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Wind Tunnel Simulation on Turbine blades of wind mills under various critical speeds

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Abstract: ***Rapid deployment of renewable energy and energy efficiency is resulting in significant energy security, climate change mitigation, and economic benefits. In international public opinion surveys there is strong support for promoting renewable sources such as solar power and wind power. The Wind turbine is used for converting wind energy into the electrical or mechanical energy using turbines.The amount of power is transferred is based on wind speed and size of the rotor. The Wind varies with time in force and direction and the wind site potential is generally evaluated as a function of the annual average wind speed. Wind speeds can be calculated for other periods to determine hourly, daily or monthly averages. Winds vary with wind speed and height is also affected by ground features like as hills. The variation of wind speed with height is due to friction between air movement and the earth's surface(the atmospheric boundary layer). All weather officers report the wind speed at a standard height of 10meters above ground. Wind near the ground gathers speed to climb a hill, then slow on the far side of the hill. The wind speed strength and direction are measured by anemometers. In this paper we study the design, analysis and experiment on wind turbine rotor blades with different shaped wing tip at various wind speeds to discover the influence of the wing tip design in the efficiency of the wind turbine.***

Keywords: *Wind energy, Efficiency, Turbine, Blade*

Introduction:

Globally, the long-term technical potential of wind energy is believed to be five times total current global energy production, or 40 times current electricity demand, assuming all practical barriers needed were overcome. This would require wind turbines to be installed over large areas, particularly in areas of higher wind resources, such as offshore. As offshore wind speeds average ~90% greater than that of land, so offshore resources can contribute substantially more energy than land stationed turbines.

Compared with traditional energy sources, wind energy has a number of benefits and advantages. Unlike fossil fuels that emit harmful gases and nuclear power that generates radioactive wastes, wind power is a clean and environmentally friendly energy source. As an inexhaustible and free energy source, it is available and plentiful in most regions of the earth. In addition, more extensive use of wind power would help reduce the demands for fossil fuels, which may run out some time in this century, according to their present consumptions.

The wind turbine is a device which converts wind energy into the useful mechanical energy. The wind turbine consists of blade (aerodynamic surface) and fixed on a hub assembly. The control system is to control the overall system. It is mainly used to control the rotor position by adjusting the blade angle properly. The tower is to support the full unit.

An airfoil-shaped body moved through a fluid produces an aerodynamic force. The component of this force perpendicular to the direction of motion is called lift. The component parallel to the direction of motion is called drag. Subsonic flight airfoils have a characteristic shape with a rounded leading edge, followed by a sharp trailing edge, often with a symmetric curvature of upper and lower surfaces. Foils of similar function designed with water as the working fluid are called hydrofoils.

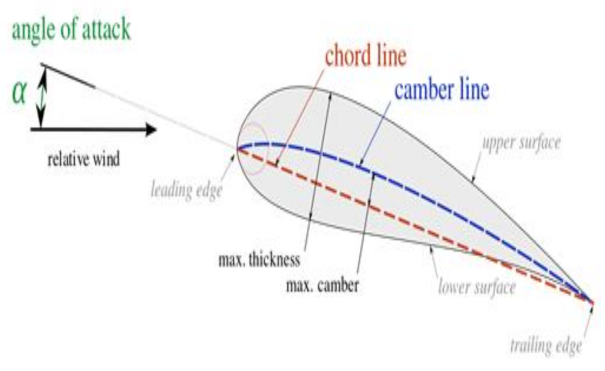


Fig: AirFoil terminology

To create the blade model based on airfoil profile.The Computational domain was designed as rectangular box shape and blade are designed inside of the domain.This Blade and the domain were created in Creo Parametric 2.0.The dimension of the domain and blade is given below.

Existing System and its disadvantage

1. Currently much research has concentrated on improving the aerodynamic performance of wind turbine blade through wind tunnel testing and theoretical studies. These efforts are much time consuming and need expensive laboratory resources.
2. Most of the existing wind turbine blades are constructed without wing tip due to manufacturing constraints. Blades with wing tip are studied by researchers and only limited numbers of research papers are available towards wing tip design and its effects.

