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Inlet Shroud Angle of a Shrouded Wind Turbine

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Abstract:** In order to utilize the wind power more economically, it was suggested that a specially designed shroud could be used to enclose the wind turbine so that its performance could be increased. Various geometries are discussed; it is shown that with a shroud a significant power augmentation can be achieved. For improving the performance of shroud, a ring-shaped flap or boundary layer control technique is introduced. It is shown that up to 80% improvement in the shroud power augmentation can be obtained by the use of an appropriate ring-shaped flap while proper bleeding of the shroud's external flow into its inner rear part will increase its power augmentation by about 25%. The main aim of this project is to reduce the length of the shroud so that such shrouds can be economically implemented for larger wind turbines and thus the power output can be increased efficiently. If we can reduce the length (L/D ratio) of the shroud it will reduce the total volume of material required, the strength of the support, space needed. If the shroud can be incorporated with the large wind farms the total power generation and efficiency will be increased

Keywords: wind energy, shroud, L/D ratio, shrouded turbine, efficiency

I. INTRODUCTION

Human activity is overloading our atmosphere with carbon dioxide and other global warming emissions, which trap heat, steadily drive up the planet's temperature, and create significant and harmful impacts on our health, our environment, and our climate.

Production of electricity causes more than one-third of U.S. global warming emissions, because a major percentage of electricity is generated by coal-fired power plants, which accounts for nearly 25 percent of United States global warming emissions and about 6 percent of total emissions are being produced by natural gas-fired power plants. In contrast, the renewable energy sources produce only negligible amount of global warming emissions. This can be depicted by the data aggregated by the International Panel on Climate change, which states that manufacturing, installation, operation and maintenance of renewable sources of energy produces minimal global warming emissions.

Energy is a hot topic in the news today: increased consumption, increased cost, depleted natural resources, our dependence on foreign sources, and the impact on the environment and the danger of global warming. Wind energy has great potential to lessen our dependence on traditional resources like oil, gas and coal and to do it without as much damage to the environment

A. Advantages of Wind Energy

1) Wind is free.
2) Absence of fossil fuel usage to generate electricity.
3) Advancement in technologies helps in more efficient production of energy
4) Comparatively lesser floor area required for wind turbine than a power station of similar capacity.
5) More freedom of location makes it possible to place the turbines in remote locations, such as offshore, deserts and mountains.
6) Higher reliability in electricity production when wind energy is combined with other alternative sources of energy.

A major advantage to the wind energy is that the energy is free. However, it is important that when established, it is in an area with plenty of wind and resources to create the power, so that a long-term project can supply energy for a sustained lifetime. Wind energy can be used to generate adequate amount of power required for an entire neighborhoods and its associated businesses with the help of a turbine grid set up. It can be used as a source of power supply not only to large areas, but also to smaller vehicles and buildings. Wind energy is considered as an important resource due to its versatility. Depending on the requirement of power, large or small-scale turbines can be implemented. However, this could be a major consideration for the engineers to choose the quantity of power going back into the grid.

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In the first stage of erection of wind turbine, the output power will not be known. Studies about the wind speed are normally implemented during this stage and this data helps in giving a long- term projection. Conventionally, the wind turbine could produce more energy when more wind velocity is available, so as there is an increase in wind speed, the energy production is also increased. So, this means that when the wind velocity increases from 6 m/s to 10 m/s, the energy production could increase from 67 percent to 134 percent[1]. Thus, a huge amount of energy can be produced and added to the power grid for a smaller increase in wind velocity. The variations in wind speed are to be studied and proper measures are to be taken to obtain a higher value for wind velocity, to account for the anticipated production of wind energy.

Wind energy is also important, since on a smaller scale, farms and small plants can use this power, saving the farmer money, as well as allowing them to supply their own energy to the area. Even though the speed of wind can vary at these locations, the energy obtained by such small scale turbines can be used to power small vehicles and machineries. This allows the company to become more self-sufficient. When there is an increase in output power from such small scale turbines, it helps in producing enough power to run the entire neighborhoods and its associated businesses. This extra power thus produced can be used to sustain these areas, and thereby reducing the stress of a typical conventional power plant.

