CFD ANALYSIS ON AERODYNAMIC AIRFOIL HORIZONTAL AXIS WIND TURBINE ROTOR BLADES

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Abstract: Wind turbines are extensively used for land based power generation and industrial power generation applications the efficiency of wind turbines is increasing with increasing rotor winglet angle. In the present work to examine the aerodynamic airfoil. CFD analysis of horizontal axis wind turbine rotor with three different models consisting of blade with without winglet and blades with varying winglets (0^0,45^0,90^0) we analyzed to find out the optimum angle. The analysis is carried out using commercial CFD software FLUENT has been used. On evaluating the tabular column the blade with minimum speed at a winglet of 45^0 having losses static pressure and it is considered as it is considered as optimum.

***Keywords*- Computational Fluid Dynamics software FLUENT, Horizontal axis Wind Turbine, Winglets 0^0,45^0,90^0, Analysis.**

1. INTRODUCTION TO CFD

CFD is one of the extensions of fluid mechanics that uses numerical systems and calculations to take care of the break down issues that include fluid flows. Computers are utilized to perform a huge number of calculations required to stimulate the interactions of fluids and gases with complex surfaces used in the engineering.

2. DESCRIBING THE PROBLEM

Producing a computer simulation of a flow problem requires the analyst to provide a large amount of data to the solver program. It is the quality of this data, in terms of both suitability and accuracy that may well determine the quality of the results of the simulation. The key to a sound analysis is the production of a specification of the flow problem. This is a clear exposition of the reasons why the simulation is being carried out and of what the physical flow situation is. Once it has been produced it can be translated into the set of data that is required by the simulation package.

3. MATERIAL PROPERTIES OF CARBON FIBER

Details of a wind Turbine Blade Length of wind:

turbine blade = 54cm Leading edge of wind
turbine blade = 3cm Trailing edge of wind
turbine blade = 9cm

Thickness of wind turbine blade at different places = 0.5, 0.7, 1cms

Table 3.1: Mechanical properties of Carbon fiber

Properties	Units	Carbon fiber
E	Mpa	$70*10^3$
ρ	Kg/cu m	$1.6*10^{-3}$
K	W/m-k	20
μ	-------	0.77
Melting point	°F	2200

4. MODELING AND MESHING

4.1. Gambit:

Gambit is modeling software that is capable of creating meshed geometries that might be read into FLUENT and other analysis software.

4.2. Coordinate Format:

Since the wind turbine blade airfoil geometry is characterized by sets of coordinate points, the more points characterized will increase the precision of the model. Airfoil geometry definite by twenty points for both the top and bottom surface will result in an accurate definition. The on the left is the x-coordinates. The central column is the y-coordinates and the right column is the z-coordinates. There must be no blank lines between the rows of coordinates and at least one space dividing the columns of coordinates from each other. The coordinates should also be recorded vertically moving from the trailing edge of the airfoil toward the leading edge for the top surface first and then the bottom surface. The two coordinates that define the tail of the airfoil don't bring the geometry to a single point.

4.3. Creation of the Wind Turbine Blade Geometry:

Launch Gambit. Once Gambit is open make certain the solver is situated for the suitable output, i.e. **FLUENT 17.2**, by selecting **Solver- FLUENT 17.2**. The coordinate document should be created by the create point tool. The upper and lower surface of the airfoil must be unite with each other, **Geometry Operation-Edge command-Nurbs** operation create the vertices as edges, **Geometry Operation-Face command-Create face from wire frame** create the edges as a face, and then **Geometry Operation-Face command-Sweep face** select the face and mention magnitude 0.624m in positive Y-coordinate system finally volume is created.

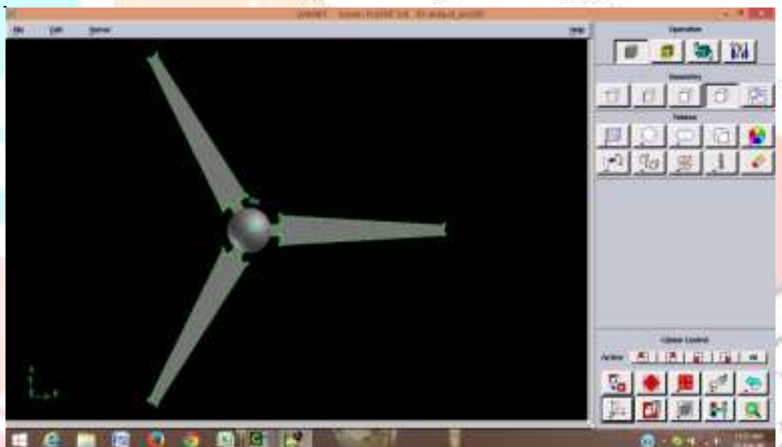


Fig 4.3.3: Creating Volume

4.4. Creating Boundary:

Geometry operation-volume command-Brick size of 0.05x0.2x0.05m size volume as a boundary of a blade, **Geometry operation- volume command-Blend real volumes** champers left range 0.02, right range 0.01m, then it create the blade boundary .

