EXPERIMENTAL INVESTIGATION OF LIFT & DRAG PERFORMANCE OF NACA0012 WIND TURBINE AEROFOIL

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ABSTRACT

Wind is becoming a competitive energy source, dragging more and more attention as renewable, economically possible and greater alternative to traditional source. Much of current wind turbine research focuses on large scale (> 1 MW) technologically complex wind turbine installed in areas of high average of wind speed (>20 mph). To pursue this approach design methodology for small scale wind turbines must be developed and validated. This work addresses one element of this methodology i.e. aerofoil performance prediction. The tendency of flow separation over aerofoil at low Re has prompted the investigation of separation control methods. In this work an attempt is made to control the flow separation over aerofoil by adding dimples with various sizes of 1%, 2% and 3% of chord length.We obtain the characterize performance of NACA0012 at various angle of attack for regular and dimpled surface. We found that for dimple size with 3% of chord lengththe performance was improved. Thus addition of dimples results in increased performance of aerofoil.

Keywords: Aerofoil, chord length, dimple on surface, angle of attack

I. INTRODUCTION

Energy is very important for human life. As it is well-known, energy is produced by fossil fuels, but fossil fuels have two problems. First, its resources are very limited. Second, they lead to environmental pollution. For this reason, renewable energy becomes an alternative. One of the renewable energy is wind energy. Wind turbines use wind energy to transform into electrical energy, but wind turbines efficiency is not good. Because of that, a number of scientists are investigating over wind turbines and wind turbines parameters. One of the most important parameter of wind turbines is wing because wind hits to the wings and energy of wind is transformed into the mechanical energy by wings. Aerofoil profile is the important parameter for wing design because wing efficiency depends upon aerofoil profile. [10, 13]

The performance of an aerofoil is measured by Lift to drag ratio, which can be increased by either increasing the lift force or decreasing the drag. This work is focused on increasing the performance of the aerofoil by making delay in flow separation. Fluid flow separation can be controlled by various ways such as co-flow jet system, solid wall, providing dimpled surface/ surface roughness etc. This work is focused on investigation of effect of addition of dimpled surface on leading edge and varying the percentage of dimpled surface

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II. LITERATURE REVIEW

Dynamic roughness has ability to eliminate both the short and long separation bubbles inherent in a low Reynolds number leading edge flow operating at a moderate angle of attack, while also maintaining some physical advantages over other techniques.(P. D. Gall et al., 2010)[3]

2-Dimensional CFD is done on outward and Inward dimples on the wing model using k-w turbulence model, thereafter based on its results the better of the two is chosen. After choosing the better dimpled configuration, different shaped dimples are tested and compared to the plane aerofoil model. This CFD analysis is done in 3-D by taking a segment of the aerofoil with one dimple on it. Addition of dimples has proven to be effective in altering various aspects of the flow structure. With such significant flow structure the resultant lift and drag forces are also altered. (DeepanshuSrivastava, 2012)[4]

The applicability of the turbulence models for the different aerofoils numerical simulation was investigated, and the flow field structure was analyzed. The calculation results provided a reference for the research and development of wind turbine aerofoils. The aerodynamic performance of wind turbine aerofoils was an important foundation for the aerodynamic design and the performance analysis of the wind turbine.(JiYaoa et al., 2012) [5]

Experimental investigation is done on the stall flutter boundaries of a NACA0012 aerofoil at low Reynolds numbers (Re∼104) by measuring the forces and flow fields around the aerofoil when it is forced to oscillate.(Shantanu S.Bhat et al., 2013)[6]

The DU 96-W-180 aerofoil was tested with four different symmetrical V-shaped riblet sizes (44, 62, 100, and 150-lm) at three Reynolds numbers (1e106, 1.5e106, and 1.85e106) and at angles of attack spanning the low drag range of the aerofoil. Results showed that the magnitude of drag reduction depended on the angle of attack, Reynolds number, riblet size, and riblet location. Trends in the results indicated an optimum riblet size of 62-lm for the range of Reynolds numbers at which tests were conducted. The aerofoil chord was 18 in (0.457 m). Results also showed that each riblet size performed best at a given Reynolds number with the optimal Reynolds number decreasing with an increase in riblet size (AgrimSareen et al., 2014) [11]