The importance of wind energy lies in its capability to be used forever, as long as there is wind. Since wind is a natural process, caused due to the flow of air from a higher pressure region to a lower pressure region, it is a non-ending process and one of the cleanest form of energy. The process of converting wind velocity to useful energy is environment friendly as no harmful emission of pollutants are associated with it. Therefore the wind energy has a very minimal impact on the atmosphere. Once the wind farm is setup, it provides clean and sustainable energy without much operating costs.

The kinetic energy associated with the wind's velocity is effectively converted to useful energy with the help of a wind turbine. Due to the higher potential of wind energy to become an effective alternative fuel for the conventional fossil fuels, many researches are being developed in the recent years regarding the horizontal axis and vertical axis types of wind turbines. Battery charging for auxiliary power can be obtained by operating the smallest sized turbines, especially in areas of lower wind velocities. Medium sized turbines proved to be effective in supplying power for domestic purposes and also to supply the excess power generated to the electrical grid. Large turbines are grouped together to form arrays, known as wind farms. Such wind farms are effectively utilized by many countries as renewable energy source as part of their strategy to reduce reliance on fossil fuels.

Wind turbine design is the process of defining the form and specifications of a wind turbine to extract energy from the wind. A wind turbine installation consists of the necessary systems needed to capture the wind's energy, point the turbine into the wind, convert mechanical rotation into electrical power, and other systems to start, stop, and control the turbine.

The German physicist Albert Betz, in 1919, illustrated that for an ideal hypothetical wind-energy extraction machine, not more than 16/27 (59.3%) of the kinetic energy of the wind can be captured. His theory was based on the fundamental laws of conservation of mass and energy [2]. In modern turbine designs, about 70 to 80% of the theoretical Betz limit can be achieved.

B. Shrouded Wind Turbine

A modification made to the existing wind turbine so as to make it more efficient in capturing the wind energy is the shrouded wind turbine. A ring shaped structure known as a "brim" or "wind lens" is added to the turbine, which surrounds the blades, and helps in diverting the air away from the exhaust of the blades. The turbulence created as a result of the new configuration creates a low pressure zone behind the turbine, causing greater wind to pass through the turbine, and this, in turn, increases blade rotation and energy output.

Wind power is proportional to the wind speed cubed [1]. If we can increase the wind speed with some mechanism by utilizing the fluid dynamic nature around a structure, namely if we can capture and concentrate the wind energy locally, the output power of a wind turbine can be increased substantially. A new and more efficient wind power extraction turbine system has been developed. A diffuser shroud is provided for this system, at the circumference of its rotor so as to enhance the wind energy concentration. The shroud which is now acting as a diffuser is named "Wind lens". A compact collection-acceleration device is being developed to apply the wind-lens structure to larger size turbines [2]. There are several ongoing projects in which the wind-lens turbines are involved.

C. Shrouded Wind turbine and its Drawbacks

The main problem for this shrouded design is the length of the shroud. Because of this length (L/D), we can't use wind lens for larger diameter turbines. The shroud length is taken as L/D=1.5 in most of the research papers which are too large, so that it not

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considered as economical to be used. Length of the shroud is 1.5 times the diameter of the turbine [3]. Normally the size if the bigger wind turbines range from 20-60 meter so the length of the shroud will be 30-90 meter that is not at all practical because of the cost of construction and the space requirement for the same. So in this project the primary aim is to reduce the length of the shroud. But from the early research papers already published in this topic the relation between this length of the shroud and the velocity augmentation is proportional. It is observed that for a shroud length corresponding to 7D, maximum wind velocity is obtained. So if we decrease the length of the shroud it will affect the power augmentation. So the optimum value for which the output can be maximized by changing the height of the brim, using different shapes of diffuser.

II. NEED FOR NEW DESIGN

This paper discusses the effect of shroud when the length of the shroud is reduced to 0.5 D. The inlet of the shroud is designed in such a way that maximum velocity augmentation is produced inside the shroud.