4.5. Create wind turbine with different winglets:

Geometry operation- volume command-Cylinder size height 0.2and radius0.0003m, and select move/copy option and move mid cord of the airfoil, the turbine blade with 0 winglet and blade with 45 and 90 winglets are created. **Geometry operation-volume command-Subtract real volumes** Subtract blade volume to cylinder select apply.

4.6. Meshing:

Meshing is done in GAMBIT for accurate meshing, by selecting the mesh this opens the surface mesh window. **Surface Mesh →Part mesh setup → Compute Mesh.** The volume mesh will be a Tetra element mesh and type Tetra/ hybrid, mesh method is Robust. The spacing worth will focus the density of the volume mesh. The spacing value will be 0.003 for this process. The lesser the spacing value will increase the mesh quantity. Consider that while a denser mesh gives accurate results, the calculation time is also improved. After compute the mesh turbine blade with different winglets are meshed.

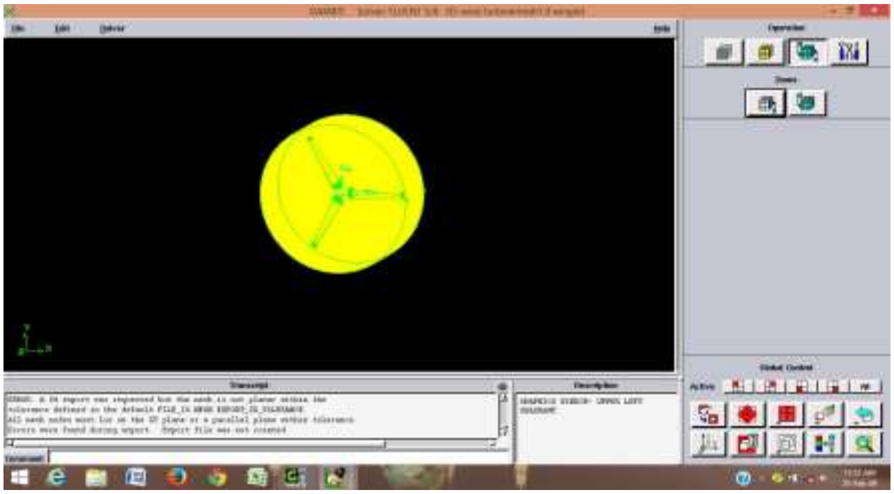


Fig 4.6.1: Blade mesh with 0 degrees winglet

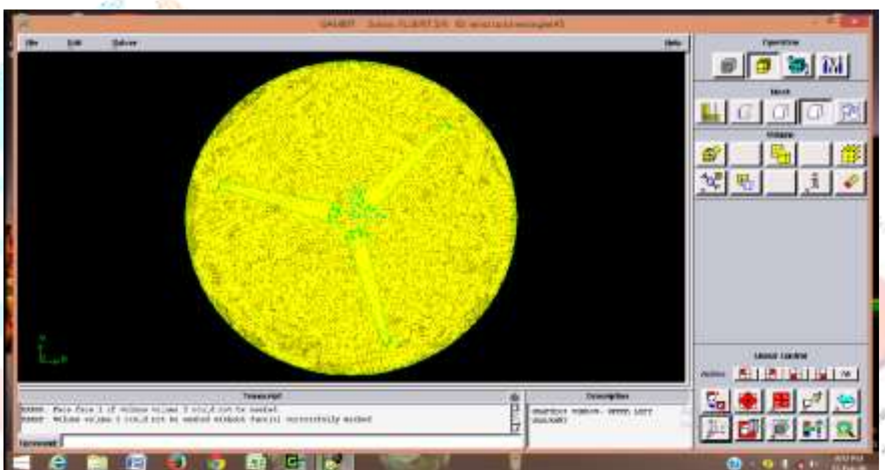


Fig 4.6.2: Blade mesh with 45 degrees winglet

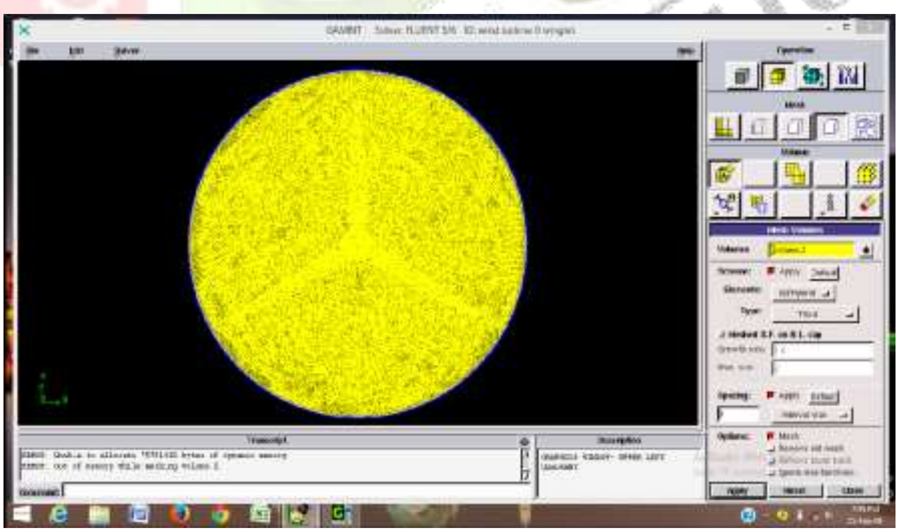


Fig 4.6.3: Blade mesh with 90 degrees winglet

5. RESULTS AND DISCUSSIONS

5.1. CFD Analysis of Turbine Blade:

The CFD analysis is carried out with different models using turbine blade with 0 winglet and 45 and 90 degree winglets

Table 5.1: Shows the variation of static pressure, velocity magnitude, with respect blade with 0 winglet and blades with 45 and 90 degree winglets.

