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Power, lift and drag coefficients analogy of wind turbine blade from aerodynamics characteristics of NACA2412 & NACA0012

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ABSTRACT:

In this paper analysis of two dimensional airfoils model of NACA002412 and NACA0012 for the aerodynamic characteristics at various Reynolds number for a range of attack from lift through stall, based on the chord length of the airfoil. Using the Spalart-Allmaras, the k-epsilon (RNG) and the k-omega shear stress transport (SST) models are used to simulate drag, pressure coefficient, local characteristics and the lift. In the wind tunnel of NACA(National Aeronautics Advisory Committee) experimental measurement and comparison prognosis for selected aerodynamic airfoils are presented. The geometric parameters of blade including twist angle distribution and chord are determined based on aerodynamic parameters results at a specific Reynolds number. This study is carried out by providing an optimal blade design strategy for horizontal-axis wind turbines operating at different Reynolds numbers. In this approach can be further developed to create the most efficient of horizontal axis wind turbine blade design. As a conclusion the experimental results were compared with simulation results, good concordance were noted.

INTRODUCTION:

Nowadays in market the upward three bladed horizontal axis in wind turbine are leading player.the range of the different turbine construction found to be best industrial compromised(P. J. Musgrove-1987). When the development of individual turbine components to conducting the current wind industry innovation.the blade performance of output measure response the blade geometry(M. O. L. Hansen-2000), the chord , twist, airfoil type distribution along the span.therefore the overall turbine performance(J. Johansen& N. N. Sorensen-2007) can be improved the optimal wind blade geometry.the control problems, aerodynamical and structural involved the design of optimal blade.iterative and stepped method where the design cycle is approached practically. the blade can be model as serious section along pitch axis by the aerodynamical optimization.the results of collection of pitch angle and local twist one by each section has an airfoilshape,chord length and attach angle the control strategy of whole energy systems depends of this last property of blade while pitch angle.

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The purpose of this paper is to asset twist distribution and chord of wind turbine design. The design process includes thedetermination of the blade airfoil, twist angle chord length distribution along the radius and the selection of the wind turbine type.There are enhance based on theory of aerodynamic forces on an airfoil and conversion of angular momentum. BEM (Blade Element Momentum) theory is first derived then used to conduct a parametric study that will determine if the enhance values of blade twist and chord length create the most efficient blade geometry. One of the most efficient wind turbine blade is analyzed finally from the two different airfoils. CFD (Computational Fluid Dynamics) software is used to simulate wind turbine and offer aerodynamic blade analysis. This experiment includes a analysis of the most important parameters of maximum efficiency for wind turbine blade. Lift and drag coefficient,power output around airfoil and lift to drag ratio were calculated and compared.In this study, numerical simulation of NACA2412 & NACA0012 airfoils was performed to determine optimum angle of attack.

MATHEMATIC MODEL:

The governing equations are the Navier-Stokes and continuity equations. This has the advantage of making our simulation not require a moving mesh to account for the rotation of the blade.These equations are written in a frame of reference rotating with the blade.

MATERIAL AND METHOD :

CFD is the most of the important components of Aerodynamics and fluid mechanics industries. already to exist the most of the all aerodynamics in our world. but connection with an fluid dynamic for the analysis of moving cases. (like flow around object) in CFD toolboxes. There arehypothetical to exist(left) the model for turbulent simulation. The material and method explain about briefly as follow.

A. The Spalart-Allmaras model :

The Spalart-Allmaras model (1992) model is relatively easy of equation model an solve to other transport equation for the K.M eddy (turbulence) viscosity. It is designed by the especially for aerospace and spacecraft are applicable an involving the wall-boundary flows has been given accurate decision for boundary layer subjected to adverse pressure gradient(P.R.Spalart& S. R.Allmaras-1992) . For turbo machinery application is also gain popularity . It is authentic (original) create a low-Reynolds number model is effectively , The viscous affected region of the boundary layer to be properly resolved.

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B. The k-omega SST turbulence model :

The k-omega SST turbulence model is a two equation of turbulence viscosity model as very popular(F. R. Menter-1993). The shear stress transport (SST) expression to combine the two world. Here use of k-omega expression is the inside part of the boundary layer to make the model directly . Able to all way is down to the wall passing the viscous sub-layer. The low Reynolds turbulence has been used the K-omegaSST model without any extra damping process. The SST expression also switches to K-omega problem that the model is fielding to the inlet free stream turbulence property. The adverse pressure gradients and separate flow is the author who use the SST K-omega model after advantage for it is normal behaviors.