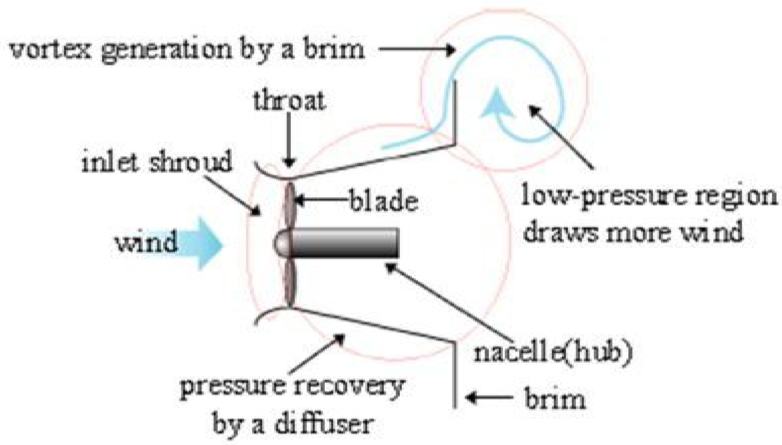

Fig. 1 Shrouded Wind Turbine

Here the inlet shroud is playing an important role in the velocity augmentation. The optimum angle and profile is needed to get the best result.

III. METHODOLOGY AND DESIGN

In the existing design the brim is kept perpendicular and the L/D ratio is taken as 1.5. The velocity augmentation for this design is 1.6 - 2.4.

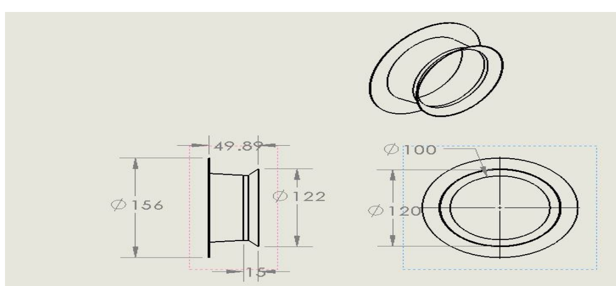

Fig. 2 Diamension od the shroded wind turbine

In this design the L/D ratio is kept at 0.5 and the velocity profile is been noted. Then the flange height is changed to get the optimum value for the shroud.

L/D = 0.5 D

D=100 mm

L=50mm

Inlet shroud angle vary from 30˚, 45˚ and 60˚. Flange height fixed as 0.5 D

Inlet vlocity values are 6m/s, 10m/s.

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A. Results When the Shroud Inlet Angle is Kept at 30˚,45˚,60˚and Velocity at 6 m/s and 10m/s

