INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
*(Volume3, Issue2)*
Available online at www.ijariit.com

# Experimentation of Diffuser Augmented Wind Turbine

**Ajitkumar Manedeshmukh***
*Mechanical & SKNSCOE, Pandharpur*
ajit.am37@gmail.com

**S. G. Kulkarni**
*Mechanical & SKNSCOE, Pandharpur*
swanand293@gmail.com

**S. R. Koli**
*Mechanical & SKNSCOE, Pandharpur*
somnath_koli@rediffmail.com

***Abstract***— ***Wind lense is collection-acceleration device which shrouds a wind turbine. For given turbine diameter, the power augmentation can be achieved by Shroud diffuser, popularly known as wind lens. In this paper, a comparative numerical prediction of mass flow rates in the wind turbine has been carried out with various types of wind lens like straight diffuser with brim, curved diffuser with brim, stepped diffuser with brim, bumped diffuser with brim. All these eight diffusers are firstly analysed in Ansys Fluent R14.5 for its velocity variation and pressure variation at inlet and outlet of diffuser. From the CFD result From above CFD analysis it is concluded that stepped diffuser with brim shows higher percentage increase in velocity i.e. 80.33 %, as compared to bare wind turbine so stepped diffuser gave the good performance.***

***Keywords— DAWT, Windlens, shroud, wind lense, CFD***

## I. INTRODUCTION

For application of an effective energy resource in future, the limitation of fossil fuels is clear and the security of alternative energy sources is very important subject. Furthermore, due to environmental issues, i.e., global warming, etc., application of renewable and clean energy is strongly expected. Amongst all others, wind energy technology has developed rapidly and are about to play an important role in a new energy field. However, making comparison with overall demand of energy, the scale of wind power usage is still small. Power generation by using wind is proportional to the cube of wind speed. Therefore, for increasing the output power, the velocity of the approaching wind should have to be increase. By utilizing the fluid dynamic nature around a structure or topography will increase the wind speed. This study is regarding the improvement of a wind power system with more output, aims at determining how to collect the wind energy effectively and which kind of wind turbine can generate energy efficiently from the wind. There are some hopes for utilizing the wind power by more efficient way. In this present study, the concept of accelerating the wind was named the "windlens" technology. The wind turbine with a brimmed or flanged diffuser shroud so called “windlens turbine”- is developed as one of high performance wind turbines.

## II. LITERATURE REVIEW

Balaji et al. (2014) [1] introduced the wind power generation using horizontal axis wind turbine with convergent nozzle. Commercial CFD software which is used for the nozzle with different tapering angle has also been analysed. Then they come to conclusion that when they use the DAWT turbine then there will 40% increase in output power of turbine.

Cortes (2013) [2] analysed a diffuser augmented wind turbine using a computational fluid dynamic approach. For his analysis, he used Ansys-Fluent. The set up for the wind turbine consist of: a converging nozzle which takes the air inside, a cylinder increasing the velocity of the incoming air, followed by a short cylinder contains the wind turbine which is followed by a diverging nozzle that creates pressure lower than atmospheric pressure at the outlet helping to draw out the air faster. The results show that the Nozzles increase the amount of power generated by the wind turbine. As the diameter and length of the converging nozzle increased so did the amount of power generated and the percentage of the power captured from the power available

Foreman (1980) [3] summarized work prepared by Grumman Aerospace Corporation, Bethpage, New York for SERI, Golden, Colorado under Subcontract XH-9-8073-1. A diffuser is an augmentation device which increases the efficiency of a wind turbine, and consists of thin shell shrouds downwind from the rotor. The exit diameters of these shrouds are varying from 15 (for 9 ft. rotor dia.) to 60 feet (for 36 ft. rotor dia.) with lengths of 5 to 20 feet. A key to the overall effectiveness of the diffuser concept is to select a material that not only meets the structural requirement of the system but lends itself to minimum costs through volume production. Results of the study indicate that ferro-cement is a suitable material for wind turbine diffusers.