C. The K-epsilon RNG model :

The K-epsilon is the most one of the general turbulence models(W. P. Jones, B. E. Launder-1972). Even though it is doesn't perform well in case large adverse pressuregradient(B. E. Launder, B. I. Sharma-1974). This is that two equation model that means including both extra transport equation can be represented the turbulence flow of property. Here involving the two equation is like convection and diffusion of turbulent energy. Denoted by K. The second variable of type turbulent distraction , Denoted by ε. To variable that determine the scale of turbulence , the first variable is K, secondary energy has been determine the turbulence. The RNG model was developed using Re-Normalization group (RNG) method by the Navier-Stokes equation , the effect of smaller scale of motion(V. Yakhot, S. A. Orszag et al-1992).

D. Blade Element Momentum (BEM) Theory :

The Blade Element Momentum (BEM) Theory is a collection of two moment theory and blade element theory(J.L.Tangler-2002). Momentum theory , which is useful in conclude ideal efficiency and the flow velocity, It is resolved of force acting on the rotor to reduce the motion of the fluid. the theory resolved to the force on the blade the conduction of finale the motion of the fluid in terms of geometry blade parameter. Density is 1.2043 Kg/m^3, wind speed is 14.383, 2.09888, angle of attack is -18:0.25:18, chord length is 1 m, temperature is 273 K and reference pressure is 1 atm above mentioned are the computational conditions.

To study of the incompressible flow. so assume to be turbulence over all entire airfoil. The computational domain is the located at chord length is 100 away from the leading edge, and The chord length 200 located at the trailing edge . Boundary condition and flows as show in Fig(1).

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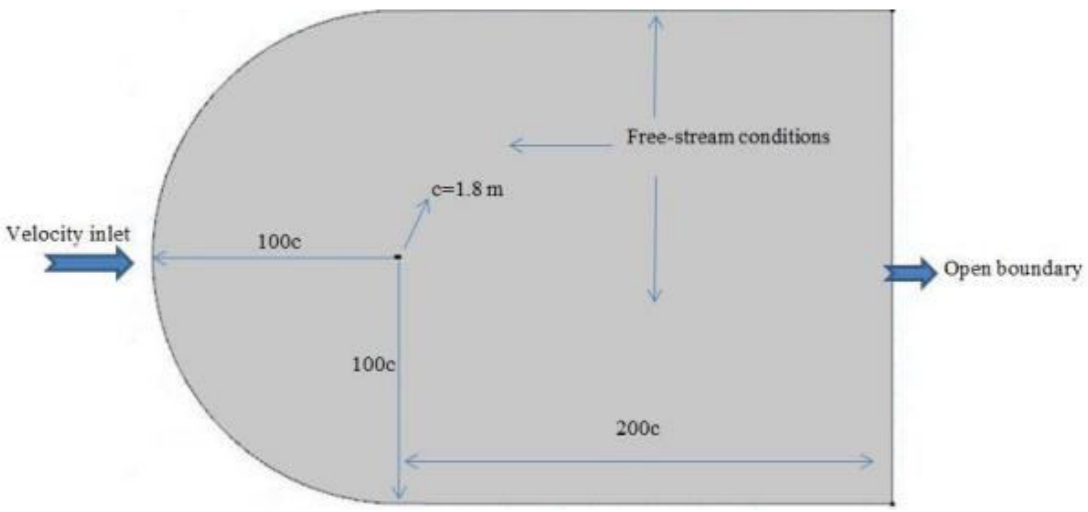

Fig.(1) Boundary condition and flow domain.

RESULTS AND DISCUSSION:

The study has been conducted using simulation software NACA2412 & NACA0012 airfoil and pressure coefficient formed around two airfoils has been compared with different angle of attack of airfoil. Numerical calculation were carried out at different angle of attack. The first objective of this calculation is to find optimum angle of attack to obtain maximum lift to drag ratio. Angle of attack for inclined airfoil and lift coefficient for different angle of attack are calculated and shown in Table 1 and Fig(II) respectively.

