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CFD Simulation of Wind-Lens at Different Velocities

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ABSTRACT

The current research is an attempt made to study a computational model of flow through wind-lens which can be used as efficient way of predicting the wind velocity variations at throat of wind-lens using computational fluid dynamic (CFD) software. The fluid flow simulations are obtained with the fluent software package of ANSYS. A way of analyzing the results and some of the outputs of the simulation along with analysis has been presented. The CFD simulations were performed on the computational model of a wind-lens (shroud with brim). The simulation aims to perform a CFD analysis on a wind-lens to accelerate wind using fluent solver. While performing the simulations, meshing techniques, preprocessing and post processing sections, the evaluation of simulations being learnt. Velocity magnitudes are recorded for various free stream wind velocities. These values were also compared by running different simulations with change of input parameters i.e free stream velocity.

Keywords: Wind Lens, Computational Fluid Dynamics, Brim.

I. INTRODUCTION

An wind-lens is a shroud attached as a upgrade to the wind turbine which increases the power output by accelerating the wind flowing over the blades. By this upgrade, tail of wind turbine can be removed because the yaw motion will be provided by the lens as wind direction changes.

The wind-lens has a collector + diffuser + a brim. The collector collects the wind and diffuser accelerates the wind at throat of lens and the brim generates strong vortices which lead to negative pressure gradient formation at behind of the lens which boosts the acceleration of wind flowing through the throat.

The increase in kinetic energy of the wind increases the power of the wind flowing through the blades. The wind lens can be of different designs and sizes but in current simulation the attempt is only on 1m throat diameter and cii type design based on the research paper published by the Prof Yuji Ohya and Takashi Karasudani Kyushu University.

The power output of a wind turbine depends on the wind velocity flowing over the blades, which is the only source of power generation in wind turbines. As the velocity increases the power output of the wind turbine increases.

The velocity of free stream depends on the pressure variations in the geographical scale. The wind always flows from high pressure region to low pressure region. The design of wind lens creates such pressure variations in the front to back of the wind turbine. The wind tries to flow from high pressure region to the low pressure region created by lens so, the wind gets accelerated at throat.

Power of wind is directly proportional to the wind velocity cube

$$P \alpha v^3 \quad (1.1)$$

Even in slightest increase in wind velocity can increase the power potentially.
The working of wind lens depends on the throat area, exit area, height of the brim, and length of lens.

- Throat area is the smallest area which is in between the entrance and exit of the lens.
- The exit area is the area of outlet of lens
- Height of brim is the plate height which is attached at exit of the diffuser which generates the vortices.

- Length of the lens is the total length from inlet to outlet of lens.

Prof Yuji Ohya and Takashi Karasudani are the persons developed this wind lens technology. The model used for simulation is one of their model which is a cii type of lens Lt/D = 0.221, μ = 1.294 and the collector diameter is reduced by 0.06m which is less than the original diameter. The D = 1m considered for above standards.

Where μ is the ratio of exit area to throat area

Lt/D is the ratio of length of lens to the throat diameter

The dimensions are derived from the above standards.

II. METHODS AND MATERIAL

MODELING – The 3D geometry is generated in Catia

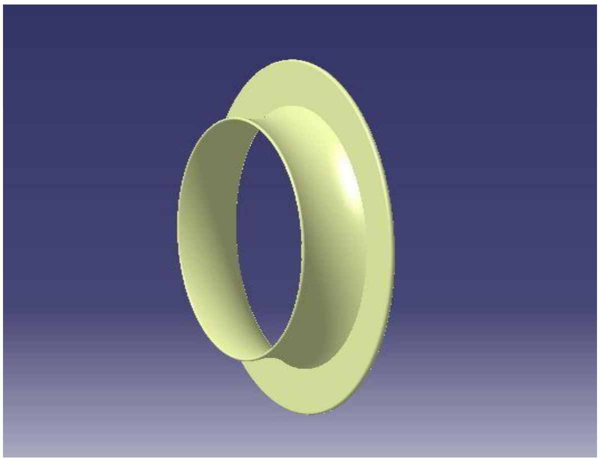


Figure 1. Wind-Lens in CatiaV5

The IGS format file is imported to ANSYS and 2D model surface is created in design modeller in ANSYS workbench.