Proposed System and its advantage

1. In the proposed system, in addition to wind tunnel study and Blade momentum theory, the blade with different shaped wing tip is studied and numerically simulated through Computational Fluid Dynamics software which offers inexpensive solutions. Comparing to traditional theoretical and experimental methods, numerical method saves money and time for the performance analysis and optimal design of wind turbine blades.
2. The function of the wing tip devices commonly used in the aeronautical industry reduces drag on airplanes. In the proposed system, this idea is reassigned and implemented in the design of wind turbine blade in order to enhance its efficiency.

Flat blade(existing)

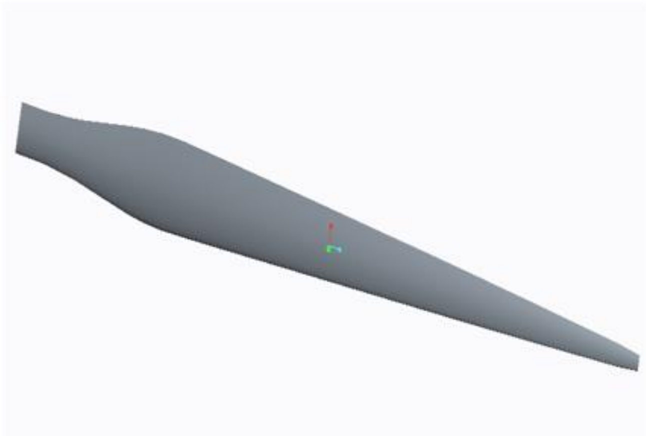
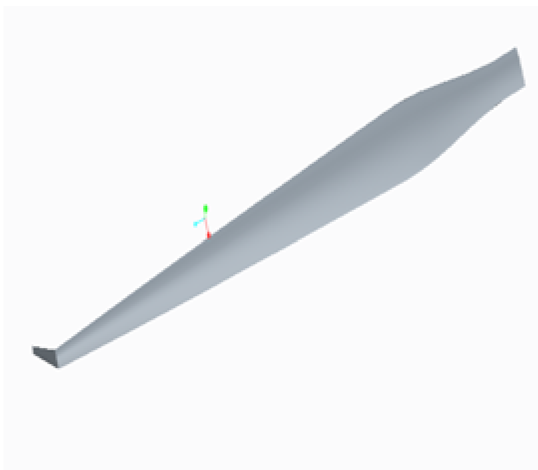


Fig. Flat blade(existing)

Blade length	26.5m
Area	83.7267m^2

Table: flat blade length and area

Concept 1(45 inclined/2m winglet)



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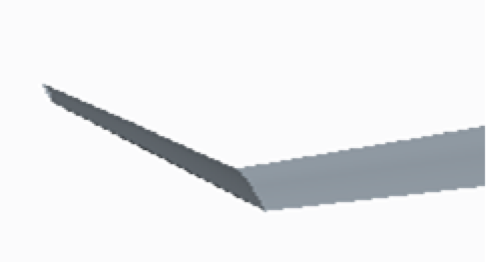
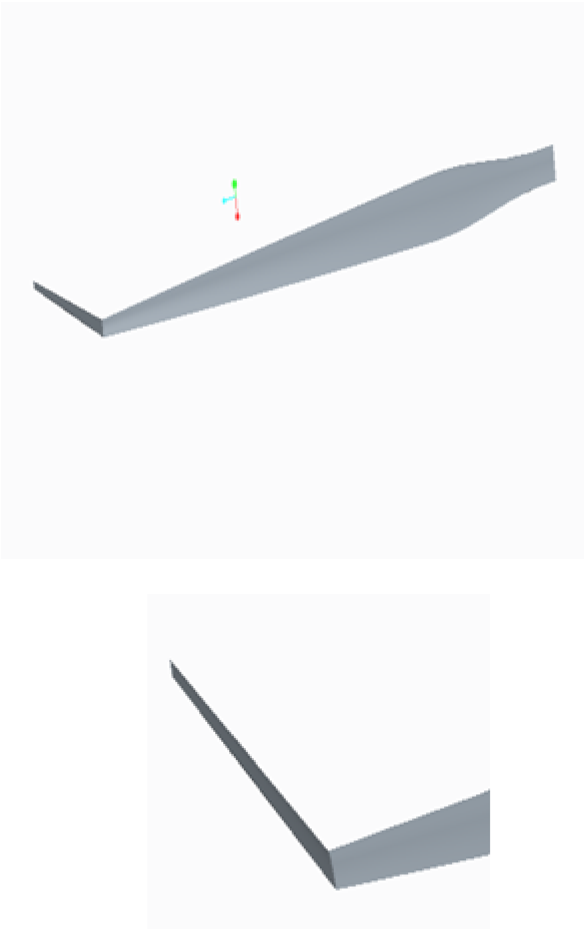