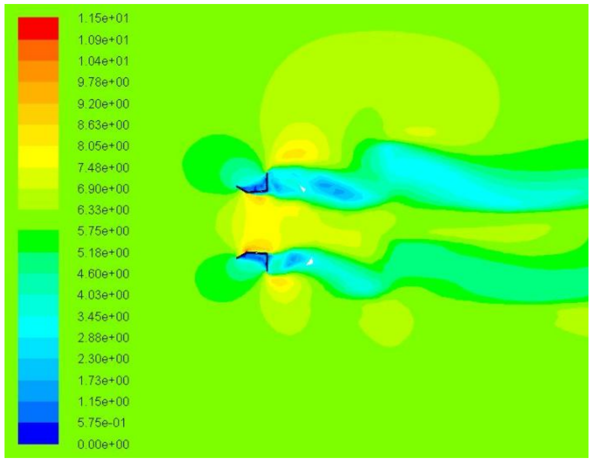

Fig 3 lnlet angle at 30° and wind velocity 6 m/s

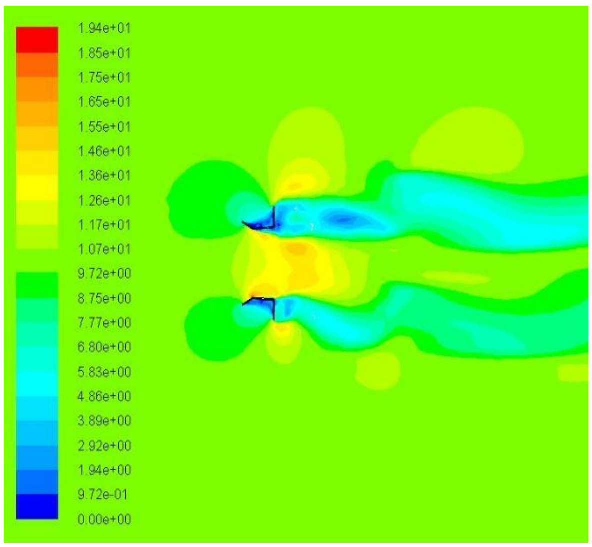

Fig 4 Inlet angle at 30° and wind velocity 10 m/s

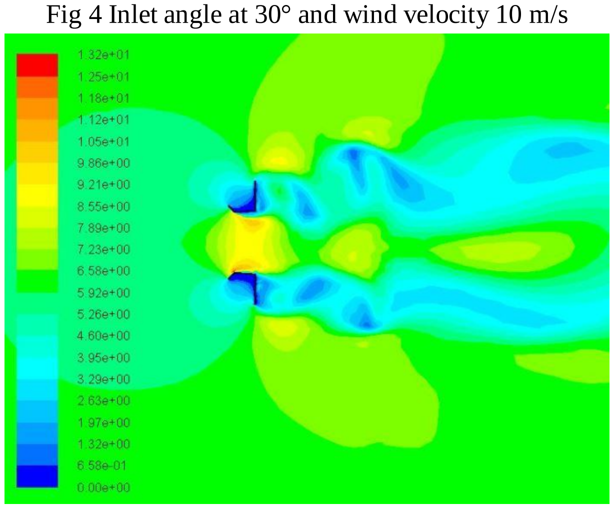

Fig 5 Inlet angle at 45° and wind velocity 6 m/s

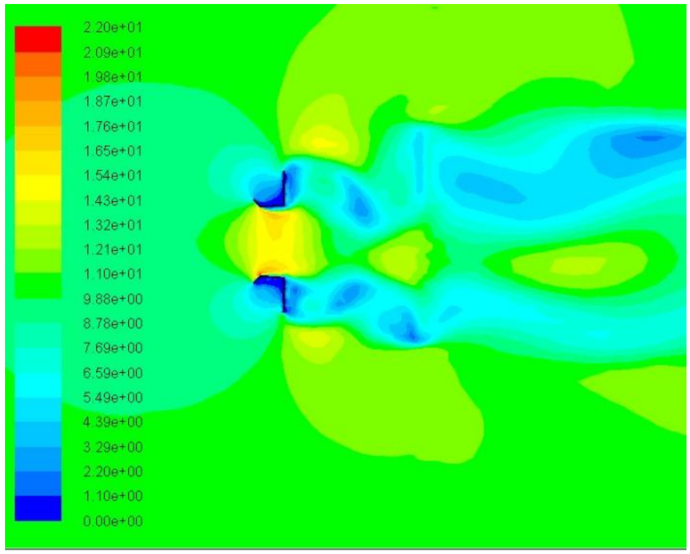

Fig 6 Inlet angle at 45° and wind velocity 10 m/s

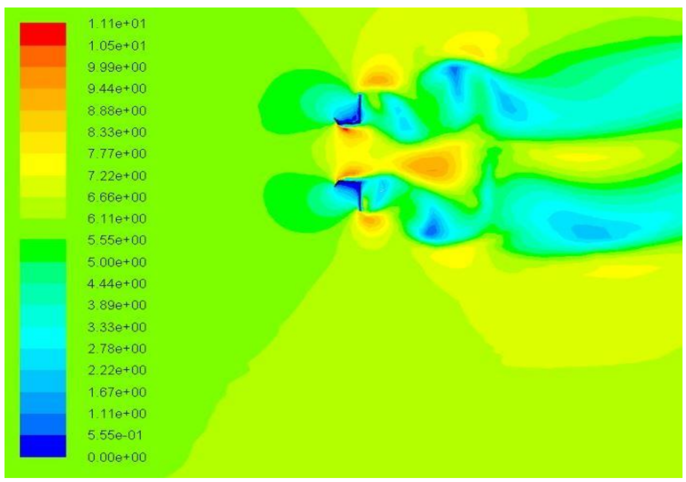

Fig 7 Inlet angle at 60° and wind velocity 6 m/s