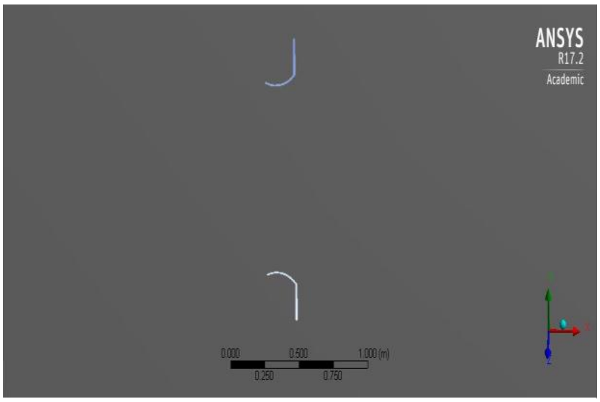


Figure 2. 2D surface model of Wind-Lens

Mesh Generation – The surface model is imported to Mesh edit and meshing is generated with fine mesh using meshing method as all triangular, face refinement and mesh sizing at edges of lens as 0.008m.

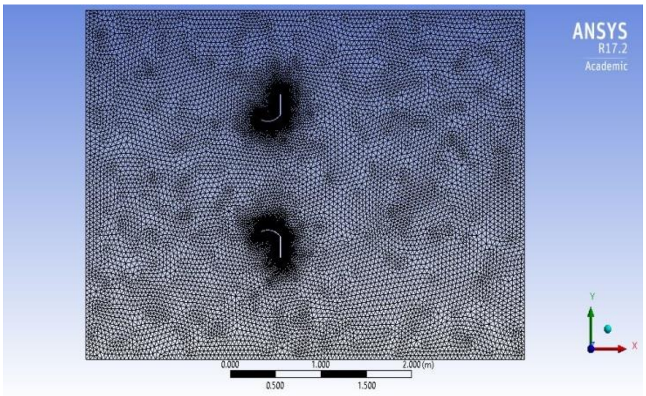


Figure 3. Mesh in wireframe

CFD analysis and study of rests are carried in 3- steps: Pre-processing, solving and post processing, by using fluent solver in ANSYS workbench.

Velocity Inlet: The inlet boundary condition involve velocity component which is varied for all the cases.

Pressure Outlet: The ambient atmospheric condition is imposed at outlet.

Operating conditions:

Velocity – 2m/s, 4m/s, 6m/s, 8m/s, 10m/s.
Nodes – 16221
Elements – 31616
Pressure based
Viscous – Laminar
Solution control SIMPLE, second order

III. RESULTS AND DISCUSSION

Analysis setup of all cases is carried out in ANSYS fluent solver. Result analysis is done using ANSYS post processor. Velocity and pressure plots are plotted for all the cases of study.

Case 1: The inlet velocity is 2 m/s

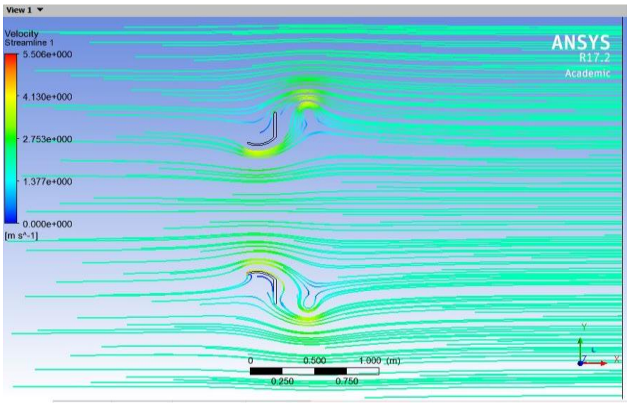


Figure 4: velocity stream lines at 2m/s

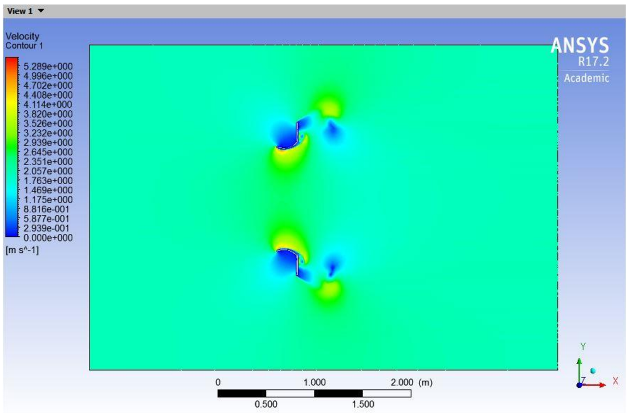


Figure 5: velocity contour plot at 2 m/s

Case 2: The inlet velocity as 10 m/s

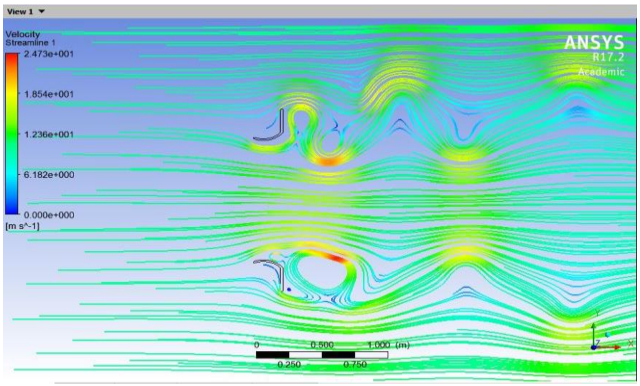


Figure 6: velocity stream lines at 10 m/s.