The flow separation of aerofoil is controlled by providing partial dimpled on the upper surface of the geometry. For the analysis purpose NACA 4315 was chosen. Two models were generated (i) regular aerofoil using NACA 4315 profile (ii) providing dimpled surface on the NACA 4315 surface on the trailing edge at 80%C. Numerical approach is undertaken to observe the flow separation on the aerofoil. From the observation it was noted that by using the dimpled surface on the upper surface of the aerofoil the flow separation was delayed. Flow separation occurs at 9 degree angle of attack in the smooth surface whereas in dimpled surface it occurs at 15 degree angle of attack. (SyedHasib Akhter Faruqui et al., 2014) [12]

Numerical and experimental analysis for lift and drag performances of NACA 0015 aerofoil at different attack angle at low Reynolds numbers (Re) is done by measuring the forces every two degrees from 0° to 20°. The experiment test was conducted in low speed wind tunnel, and the numerical analysis was performed using CFD program which was FLUENT. The results obtained from experiment and numerical were compared. In this study, stall angle depended on turbulent occurred behind aerofoil was determined. As result, effect of the stall angle of aerofoil performance was investigated (IzzetŞahin and AdemAcir, 2015) [13]

NACA 0012 profile was considered for analysis of wind turbine blade. Lift and drag forces were calculated at different angles of attack for Reynolds number from 10000 to 800000 by CFD analysis.(BhushanPatil, Hitesh Thakare, 2015) [14]

III. EXPERIMENTAL SETUP

For experimental this work NACA0012 aerofoil profile was selected as a model. It is a symmetrical aerofoil.The following figure shows a sample NACA0012 aerofoil without dimple. It has Chord length 300mm, Span 250mm and Maximum thickness 36mm.

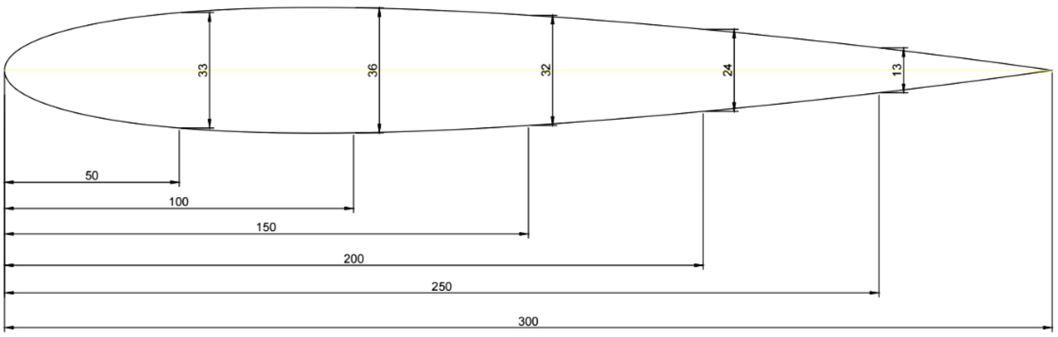

Fig.1 NACA0012 aerofoil

Two types of models were prepared.

a) Regular surface model

b) Partial dimpled surface model.

Fig.2 Regular surface model **Fig.3 Partial dimpled surface model**

The experiments were conducted using subsonic wind tunnel having 300 mm x 300 mm test section.The NACA0012 aerofoils with regular surface and with dimpled surface were tested for lift and drag forces by varying following parameters:

Free stream velocity (m/s)	6 and 10
Angle of Attack (Degrees)	0^0, 10^0, 12^0, 15^0, 17^0, 19^0, 21^0 and 23^0
Percentage of dimpled surface (% of chord length)	1%, 2% and 3% of

Fig. 4 Wind Tunnel Setup

Fig.5 Aerofoil mounted in test section

IV. RESULT & DISCUSSIONS

The NACA0012 aerofoil with and without dimpled surface were tested on wind tunnel setup for the lift and drag forces. Coefficient of Lift and drag were calculated based on the values of lift and drag forces. The ratio of coefficient of lift to coefficient of drag was calculated in order to determine performance of aerofoil.