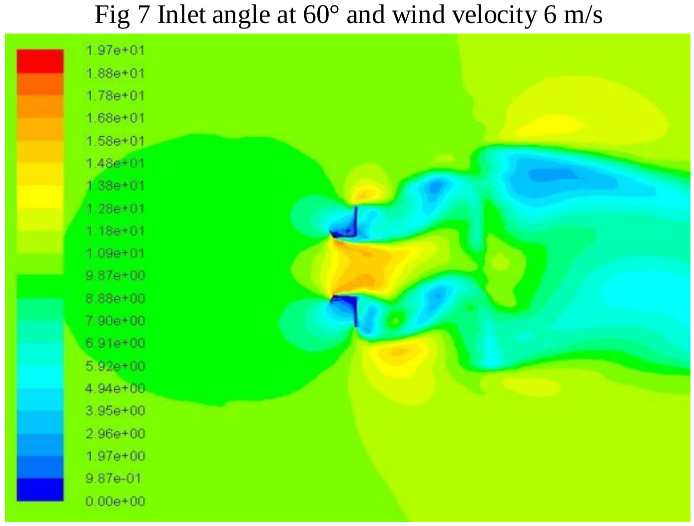

Fig 8 Inlet angle at 45° and wind velocity 10 m/s

From this analysis 30° is giving the maximum augmentation of velocity and we can fix 30° as the optimum value form this results.

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The profile is changed at 30˚ to get better augmentation.By introducing a NACA 4481 aerofile profile to this inlet shroud at 30˚ is giving a better result.