Fig Concept 1(45 inclined/2m winglet)

Blade length	27m
Area	84.1223m^2

Table :concept1 blade length and area

Concept 2(45 deg inclined/3m winglet)



FigConcept 2(45 deg inclined/3m winglet)

Blade length	29m
Area	86.217m^2

Table:concept 2 blade length and area

Concept 3(winglet inclined at 45 deg)

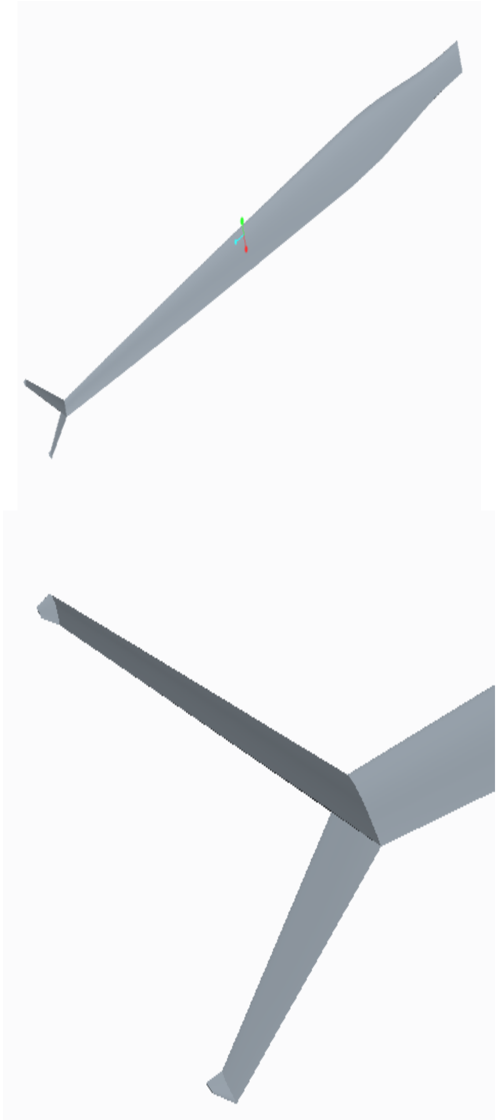


Fig: Concept 3(winglet inclined at 45 deg)

Blade length	27.8m
Area	86.42m^2

Table :concept 3 blade length and area

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Concept 4(vertical winglets)