Foreman (1987) [4] investigate the diffuser augmented wind turbine for cost effectiveness and comes to conclusion that power augmentation increases with diffuser exit-to –inlet area ratios up to 3. The presence of ground plane within 1/2 a turbine diameter from the exit plane seems to improve augmentation. A combination of simulated wind profile and ground plane effects produce up to 10 % improved augmentation, compared to a no ground, uniform flow conditions. Center bodies with cross-sectional areas up to about 10 % of the turbine disk area produce negligible effect on augmentation in screen tests. Small angular changes in pitch or yaw to about 15 degree create negligible variation in overall diffuser core flow and performance.

Gat et al. (2015) [5] in his review paper he concludes that Wind turbine geometries, increase power coefficients peaking at Cp = 0.39, victimization commercial size. An optimization analysis in Rotor, shown that power coefficients Cp = 0.5 for lower wind speeds, and even higher at fastest wind speeds, can be achieved with minor modifications in design.

## III. RESEARCH GAP

Most of the researchers uses curved diffuser with flange [1-4] but Raju Govindharajan [6] uses bumped diffuser with flange. Many researchers said that there was increase in power output by 40% [1] to 60 % [10], but in some literature gives 400 % increase in power. Literature does not clarify that any other diffuser without flange gives good result or Not? The objectives of most of the work carried by various authors were to work on the diffusers. The literature review is concerned with the studies on design, analysis, experimentation and validation of diffuser wind augmented turbine.

## IV. OBJECTIVES

The purpose of the wind lens is to improve the wind turbines power generating capability by:
1) Check high efficiency diffuser amongst straight diffuser, stepped diffuser, curved diffuser, bumped diffuser.
2) Increasing the wind kinetic energy through the rotor experimentally.
3) Increasing wind turbine rotor speed experimentally.

## V. CAD MODELS

The basic 3D model was drawn on CREO tool. Following figures shows the cad model of various type of diffusers i.e. straight diffuser with brim, curved diffuser with brim, stepped diffuser with brim, bumped diffuser with brim.

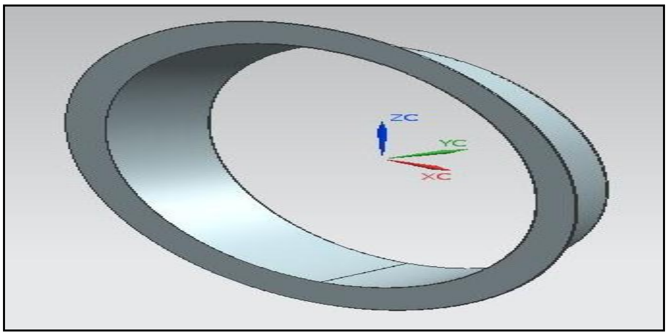
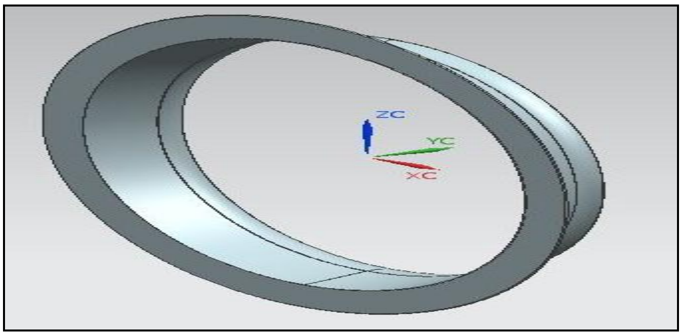