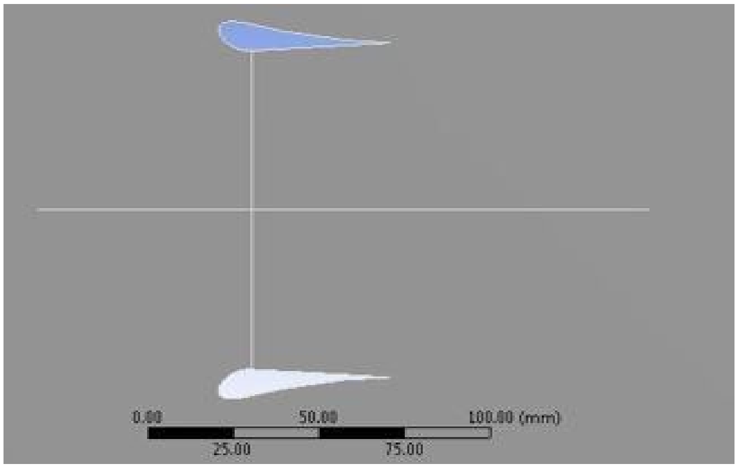

Fig 9 NACA 4418 aerofoil

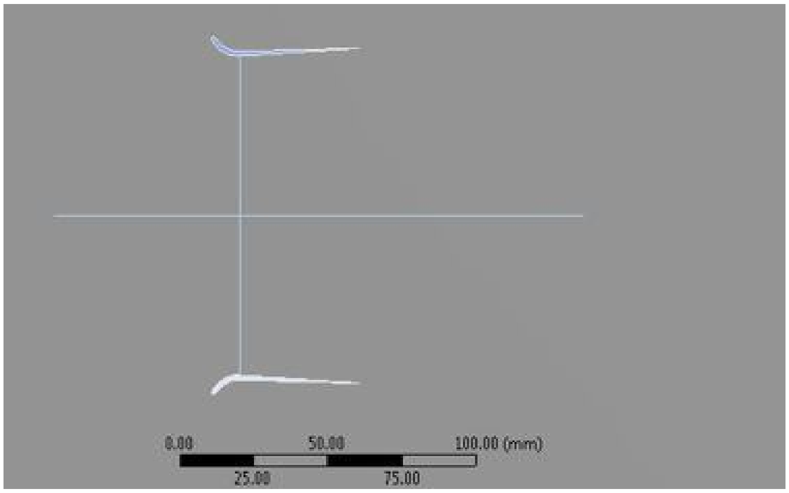

Fig 10 New inlet profile

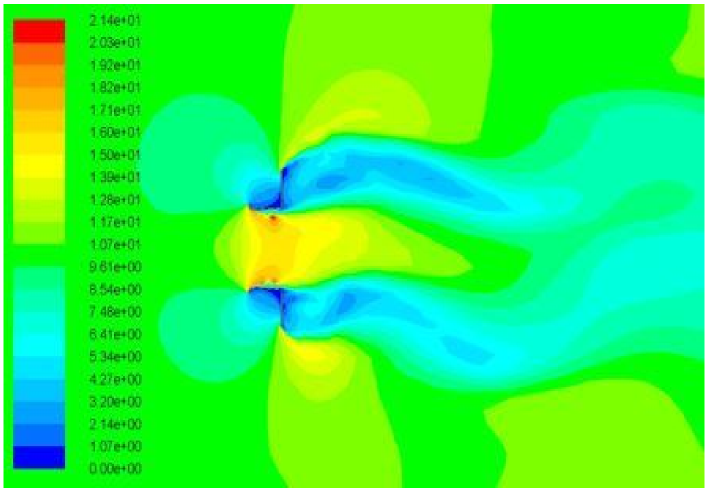

Fig 11 New profile at velocity 10 m/s

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IV. RESULT AND CONCLUSION

A. Comparison of Angles

Shroud with L/D ratio 0.5 and the brim height 0.5 d is used for the analysis. 6m/s and 10 m/s are the velocity tested for the comparison, when the inlet velocity is 6m/s the velocity augmentation of 30˚ inlet shroud is found to be maximum. The radial velocity distribution inside the shroud is given in the figure

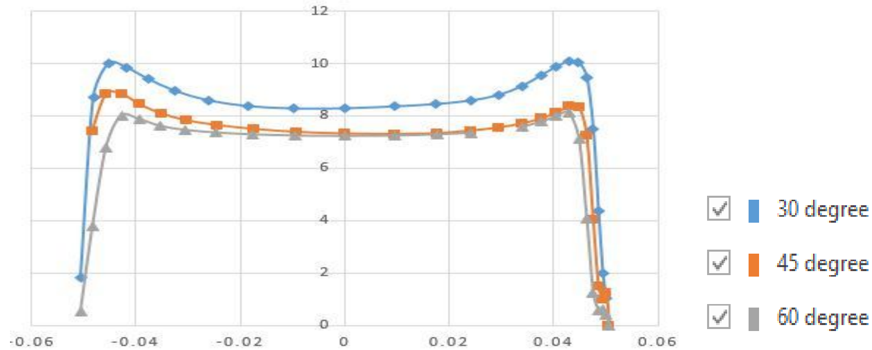

Fig 12 Radial velocity distribution at 6m/s

From the graph it is clear that the maximum value as well as thr average values of the velocity augumentation is more for 30˚ inlet shroud. 60˚ shroud has the minimum velocity augumentation and 45˚ will be in between 30 and 60 degrees. So we can conclude that at 6m/s velocity 30˚ inlet shroud will be better compared to the others