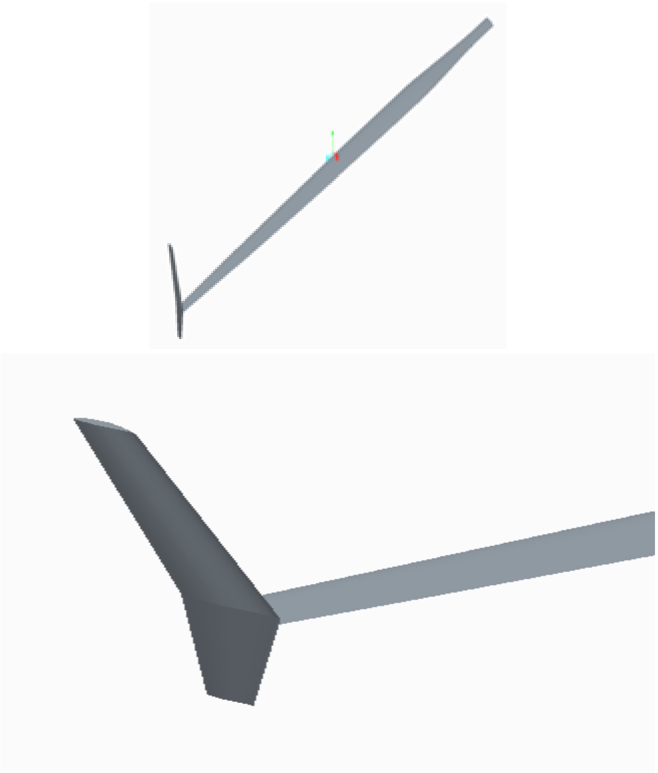
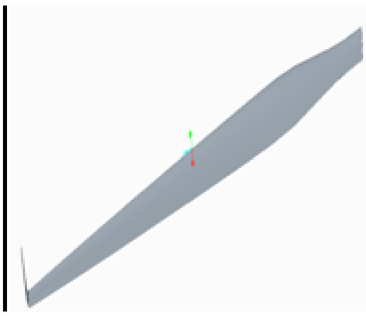


Fig: Concept 4(vertical winglets)

Blade length	27m
Area	86.286m^2

Table:concept 4 blade length and area

Concept 5(vertical winglet/2m)



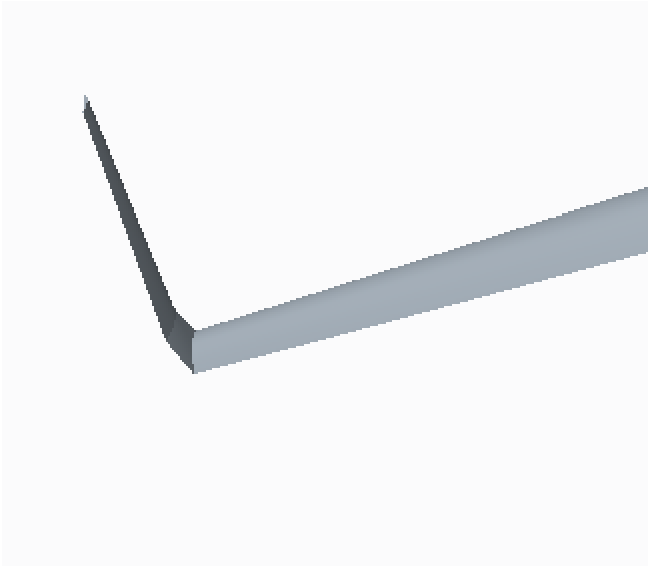
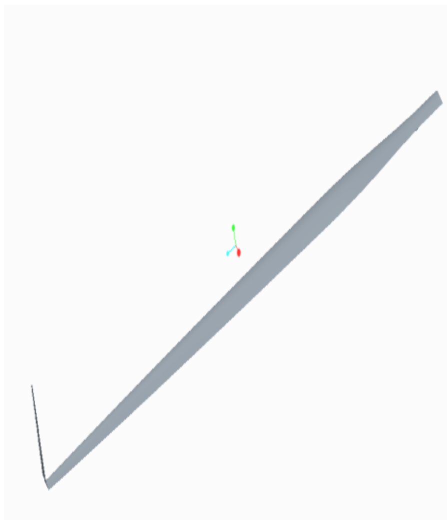


Fig:Concept 5(vertical winglet/2m)

Blade length	27m
Area	84.39m^2

Table: concept 5 blade length and area

Concept 6(vertical winglet/3m)