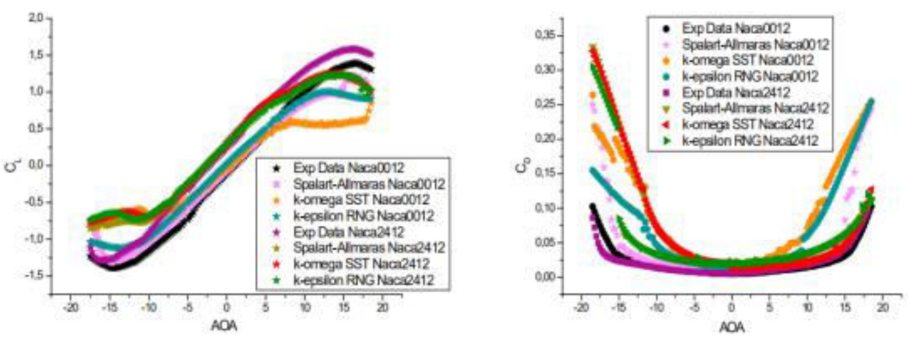

Fig.(2). (a) CL variations vs. angle of attack Re=1.106; (b) Cd variations vsangle of attack at Re=1.106from the current numerical work by using three different turbulent models' simulation compared with the numerical data.

Fig(II) shows that the result for the drag coefficient and lift coefficient is obtained by Spalart-Allmaras model, the k-omega SST, the k-epsilon RNG turbulence model. The k-omega SST, the k-epsilon RNG turbulence model are not able to predict stall condition but the Spalart-Allmaras model predict well, also the experiment can be divided into two

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system (i) pre-stall and (ii) post-stall. In pre-stall regime different experiment setups give similar lift and drag coefficient for a given angle of attack. This means we can quantitatively compare against the experiment values to validate our simulation methods.

TAB. 1 THE RESULT FOR THE LIFT COEFFICIENT AND DRAG COEFFICIENT BY DIFFERENT METHOD

	NACA0012		NACA2412	
	CL	CD	CL	CD
Experimental Data	1.0596	0.01293	0.7624	0.0077
Spalart-Allmaras	0.812363	0.02006	0.7290	0.0232
k-omega SST	0.612518	0.05746	0.7984	0.0155
k-epsilon RNG	0.867807	0.05547	0.7302	0.0232

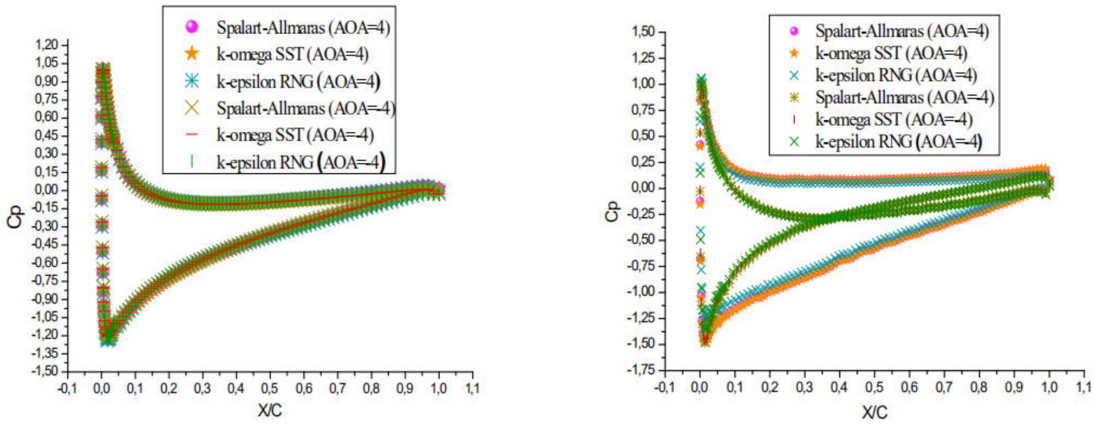

Fig. (3). (a), (b) Comparison of pressure distribution over the surface of NACA0012 and NACA2412 airfoil between angle of attack of 4 and -4 at Re=1.106

As can be seen from the Fig(3), with decreasing angle of attack from 0 to -4 degrees, the pressure distribution between upper and lower surface decrease. The pressure difference between upper and lower surface starts to increase again when the angle of starts to increase after 0 degrees. The pressure difference between upper and lower surface reach maximum when angle of attack around 4 degree.