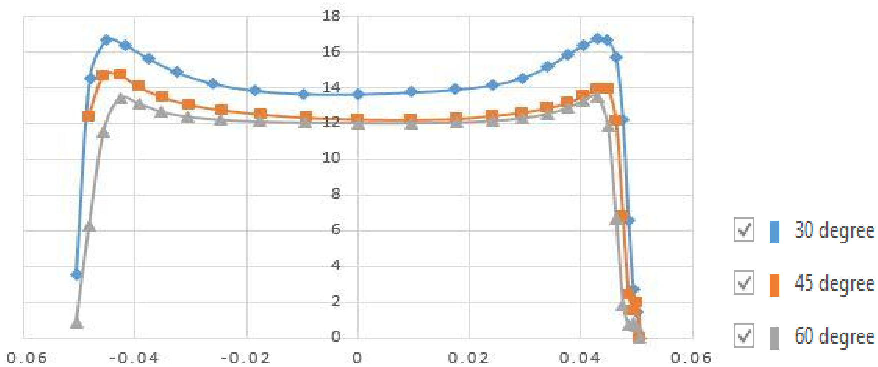

Fig 13 Radial velocity distribution at 10m/s

After completing the analysis of the inlet angle of shroud the same shroud is analysed at 10 m/s inlet velocity of air. The graph is plotted (fig 13) and in that analysis also the 30˚ inlet shroud is giving maximum output.

B. Integrating the NACA 4418 Aero Foil Profile to the Shroud

NACA 4418 aero foil profile is integrated to the 30˚ inlet shroud so that the angle is kept at 30˚ and the profile is aerodynamic so that smooth air flow is possible and thus the velocity augmentation will be maximum. The shroud is then analyzed with the new inlet profile and compared the result with the earlier results.

From the fig 14 the yellow graph represent the new profile that been created using the NACA4418 aero foil and due to better aero dynamicity of the profile a smooth flow pattern is created and its helping the shroud to attain more velocity inside. The smooth flow will reduce the drag force produced by the shroud and that will eventually help to reduce the manufacturing cost also. If the drag is more, foundation and structural cost of the wind turbine will increase and so this new design is helpful in reducing the structural cost too.

Velocity augmentation is low when the inlet shroud angle is 60˚ and it goes on increasing as the angle reduced. We can't reduce the more than 30˚ because the length of the shroud will increase with the reduction in the angle. When the inlet shroud angle is 45˚ its gives more velocity augmentation than 60˚ inlet shroud and the 30˚ inlet shroud is providing the better result comparing the other two.

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In this study 30˚ inlet shroud is taken and the profile is changed to get more aerodynamic so that the flow will be faster without any resistance form the surface.

