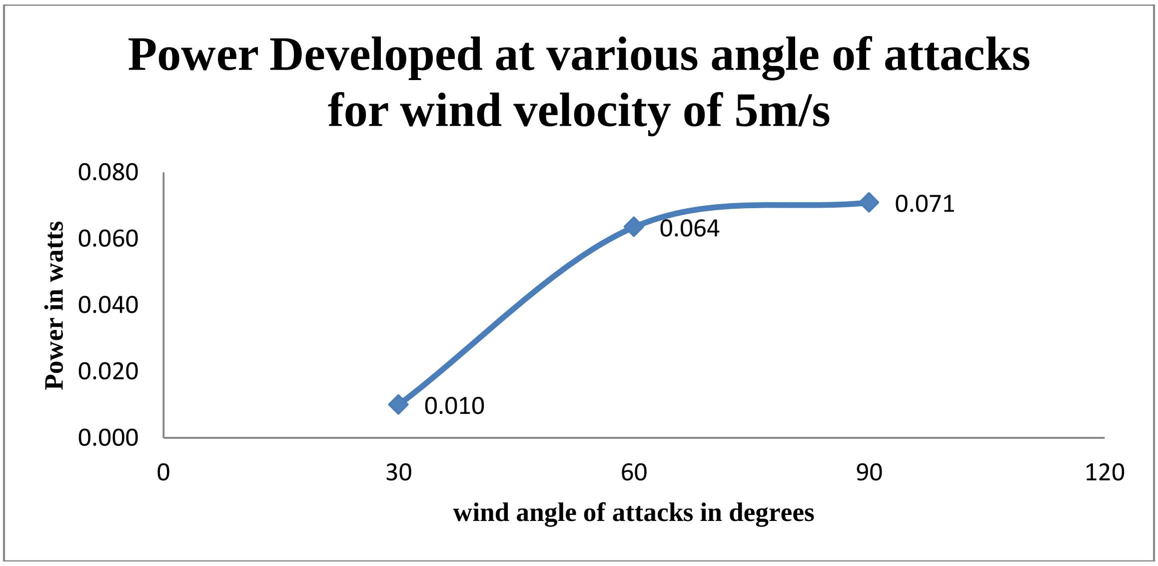

Figure 12 Power Developed at various angle of attacks for wind velocity of 5m/s

Table 9: Power Developed at various angle of attacks for wind velocity of 6m/s

sl. No.	Andle of attack	Voltage V in Volts	Current I in milliamps	Actual power Pa in Watts
1	30	2.58	8.9	0.038
2	60	2.7	21.1	0.095
3	90	2.66	22.8	0.101

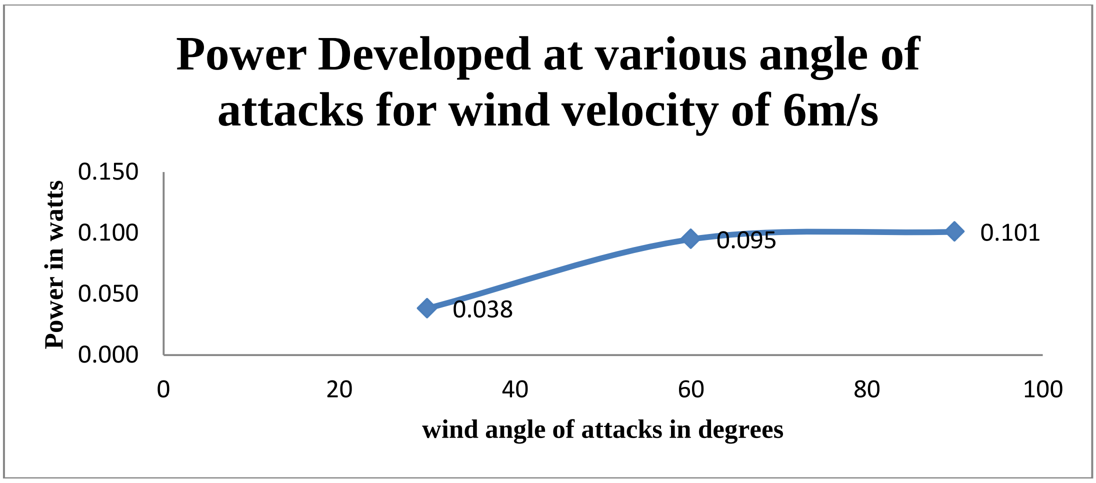

Figure 13 Power Developed at various angle of attacks for wind velocity of 6m/s

Table 10: Power Developed for different wind velocities at various angle of attacks

sl. No.	Velocity v in m/s / Angle in degrees	2	3	4	5	6
1	30	0.000	0.000	0.000	0.010	0.038
2	60	0.006	0.019	0.040	0.064	0.095
3	90	0.016	0.029	0.052	0.071	0.101

