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Performance Analysis of Small Scale Wind Turbine With Different Shrouds

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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. In this project work, the wind potential available in the hubli city is surveyed and based on that, a mode of wind turbine is created. Analysis is carried out on a bare wind turbine. The Convergent shroud with different opening angles are created for increasing the velocity of wind and analysis is carried on wind turbine along with shroud. The Divergent shroud with different opening angles are created for drawing more wind as a result of pressure drop and analysis is carried on wind turbine along with shroud. From the results it can be concluded that the maximum power can be generated for the convergent shroud with 25^0 opening angle.

Keywords—Bare wind turbine, Convergent Shroud, Divergent Shroud (key words)

1. INTRODUCTION

Large spread of wind technologies around the world has followed the constant increment on energy consumption. Urbanized areas are large consuming centers and where integration of designed Urban Wind Turbines, UWT, could be encouraged. Wind energy in urban environment shown some sustainable energy potential for exploitation. Day by day electricity becomes a decisive factor on the growth of economics and sustainable development. Thus, associated with the increasing need for electrical power, synergies with best practices should be established for it's production. Linked to the decentralization of energy production, it became possible an approach of electric power producers elements with major consumption centers. Therefore, efforts to increase of energetic wind turbine performance should be made, and small wind turbines should be considered as part of the solution. These equipment's must accommodate increase in their energy performance, such that small energy gains, would contribute more to the sustainable development. In this work, improvements on the energy production of small wind turbines (WT) were studied. It is becoming necessary to fully understand how to improve wind turbine efficiency, as energy consumption and cost reaches record-breaking levels. The cost of oil and non-renewable resources is skyrocketing, and the depletion of these resources will require a sustainable and environmentally friendly energy source. An improvement to wind turbine efficiency will allow the limits of today to be surpassed, and someday be able to extract all of the energy from the wind with only a few improvements in technology. A greater number of these high-efficiency turbines would lower the cost of energy, powering the world for less.

One such method of improving turbine efficiency is a Shroud augmented wind turbine (SAWT) as an improvement to the conventional horizontal axis wind turbine (HAWT).

2. LITERATURE REVIEW

Preliminary literature review is made to understand the fundamental concepts of the wind turbine. Some of the important contributions made by the pioneers in this field during recent years are discussed below

William and Adam [1] designed a Diffuser Augmented Wind Turbine (DAWT) for the conventional Horizontal Axis Wind Turbine (HAWT). This Investigation reveals that the extreme wind loads on DAWT will always be higher than the loads on HAWT. As a result of which the design considerations to be taken into account so that the turbine can withstand the high loads.

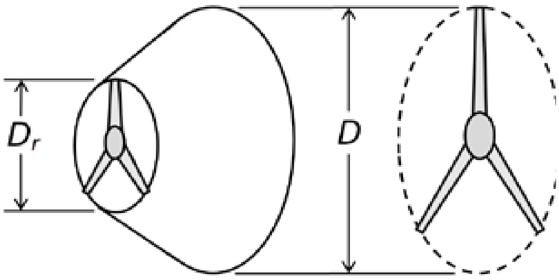


Figure 1 Diffuser Shroud

Shailesh, et al. [2] developed a diffuser model in order to augment the low available wind velocity (3 m/s to 6 m/s) and to generate the power. The model consists of a set of static nozzle and a moving rotor blades. The Investigation revealed that there is an increase in velocity of wind around 43% to 51%.

Chen and Fang [3] designed a new type DAWT with lower cut-in wind speed and the largest wind energy utilization coefficient on the principle of the Blade Element Theory. The experimental results showed that, the power generation in the turbine with a diffuser is 2.34 times more as compared with the power generation in the turbine without diffuser.

3. OBJECTIVES AND METHODOLOGY

The following are the primary objectives of the present investigation,

- To investigate the performance of bare wind turbine at different velocities
- To investigate the performance of wind turbine with different convergent shrouds at different velocities
- To investigate the performance of wind turbine with different divergent shrouds at different velocities

The following are the steps carried out in the present investigation

- Extensive literature review of various models of the shroud is made
- Objectives of the problem is defined
- Experimental setup details such as instrumentation and experimental procedure is discussed
- Experiment is conducted for each case and the results are tabulated and discussed.
- Optimization and suitable conclusion from the present investigation is done

4. EXPERIMENTATION AND ANALYSIS

The experimental set up of the present work is 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, shroud with convergent portion at entrance and then throat portion followed by divergent portion is created. Convergent portion causing for increasing the velocity of wind and impacts on blades at throat portion discharges at divergent portion. Wind turbine blades with hub and alternator arrangements will be modelled. Flow analysis will be carried on wind turbine without shroud and with shroud.