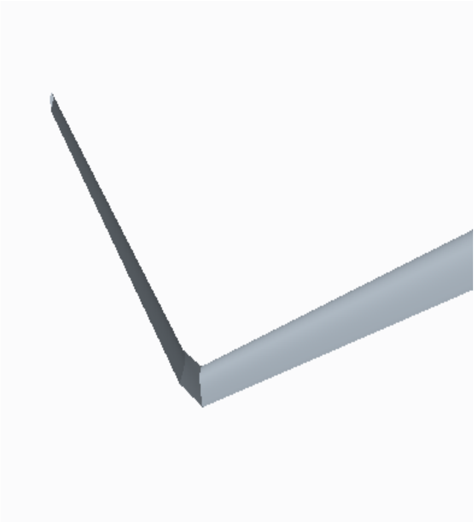


Fig: Concept 6(vertical winglet/3m)

Blade length	27m
Area	85.196m^2

Table: concept 6 blade length and area

Result and Discussion

pressure contour:

plane at 15m in the span area

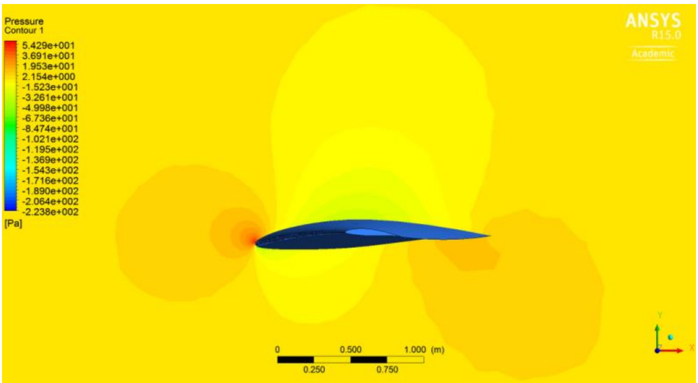


Fig.Flat blade (existing)

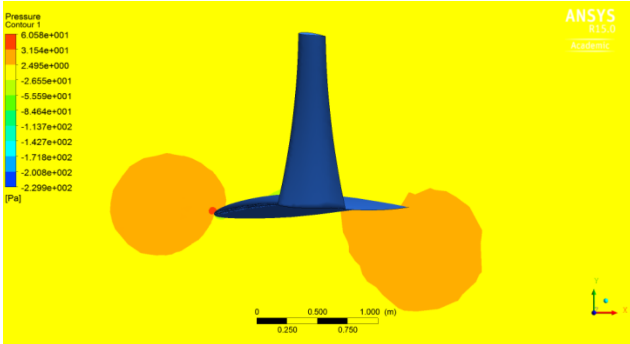


Fig.Concept 1 (45 deg inclined/2m)

pressure distribution at wide span area of blades:

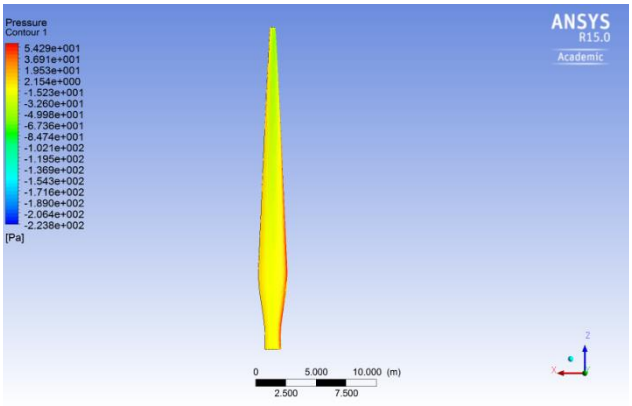


Fig.Flat blade (existing)

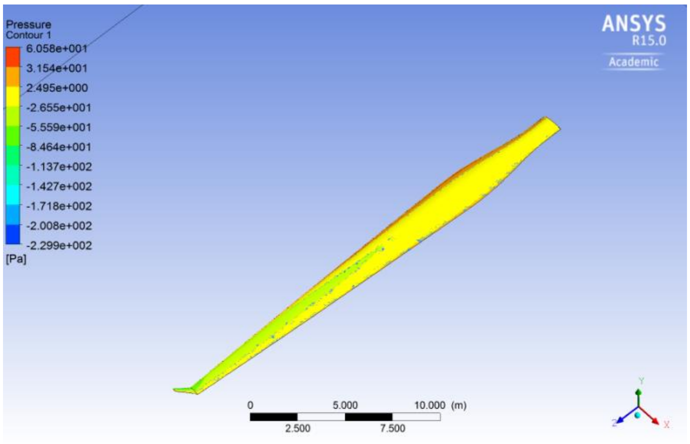


Fig.Concept 1 (45 deg inclined/2m)