Velocity	Parameter	zero degrees winglet	45 degrees winglet	90 degrees winglet
7	static velocity	8.27	8.27	8.26
	static pressure	4.48	3.08	5.67
10	static velocity	11.18	11.18	11.18
	static pressure	9.05	6.4	11.16
12	static velocity	11.42	11.42	11.42
	static pressure	11.31	9.14	11.68

5.2. Static Pressure:

Table 6.1 shows the variation of static pressure, velocity magnitude with respect blade with 0 winglet and blades with 45 and 90 degree winglets. . The maximum static pressure of blade containing 12m/s and it is11.68Pa minimum is 7m/s. and it is 4.48Pa

5.3. Velocity Magnitude:

Table 6.1 shows the variation of static pressure, velocity magnitude, with respect blade with 0 winglet and blades with 45 and 90 degree winglets. . The maximum static velocity of blade containing 12m/s and it is11.42m/s minimum is 7m/s. and it is 8.27m/s

5.4. Analysis of Blade at 7m/s:

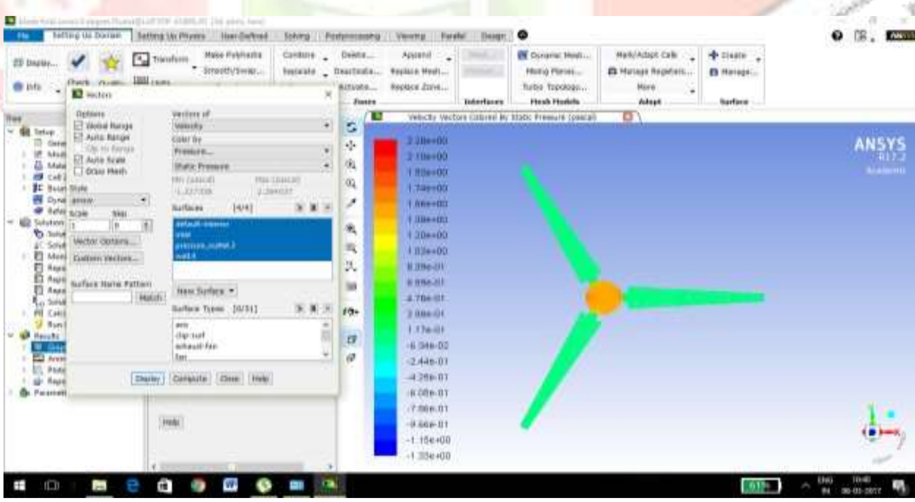


Figure 5.4.1: Static pressure of blade at 0^0winglet

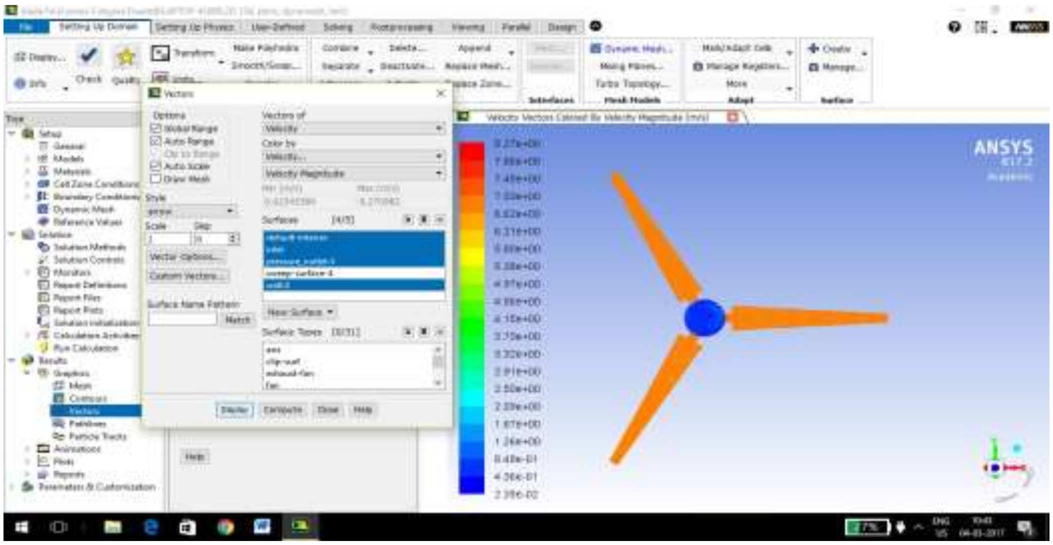


Figure 5.4.2: Static velocity of blade at 0^0winglet

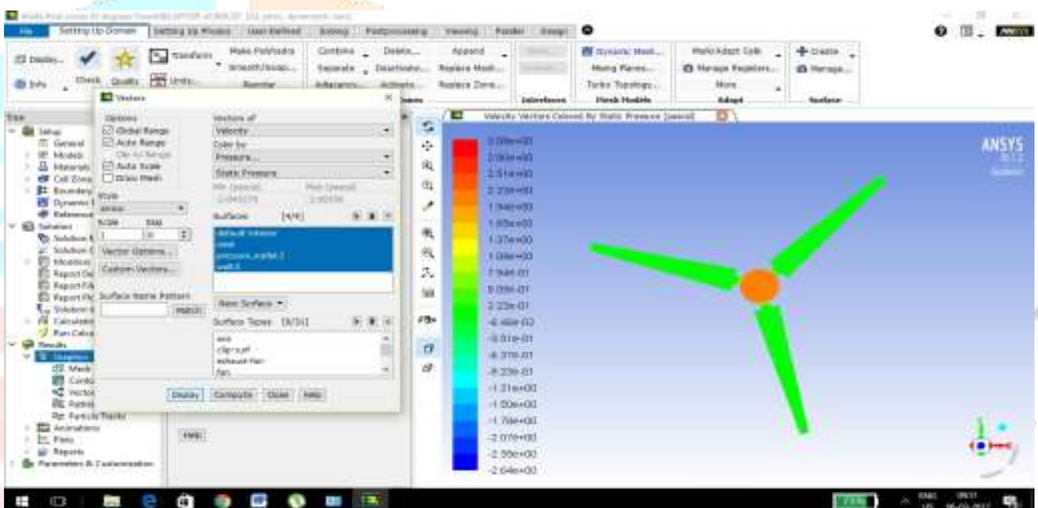


Figure 5.4.3: Static pressure of blade at 45^0winglet

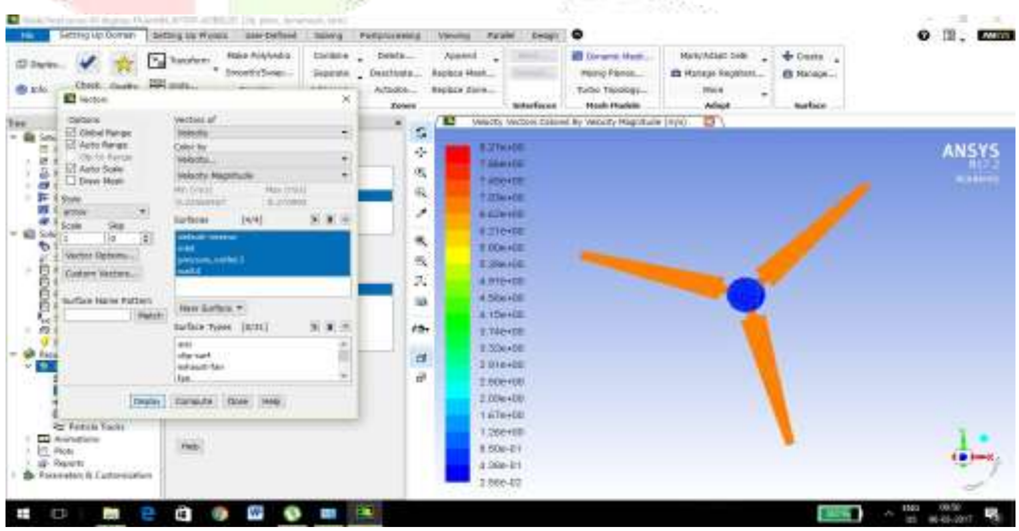


Figure 5.4.4: Static velocity of blade at 45^0winglet

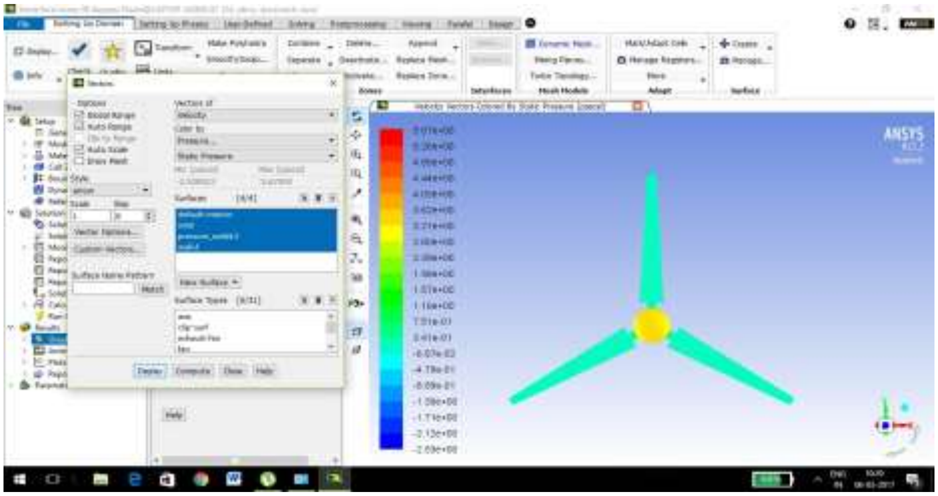


Figure 5.4.5: Static pressure of blade at 90^0winglet

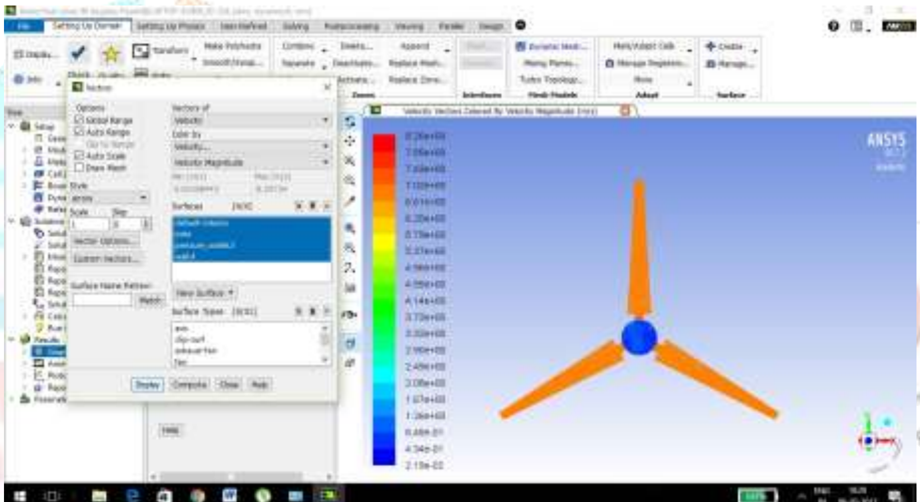


Figure 5.4.6: Static velocity of blade at 90^0winglet

The above figures shows the Variation of static pressure, velocity magnitude with respect blade with 7m/s containing 0 winglet and blades with 45 and 90 degree winglets. . The maximum static pressure of blade containing 90degrees winglet is and it is 5.67Pa minimum is at 45 degree winglet is 3.08Pa