A. Analysis of Bare wind turbine

Now the turbine blades with hub and alternator arrangements supported in hemispherical cup which is made to rest on a stand frame as shown in the figure 2. Now the experimental setup is subjected to various wind velocities and the respective rotational speed will be recorded and power outputs will be tabulated.

Figure 2. Experimental setup of bare wind turbine

B. Analysis of wind turbine with convergent shroud

Now the shroud arrangement will be made for the wind turbine and the experimental setup is subjected to same wind velocities and the respective rotational speed will be recorded and power outputs will be tabulated.

Figure 3 shows the wind turbine with convergent portion of shroud arrangement.

Figure 4shows the wind turbine with divergent portion of shroud arrangement

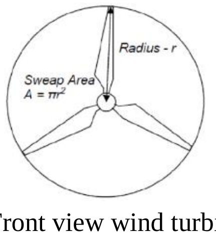
Figure 3. Wind turbine with convergent shroud

Figure 4. wind turbine with convergent shroud

5. RESULTS AND DISCUSSION

A. Analytical Calculations

A sample calculation is shown for the trial with velocity 4.5 m/s from table 2



FECD
Figure 5 Front view wind turbine

Kinetic Energy of a mass in motion is given by

$E = \frac{1}{2}MV^2$ …….(2.1)

But the power is the rate of change of energy:

$Pt = \frac{dE}{dt}$ …….(2.2)

If the kinetic energy of the wind is considered to have constant velocity then the power of the wind can be calculated by

$Pt = \frac{1}{2}V^2\frac{dm}{dt}$ …….(2.3)

Where: $\frac{dm}{dt} = \rho A\frac{dx}{dt}$

Therefore, $Pt = \frac{1}{2}\rho AV^3$

$Pt = \frac{1}{2}\rho\pi r^2V^3$

$Pt = \frac{1}{2}1.123 * \pi * 0.09^2 * 5.2^3 =$ 2.009Watts

Where ρ is the Density, A is the Sweep Area and V is the Velocity of the wind.

B. Experimental Calculations

Power Pa=V*I/Motor efficiency
For the trial with velocity 4.5 m/s from table 2,
V=8 volts, I=0.048 Amps
Assuming the motor efficiency of 75%
Pa=8*0.048/0.75=0.512Watts

Table 1: The rotational speeds and power outputs for various wind velocities on a bare wind turbine (without shroud)

sl. No.	v1	v2	N	V	A	Pt	Pa
1	4.5	4.5	750	2	0.09	1.302	0.240

2	5	5	875	3	0.08	1.786	0.320
3	5.5	5.5	1025	5	0.1	2.378	0.667

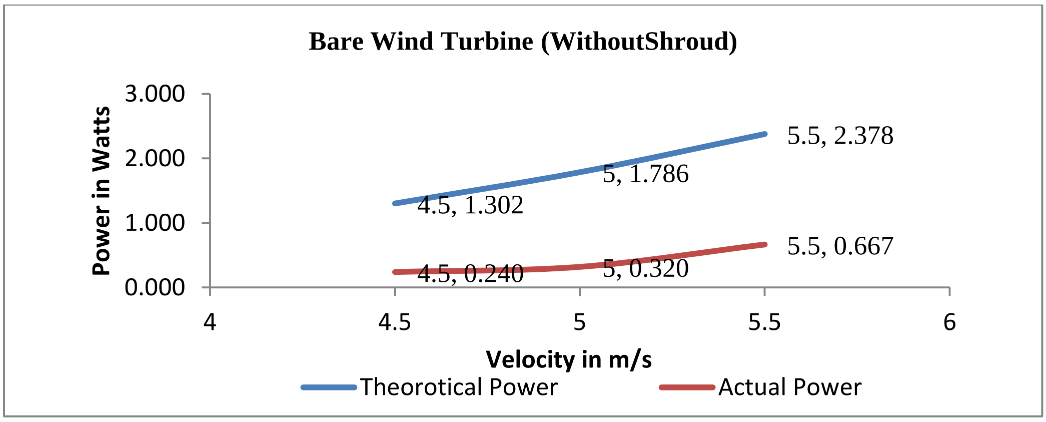


Figure 6.variation of power at different wind velocities on a bare wind turbine

Table 2: The rotational speeds and power outputs for various wind velocities on a wind turbine with 15^0 convergent portion of shroud

sl. No.	v1	v2	N	V	A	Pt	Pa
1	4.5	5.2	825	8	0.048	2.009	0.512
2	5	5.6	1000	14	0.055	2.510	1.027
3	5.5	6.1	1188	16	0.104	3.244	2.219