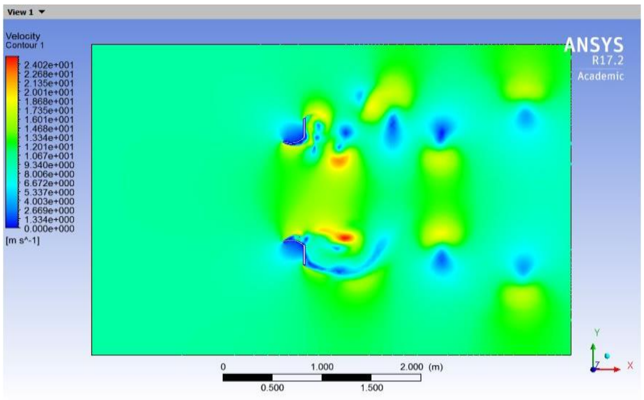


Figure 7: velocity contour plot at 10 m/s

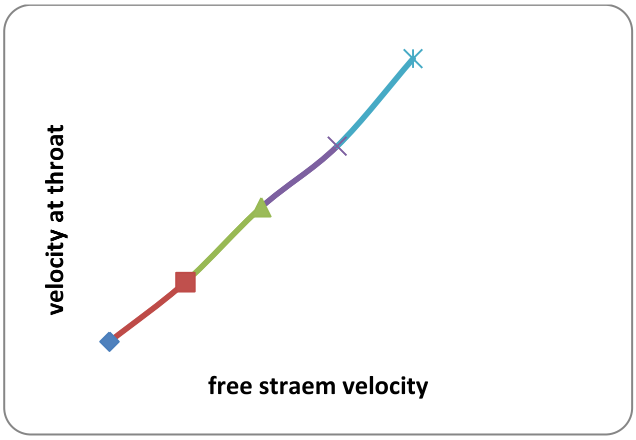
TABLES AND GRAPHS

After performing simulation method at different free stream velocities the values of velocity were observed.

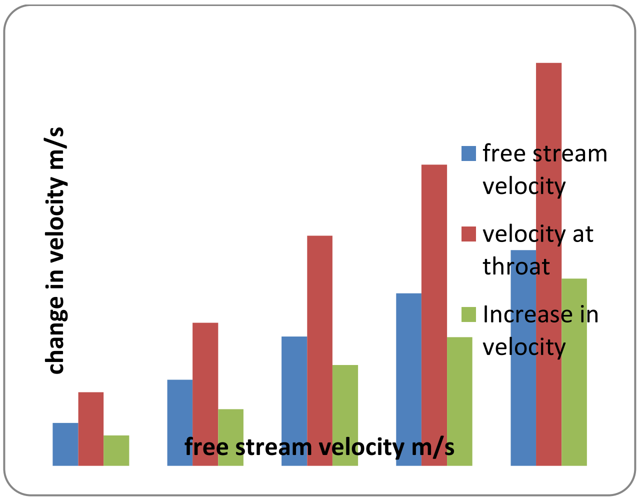
Table 1: Free stream velocity and velocity at throat of lens

Free stream velocity m/s	Throat velocity m/s	Increase in velocity
2	3.42	1.42
4	6.63	2.63
6	10.67	4.67
8	13.96	5.96
10	18.68	8.68

Graph 1: free stream velocity vs velocity at throat



Graph 2: free stream velocity vs velocity at throat vs increase in velocity



The above performances show that as we increase the velocity there is more increase in velocity at throat of wind lens. The increase in velocity grows potentially by increasing free stream velocity.

IV. CONCLUSION

The results of the simulation conclude that percentage of increase in wind velocity is about 75% in all scenarios. The increase in velocity due to the vortex generation behind the lens causing negative pressure gradient which causing suction of more air through the throat of shroud. This type of additional upgrade to any wind turbine can increase the power coefficient significantly.

V. FUTURE SCOPE

The main scope of technology is harnessing power even at low wind speeds and increases the performance along with capacity. The size of turbine can be reduced, which makes it more economical, radar interference will be reduced due decrease in size. If a mesh is placed at the inlet it will be bird friendly. By further proper development the acoustic disturbances generated by wind turbine can be brought down to minimum.

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