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Velocity contour:

Plane at 15m in the span area

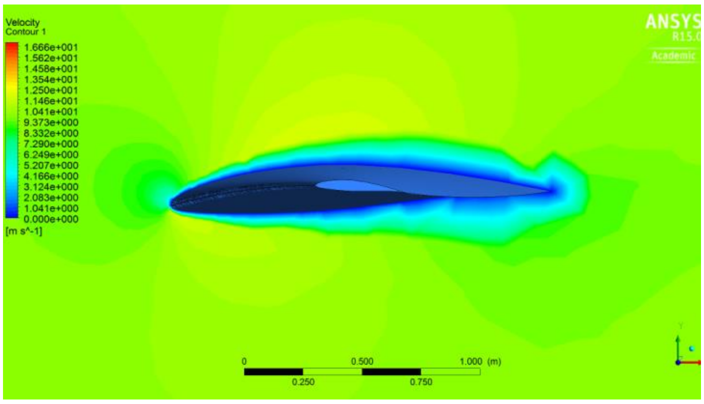

Fig. 6.15Flat blade (existing)

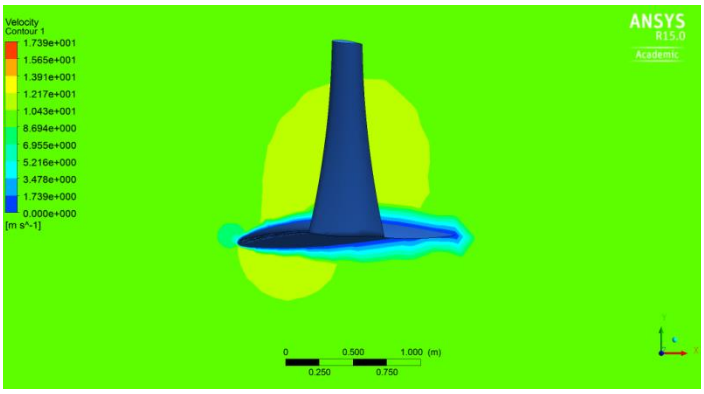

Fig. 6.16Concept 1 (45 deg inclined/2m)

Lift and drag values for different blades are found out from the cfd analysis

Blade	**Lift(N)**	**Drag(N)**
Flat blade(existing)	139.93	49.546
Concept1(45 inclined/2m winglet)	146.749	43.762
Concept 2(45 deg inclined/3m winglet)	170.853	44.694
Concept 3 (winglets inclined at 45 deg/double)	169.03	44.943
Concept4(vertical winglets/double)	118.057	43.033
Concept5(vertical winglet/2m)	116.062	42.375
Concept6(vertical winglet/3m)	120.038	42.33

Table: lift and drag values

L/D ratio:

Blade	**L/D Ratio**
Flat blade(existing)	2.82
Concept1(45 inclined/2m winglet)	3.353
Concept 2(45 deg inclined/3m winglet)	3.82
Concept 3 (winglets inclined at 45 deg/double)	3.76
Concept4(vertical winglets/double)	2.74
Concept5(vertical winglet/2m)	2.73
Concept6(vertical winglet/3m)	2.83

Table: L/Dratio

From the above table we can understand that concept 2 blade is effective one.

CONCLUSION

In present study, wind turbine blade has been designed for the rated power output of 700kw for 10 m/s and the same is analyzed by ANSYS FLUENT 15.0. then the tip modified blade is analyzed with the same software shows that lift-to-drag ratio is more for the blade with winglets. The pressure and velocity contour has also been studied which also shows a positive result. Thus the concept 2 blade has more L/D ratio than all other blades which clearly shows it is more efficient than other blades.

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