5.5. Analysis of Blade at 10m/s:

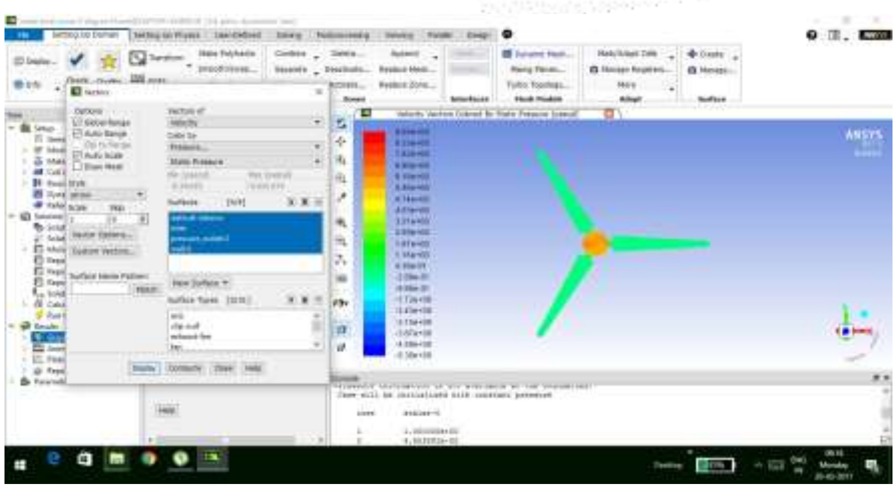


Figure 5.5.1: Static pressure of blade at 0^0winglet

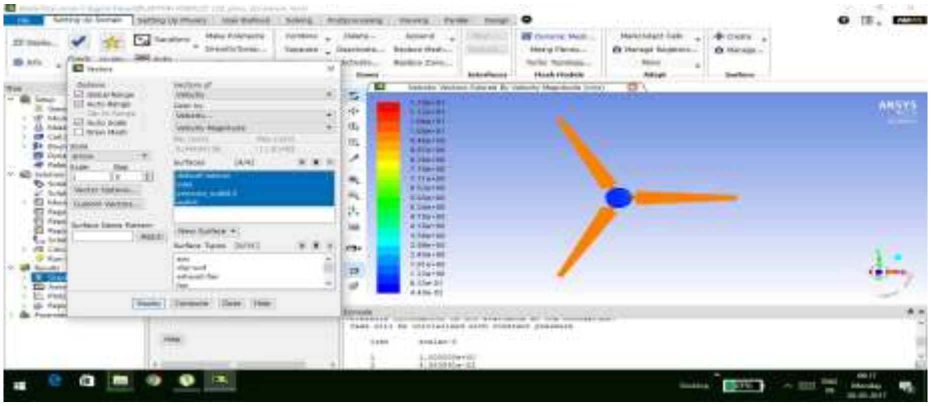


Figure 5.5.2: Static velocity of blade at 0^0winglet

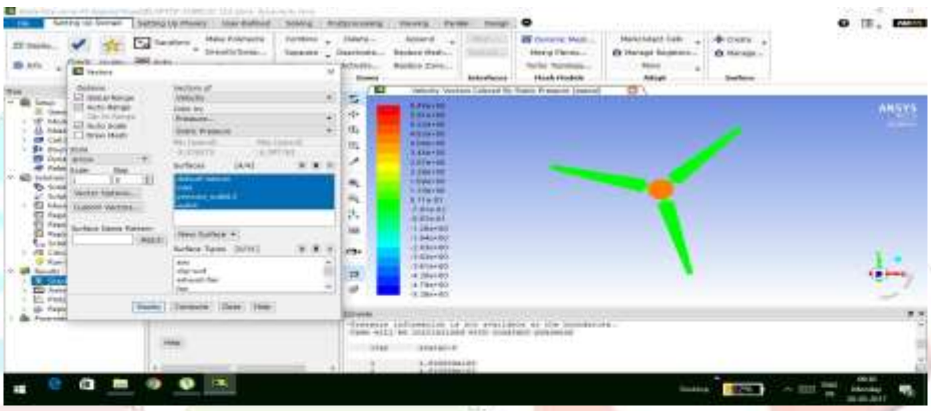
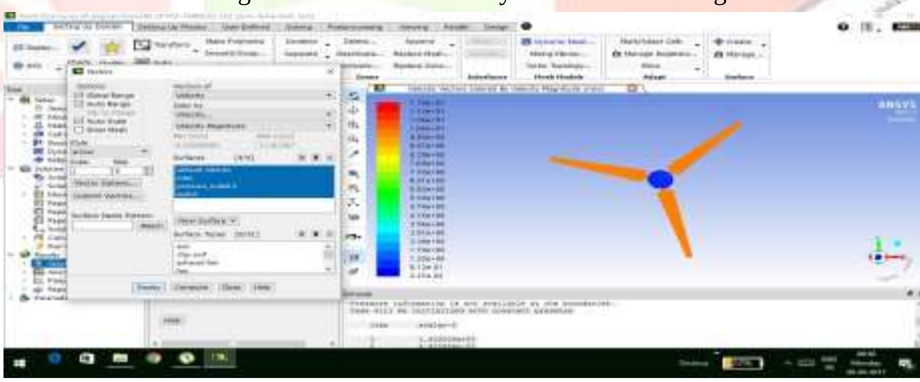


Figure 5.5.3: Static pressure of blade at 45^0winglet

Figure 5.5.4: Static velocity of blade at 45^0winglet



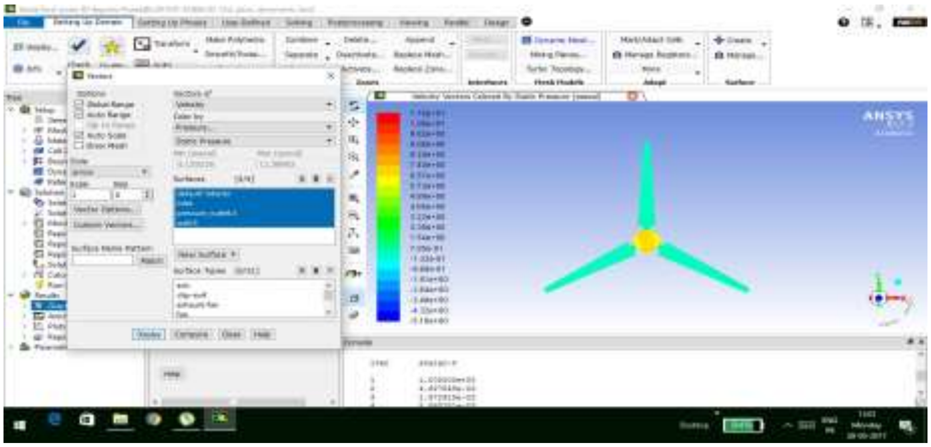