**Fig.1 Straight diffuser with brim**




I

**Fig. 2 Curved diffuser with brim**

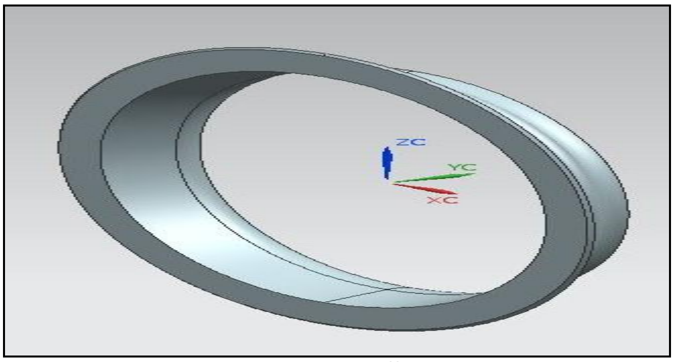



**Fig. 3 stepped diffuser with brim**

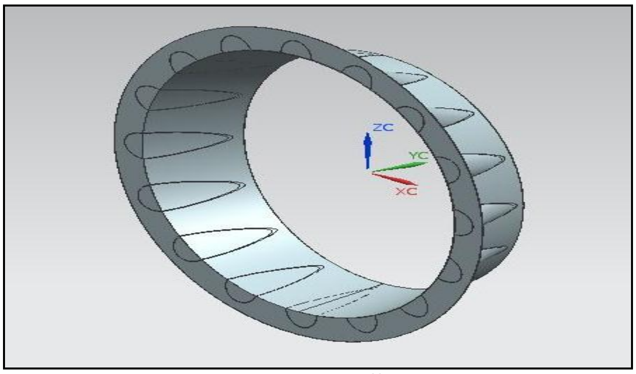



**Fig.4 Bumped diffuser with brim**

CFD Analysis

Above created 3D models of various diffusers are used for CFD analysis in ANSYS FLUENT version 14.5. Following figure will shows the velocity contour & pressure contour of all diffusers.

TABLE I
RESULT TABLE OF CFD ANALYSIS

| Turbine | Pressure drop across diffuser ($N/m^2$) | Velocity (m/s) | | % increase in Velocity |
|---|---|---|---|---|
| | | I/P | center | |
| Bare wind turbine | 0.14 | 6 | 6.2 | - |
| Straight without brim | 0.24 | 6.5 | 6.18 | 8.3 |
| Straight with brim | 3.75 | 9.99 | 10 | 63.77 |
| Curved without brim | 0.43 | 6.6 | 6.19 | 10 |
| Curved with brim | 25.86 | 10.36 | 11.2 | 72.66 |
| Stepped without brim | 0.46 | 6.5 | 6.18 | 8.3 |
| Stepped with brim | 27.22 | 10.82 | 11.6 | 80.33 |
| Bumped without brim | 7.07 | 8.977 | 9.12 | 49.61 |
| Bumped with brim | 23.56 | 10.6 | 10.9 | 76.66 |

Above table I shows percentage increase in theoretical power generated by all the diffusers augmented turbines as compared to bare wind turbine. Power generated by stepped diffuser augmented wind turbine is much more than all other diffuser i.e. 490 %.

## EXPERIMENTAL VALIDATION

From above CFD analysis it is concluded that stepped diffuser with brim shows higher percentage increase in velocity. As the velocity increases, the mass flow rate of air is also increases and available power is also increases.

In this thesis, firstly the curved diffuser with brim is used for experimental analysis, because this is the diffuser which is generally used in Japan. Because of the performance of this diffuser is also compared with bare wind turbine & with stepped diffuser wind turbine.

Initially the readings like RPM of blades (with the help of non-contact type of tachometer) and velocity of air entering into the blades (with the help of anemometer) of bare wind turbine model is taken out. After that the reading like RPM of blades and velocity of air entering into the blades of curved wind turbine model and for stepped wind turbine model taken out.

The stepped diffuser with brim is shrouded on wind turbine. The blades are inserted in the hub. The angle of attack of blades is set to be 60-80.The fan of diameter 150 cm is kept infront of the assembly shown in figure 5.2

Figure 5.1 shows the experimental set up of stepped diffuser with brim & curved diffuser with brim The figure 5.2 shows anemometer used for measuring the velocity of air and non-contact type tachometer used for measuring rotation of rotor. Table 5.1 shows observations taken through experimental analysis.

In the observation table the reading like velocity of inlet air for curved diffuser and for stepped diffuser is taken, and the RPM of rotor for curved diffuser and stepped diffuser is taken. From these observations the calculation for percentage increase in velocity, theoretically power generated by different diffusers, percentage increase in power, and percentage increase in RPM of rotor for different diffusers is done.

From this above experimental work the following observations are made. Speed of air is measured with the help of anemometer as shown in figure 5.2 (a) and the RPM of rotor is measured with the help of non-contact type tachometer as shown in figure 5.2 (b) .