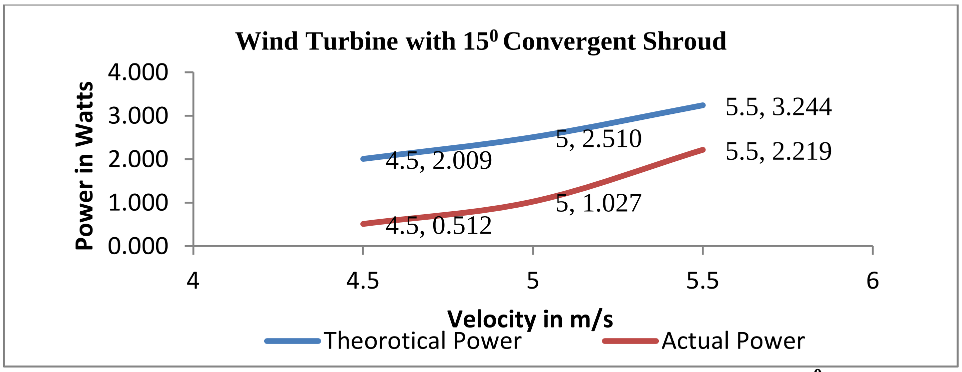


Figure 7. variation of power at different wind velocities on a wind turbine with 15^0 convergent portion of shroud

Table 3: The rotational speeds and power outputs for various wind velocities on a wind turbine with 25^0 convergent portion of shroud

sl. No.	v1	v2	N	V	A	Pt	Pa
1	4.5	4.7	838	4	0.092	1.484	0.491
2	5	5.4	963	9	0.112	2.250	1.344
3	5.5	6	1050	13	0.183	3.087	3.172

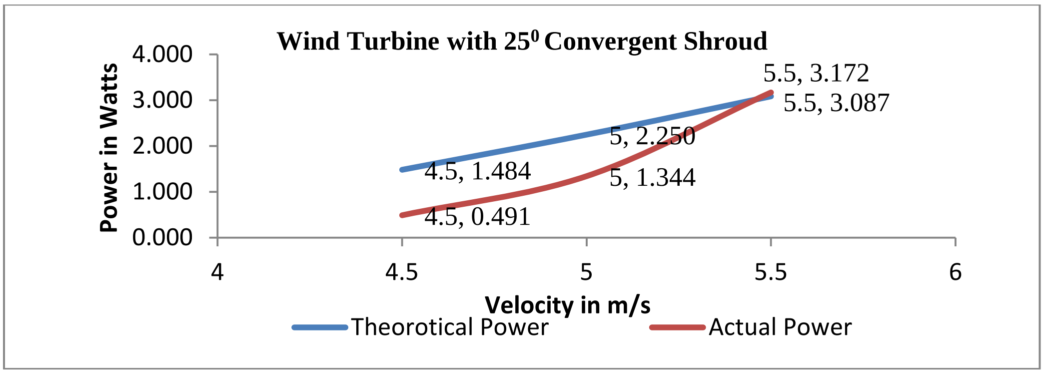


Figure 8 variation of power at different wind velocities on a wind turbine with 25⁰ convergent portion of shroud

Table 4: The rotational speeds and power outputs for various wind velocities on a wind turbine with 35⁰ convergent portion of shroud

sl. No.	v1	v2	N	V	A	Pt	Pa
1	4.5	4.7	750	3	0.087	1.484	0.348
2	5	5.4	1000	8	0.052	2.250	0.555
3	5.5	5.9	1100	15	0.142	2.935	2.840