Figure 5.5.5: Static pressure of blade at 90^0winglet

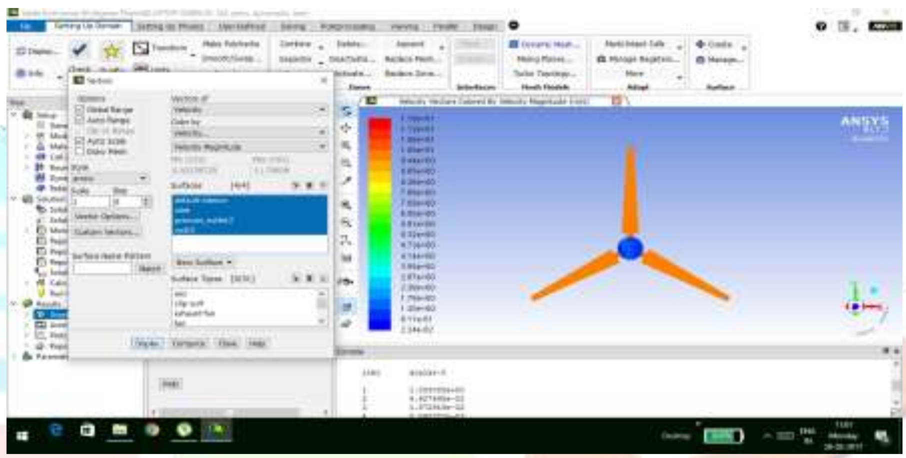


Figure 5.5.6: Static velocity of blade at 90^0 winglet

The above figures shows the Variation of static pressure, velocity magnitude with respect blade with 10m/s containing 0 winglet and blades with 45 and 90 degree winglets. . The maximum static pressure of blade containing 90degrees winglet is and it is 11.16Pa minimum is at 45 degree winglet is 6.4Pa.