TABLE II
OBSERVATION TABLE OF EXPERIMENTAL ANALYSIS

| Sr. No. | Diffuser | Speed of air (m/s) | % Increase in speed of air | RPM of rotor |
|---|---|---|---|---|
| 1 | Bare | 2.2 | - | 180 |
| 2 | Curved | 3.9 | 77.27 | 198 |
| 3 | Stepped | 4.1 | 86.36 | 215 |

## RESULT

From above experimental analysis the calculations for percentage increase in velocity, power generated from designed diffuser, percentage increase in power, percentage increase in speed of rotor is calculated with the help of different formulae's

| **Quantity** | **Types of diffusers with brim** | |
|---|---|---|
| | **Curved Diffuser** | **Stepped Diffuser** |
| % Increase in speed of air | 77.27 | 86.36 |
| Mass flow rate of air (kg/s) | 1.44 | 1.51 |
| % Increase in mass flow rate | 77.78 | 86.41 |
| % Increase in RPM of rotor | 10 | 19.44 |

## CONCLUSIONS

From above CFD analysis it is concluded that stepped diffuser with brim shows higher percentage increase in velocity i.e. 80.33 %, which is greater than the existing curved wind turbine used in china and japan. Bumped diffuser without brim shows the highest percentage increase in velocity than all other diffusers without brim. Experimental validation also shows that stepped diffuser shows 86.36 % increase in wind speed and also same mass flow rate. By experimental analysis it is shown that the percentage increase in RPM of rotor for stepped diffuser with brim is higher (19.44 %) than as that of the curved diffuser with brim (10 %) as compared to bare wind turbine so stepped diffuser gave the good performance. Percentage error between experimental and CFD results for velocity measurement for curved diffuser with brim is 6.33% and for stepped diffuser with brim is 7.5 %. It means that experimental and CFD results are nearly same. Percentage error between experimental and CFD results for power generated for curved diffuser with brim is 10.19 % and for stepped diffuser with brim is 12.50 %.

## ACKNOWLEDGMENT

I am very thankful to my project guide S.G. Kulkarni and S.R. Koli, Assistant professor, Mechanical Engineering Department, SKN Sinhgad College of Engineering Korti Pandharpur, Maharashtra, India, for their continuous encouragement and inspiration in completing this work.

## REFERENCES

[1] G.Balaji, I Gnanambal, “Wind power generation using horizontal axis wind turbine with convergent nozzle”, Journal of scientific and industrial research, vol 73, June 2014, PP 375-380.
[2] Jose Cortes, “Diffuser augmented wind Turbine”, 13th Australasian fluid mechanics conference Monash Universuty.Melbourne,2009.
[3] K.M.Foreman, “Preliminary design and economic investigations of DAWT”, final report, research department Grumman Aerospace Corporation Bethpage, New York, December 1981.
[4] K.M.Foreman, B.L.Gilbert “Further investigation of diffuser augmented wind turbine”, doe contract no.ey-76-c02-2616.m002, U.S. department of energy, 1979.
[5] Nilesh G.Gat, Vidyadhar Dixit, “Wind jet turbine”, international journal of advanced technology in engineering and science, ISSN (online): 2348 – 7550, volume no.03, issue no. 03, march 2015.
[6] Raju Govindharajan, Dr. K. M. Parammasivam,V. Vivek,R. Vishnu Priya, “Numerical investigation & design optimization of brimmed diffuser-wind lens around a wind turbine”, 8th Asia-Pacific conference on wind engineering, December 10–14, 2013.
[7] Soren Hjort, Heigi Larsen, “A multi-element diffuser augmented wind turbine”, energies 2014, ISSN 1996-1073, 7, 3256-3281; doi:10.3390/en7053256.
[8] P.D.C.Ten Hoopen, “An experimental and computational investigation of a diffuser augmented wind turbine”, ms thesis, delft university, 2009.
[9] Sandip A. Kale,Yogesh R. Gunjal,Sachin P. Jadhav,Ajinkya N. Tanksale, “CFD analysis for optimization of diffuser for a micro wind turbine”,978-1-4673-6150-7/13©2013 IEEE.
[10] T. Saravana Kannan, Saad A. Mutasher,Y.H. Kenny Lau, “Design and flow velocity simulation of diffuser augmented wind turbine using CFD”, journal of engineering science and technology vol. 8, no. 4 (2013) 372 – 384
[11] Takashi Karasudani, Yuji Ohya, “Development of shroud wind turbines with wind-lens technology poster”,Elsevier,doi:10.1016/j.renene.2005.07.008.