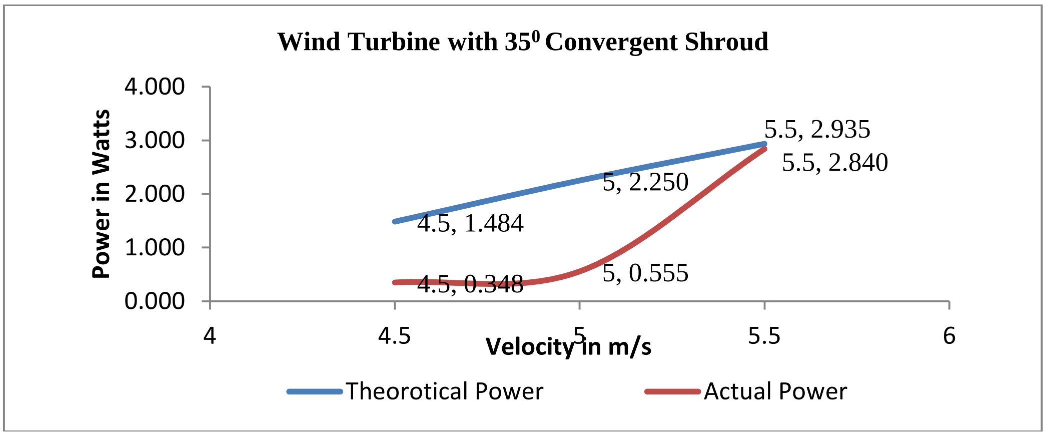


Figure 9 variation of power at different wind velocities on a wind turbine with 35⁰ convergent portion of shroud

Table 5: The rotational speeds and power outputs for various wind velocities on a wind turbine with 15⁰ Divergent portion of shroud

sl. No.	v1	v2	N	V	A	Pt	Pa
1	4.5	4.5	775	2	0.098	1.302	0.261
2	5	5	925	3	0.09	1.786	0.360
3	5.5	5.5	1050	6	0.11	2.378	0.880

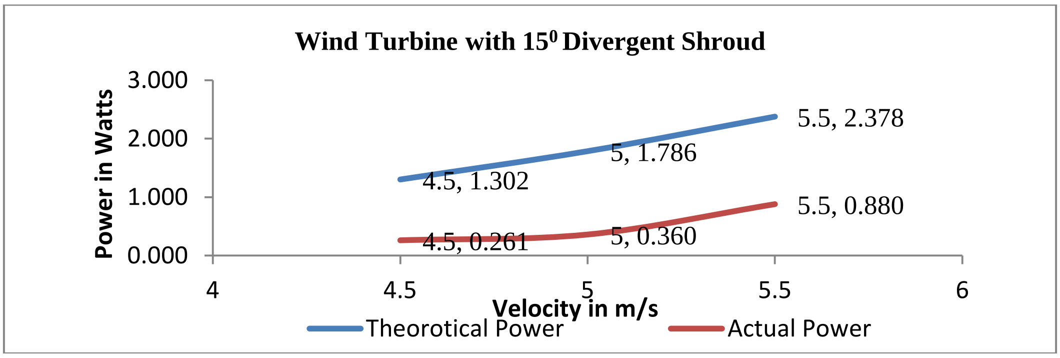


Figure 10 variation of power at different wind velocities on a wind turbine with 15^0 Divergent portion of shroud

Table 6: The rotational speeds and power outputs for various wind velocities on a wind turbine with 25^0 Divergent portion of shroud

sl. No.	v1	v2	N	V	A	Pt	Pa
1	4.5	4.5	800	4	0.102	1.302	0.544
2	5	5	1025	6	0.134	1.786	1.072
3	5.5	5.5	1200	9	0.116	2.378	1.392