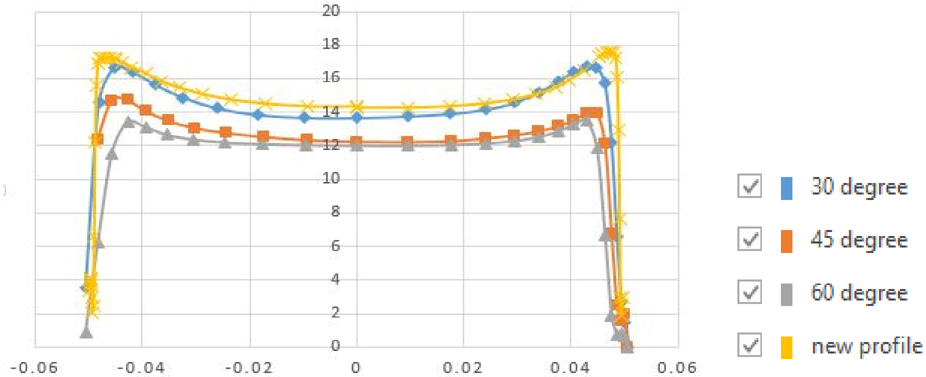
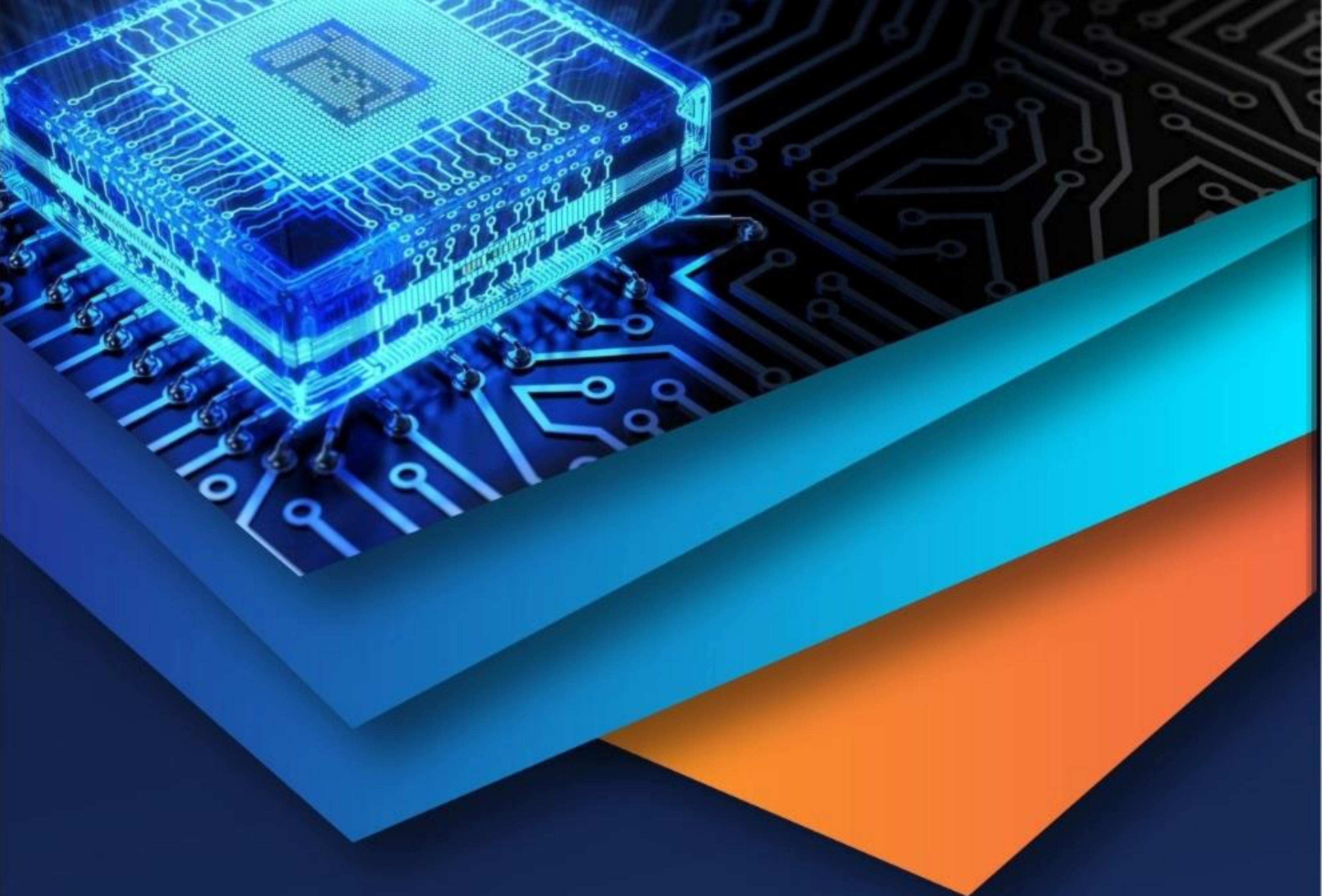


Fig. 14 analysis of the shroud with new profile

From this analysis it is clear that the new profile which is at an angle of 30˚ with the NACA 4418 profile gives better augmentation than the other profiles nearly 5% increase in the velocity.

REFERENCES

[1]. Ohya,Y.,Karasudani,T.,Sakurai,A.,Abe,K.,Inoue,M.,2008.Developmentofa shrouded wind turbine with a flanged diffuser.J.WindEng.Ind.Aerodyn.96, 524–539.
[2]. Igra, O., 1981. Research and development for shrouded wind turbines. Energy Conc. & mgmt., **21**: 13-48.
[3]. Abe, K., Nishida, M., Sakurai, A., Ohya, Y., Kihara, H., Wada, E., Sato, K., 2005. Experimental and numerical Investigations of flow fields behind a small wind turbine with a flanged diffuser. J. Wind Eng. and Ind. Aero, **93**: 951-970.



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