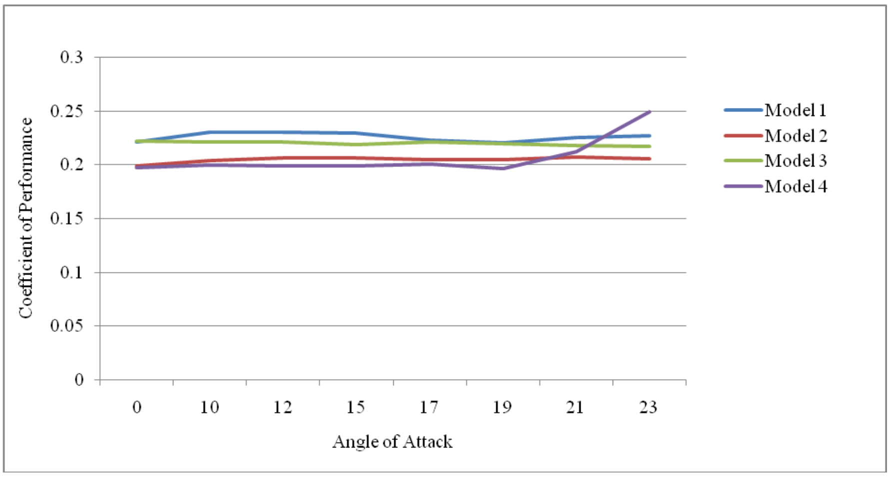

Fig.6 Coefficient of performance for 6 m/s velocity

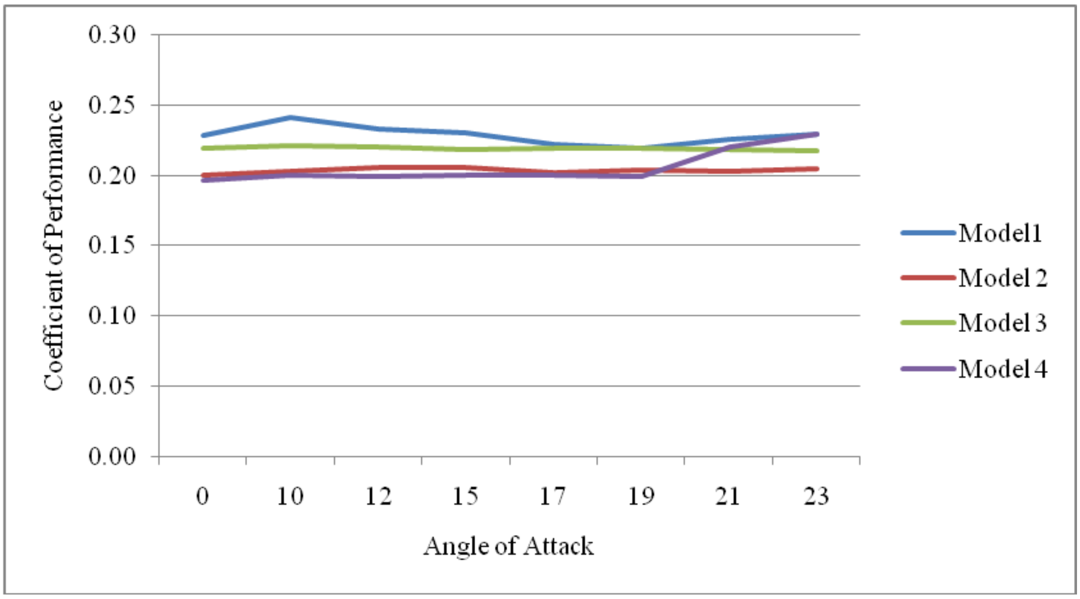

Fig.7 Coefficient of performance for 10 m/s velocity

From Fig. 6 & 7 it is observed that for Model 4 there is increase in performance as per increase in angle of attack. Incorporation of dimple surface with size 3% of chord length has shown increased performance as compared with other dimpled aerofoils. The addition of dimples on aerofoil can be one of effective method to increase its performance

VI. CONCLUSIONS

Addition of dimples on surface of aerofoil can results in increased performance of aerofoil. For NACA0012 to get higher performance the size of dimple can be taken as 3% of chord length

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