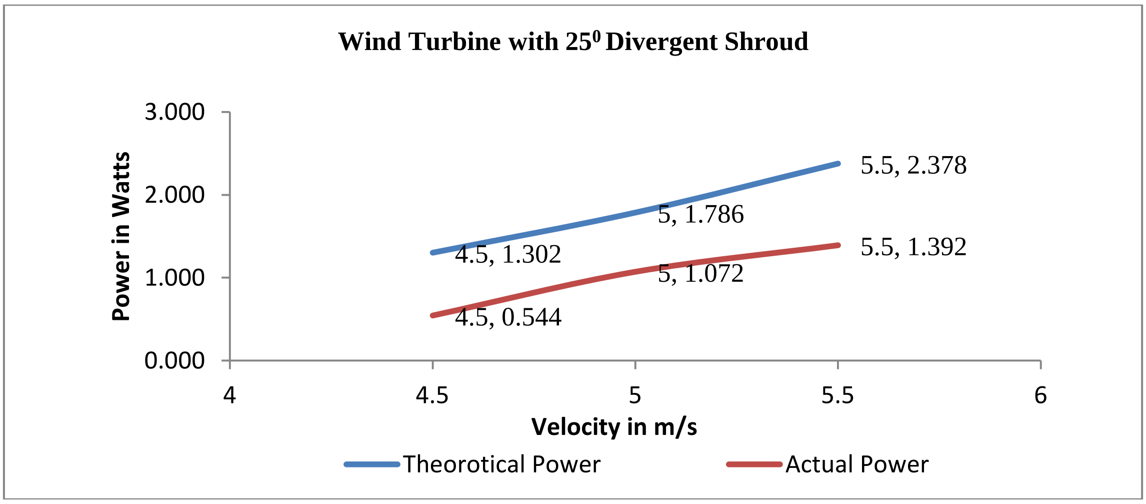


Figure 11 variation of power at different wind velocities on a wind turbine with 25^0 Divergent portion of shroud

Table 7: The rotational speeds and power outputs for various wind velocities on a wind turbine with 35^0 Divergent portion of shroud

sl. No.	v1	v2	N	V	A	Pt	Pa
1	4.5	4.5	775	4	0.103	1.302	0.549
2	5	5	1000	5	0.083	1.786	0.553

3	5.5	5.5	1175	8	0.082	2.378	0.875

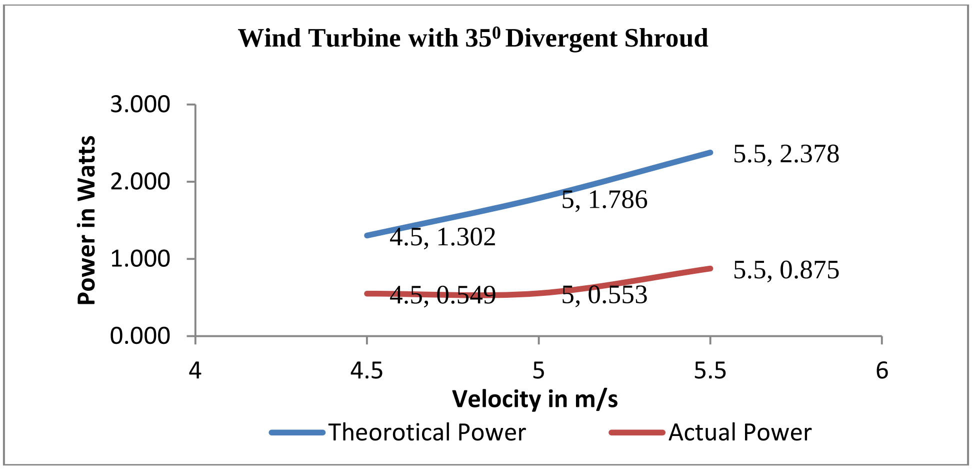


Figure 12 variation of power at different wind velocities on a wind turbine with 35^0 Divergent portion of shroud

6. 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 increased by the use of shroud and can be stored in a battery and 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.

- As per the theoretical calculations and analysis done, with the input air velocity in the range of 4.5m/s to 5.5m/s, the power output generated is ranging from 0.24 W to 3.172.
- It is giving more outputs at higher velocities.
- Also the output obtained with shroud is approximately proportional to two to three times that without shroud.
- From table 1 to 7, it is observed that the power output is increasing proportionally with respect to the wind velocity i.e., from 0.24 watts to 3.172 watts for the velocity range 4.5 m/s to 5.5 m/s
- From table 3, it is clear that maximum power is generated for the case of 25^0 convergent shrouded wind turbine at 5.5 m/s i.e., 3.172 Watts which is 4.75 times as compared with bare wind turbine

REFERENCES

[1] William David Lubitz, Adam Shomer, " Wind Loads and Efficiency of a Diffuser Augmented Wind Turbine (DAWT)", Proceedings of The Canadian Society for Mechanical Engineering International Congress 2014, June 1-4, PP 1-5, 2014.

[2] Shailesh P. Patankar, Samir J. Deshmukh, Rucha R. Kolhekar, " Theoretical Analysis of Horizontal Axis Wind Turbine for Low Wind Velocity", International Journal of Innovative and Emerging Research in Engineering Volume 2, Special Issue 1 MEPCON 2015, 93-98, p-ISSN: 2394 – 5494

[3] Chen Yaqionga, Fang Yuefa, "Design and Analysis of Small-scale Diffuser Augment Wind Turbines", International Industrial Informatics and Computer Engineering Conference (IIICEC 2015), 1088-1093.