5.6. Analysis of Blade at 12m/s:

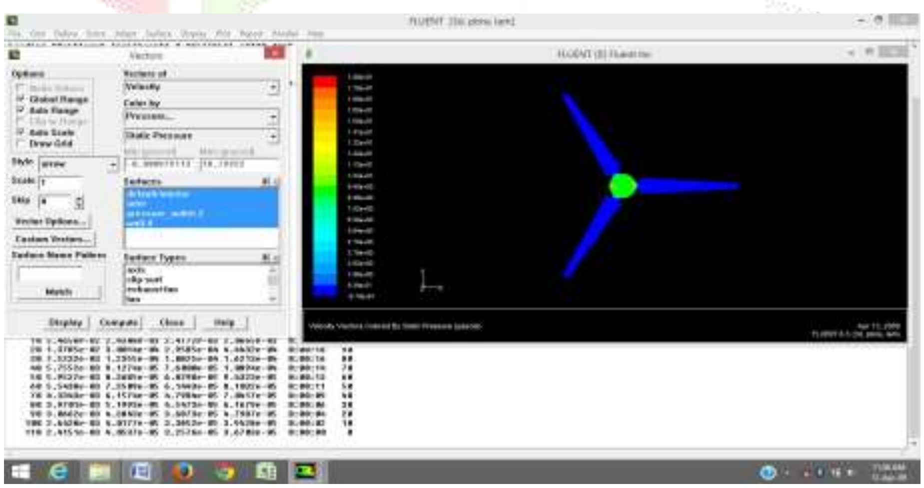


Figure 5.6.1: Static pressure of blade at 0^0winglet

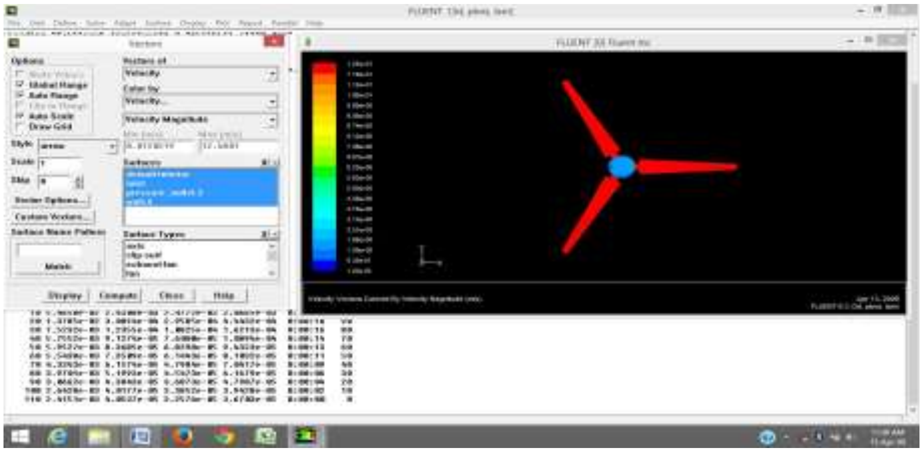


Figure 5.6.2: Static velocity of blade at 0^0winglet

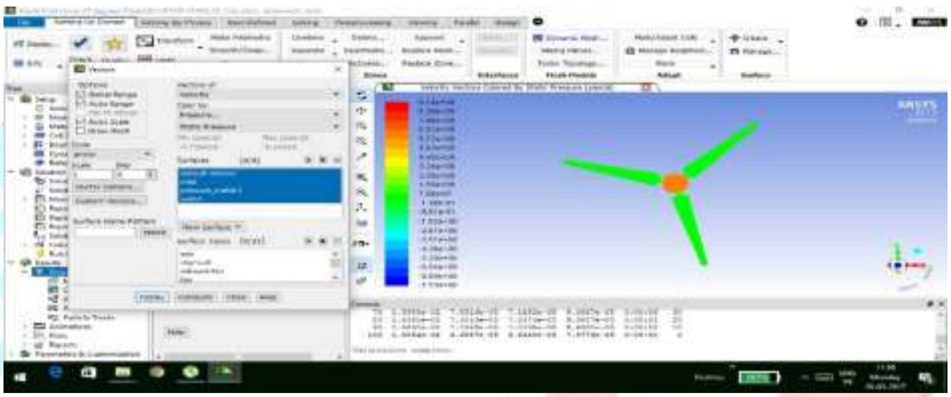


Figure 5.6.3: Static pressure of blade at 45^0winglet

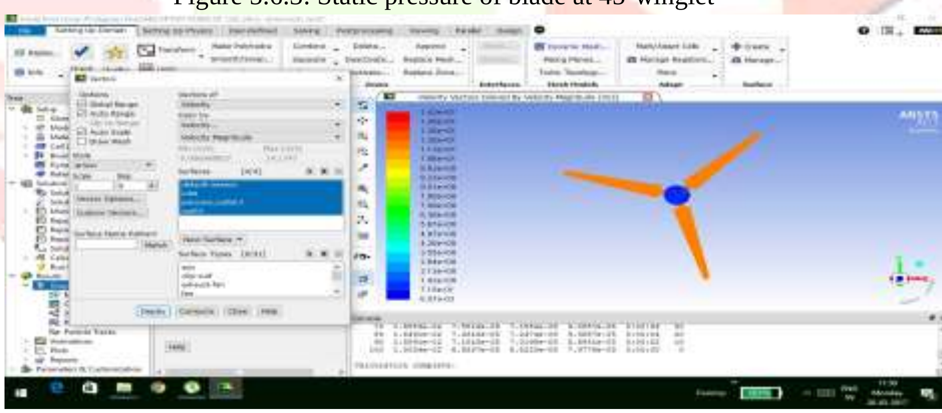


Figure 5.6.4: Static velocity of blade at 45^0winglet

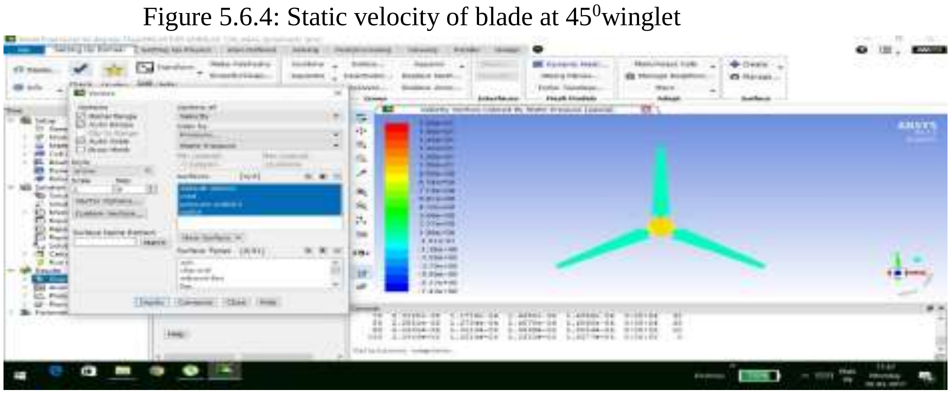


Figure 5.6.5: Static pressure of blade at 90^0winglet

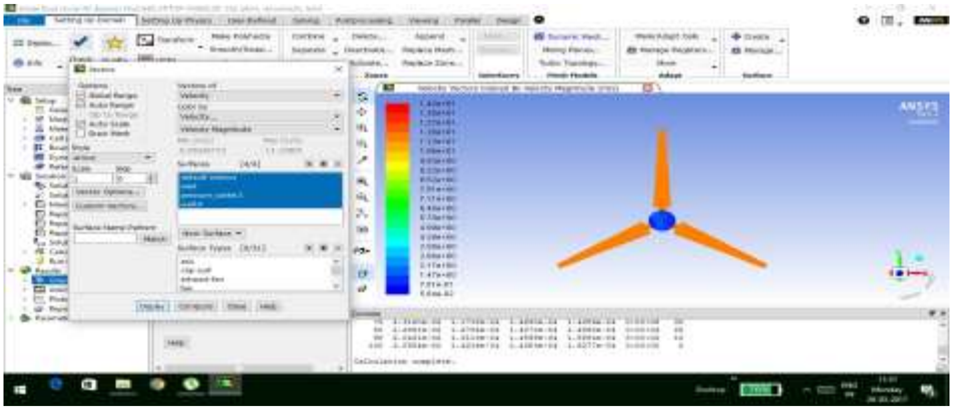


Figure 5.6.6: Static velocity of blade at 90^0winglet

The above figures shows the Variation of static pressure, velocity magnitude with respect blade with 12m/s containing 0 winglet and blades with 45 and 90 degree winglets. . The maximum static pressure of blade containing 90degrees winglet is and it is 11.68Pa minimum is at 45 degree winglet is 9.14Pa

6. CONCLUSION

CFD analysis of wind turbine blade is carried out with different models consisting of blade with 0^0winglet and blade with 45^0 and 90^0 of winglets. It is found that total pressure is maximum at 90degree winglet at a speed of 12m/s. By observing the tabular data obtained by analyzing of wind turbine blades the minimum of static pressure is obtained at 45 degree winglet at speed 7m/s and its optimum of maximum power output. Modern wind turbines have achieved much higher efficiency than their predecessor, mainly due to the advancement in experimental and computational technologies. The next obvious step is to fabricate this aerodynamic design using common materials and utilizing mass manufacturing process.

7. REFERENCES

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