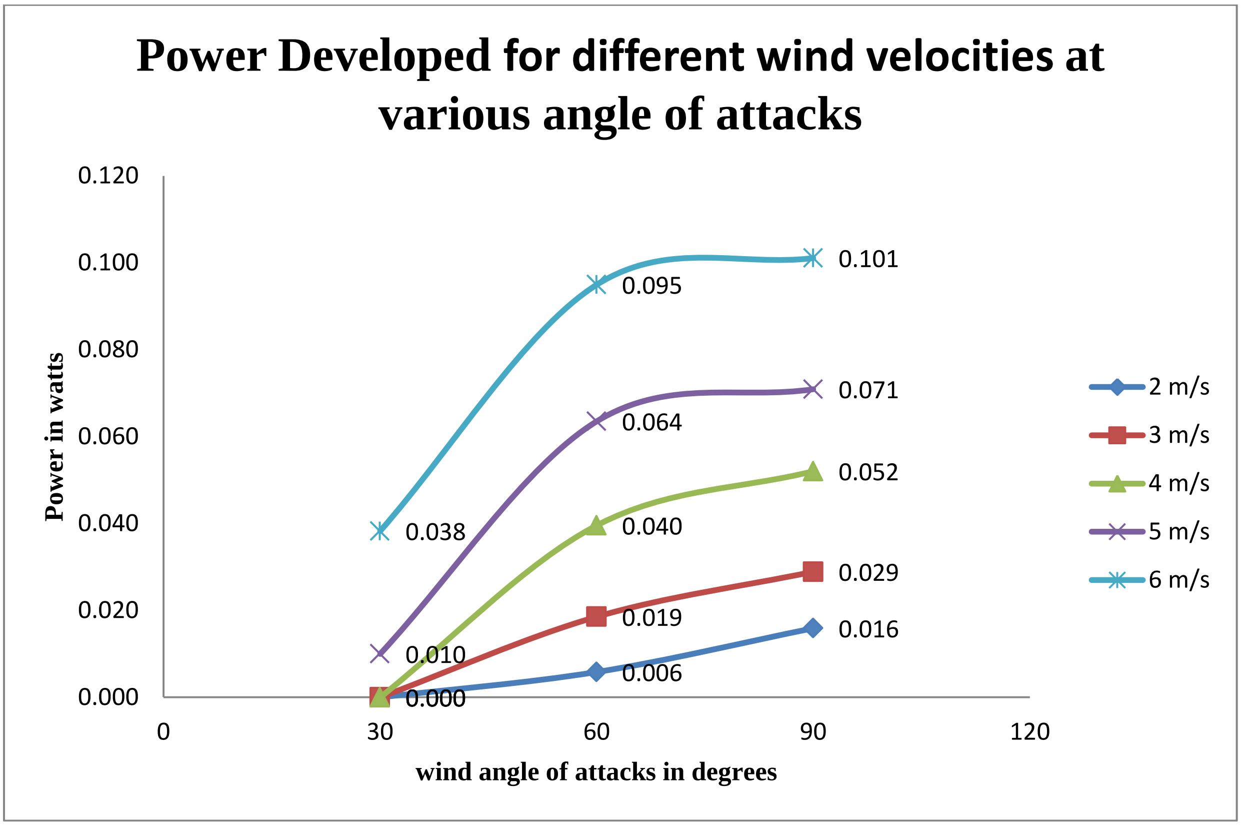

Figure 14 Power Developed for different wind velocities at various angle of attacks

5. CONCLUSION

In the work an attempt is made to design and fabricate a system which can covert the wind energy into electrical energy. Further, the generated electrical energy can be used for small scale domestic applications like mobile charging, lightening of LED both in commercial and domestic spaces and CFLs and small fans.

- From Figure 5 to Figure 8,
- it is observed that power output of turbine increasing with respect to the velocities irrespective of angle of attack
- Maximum power is developed for 90^0 angle of attack at maximum velocity of 6 m/s i.e., 0.101 watts
- At velocities lesser than 2m/s power developed will be almost negligible (approximately equals zero)
- From Figure 9 to Figure 14
- it is observed that power output of turbine is more at 90^0 angle of attack
- At 30^0 angle of attack, the power is developed at velocities higher than 4m/s

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