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a b

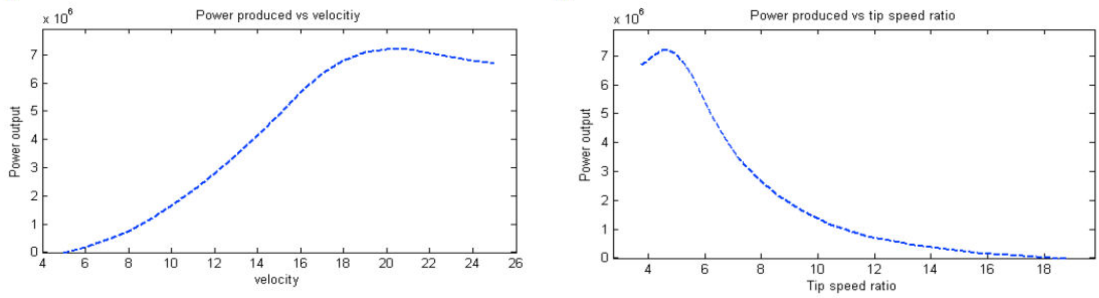

Fig. (4). (a) Power output as function of wind speed of NACA0012, (b) Power output as function of tip speed ratio of NACA0012.

c d

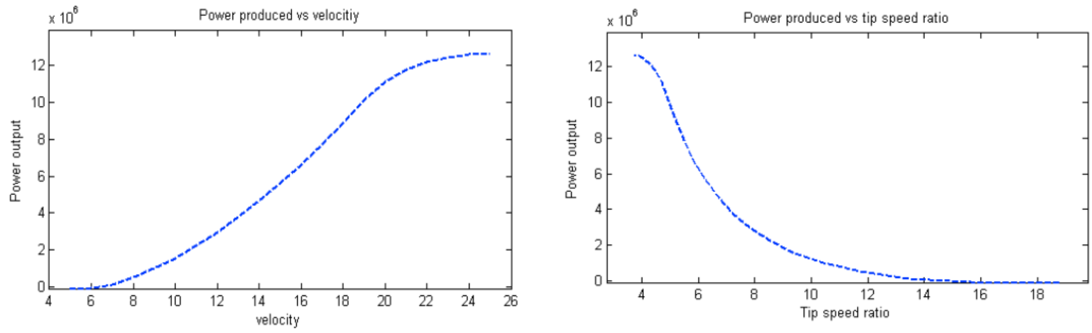

Fig. (5). (c) Power output as function of wind speed of NACA2412, (d) Power output as function of tip speed ratio of NACA2412.

e f

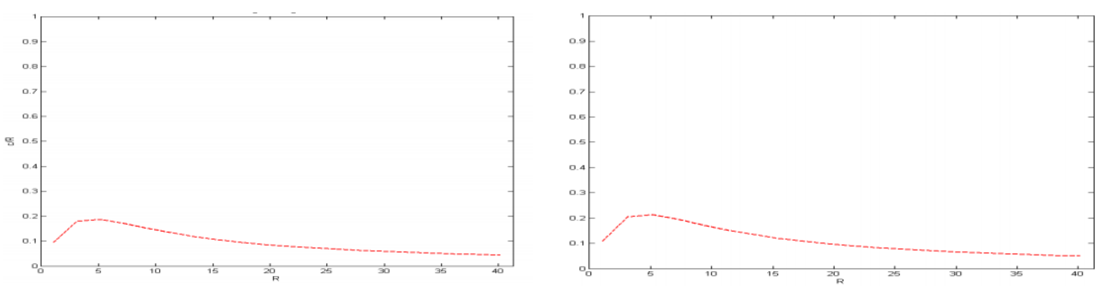

Fig. (6). (e) Chord length as function of radius for NACA0012, (f) Chord length as function of radius for NACA2412.

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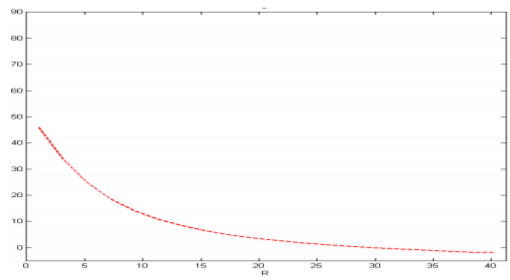

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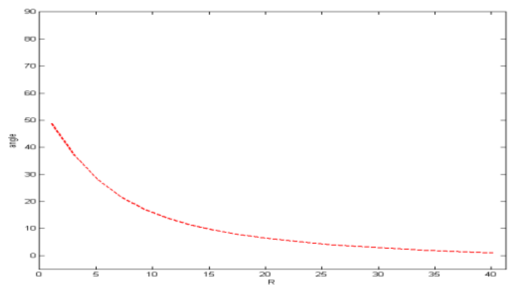

Fig. (7). (g) Twist distribution as function for NACA0012 of radius, (h) Twist distribution as function for NACA2412 of radius.

CONCLUSION:

This paper consider maximum angle of attack for two airfoils NACA2412 & NACA0012 to find maximum lift and drag ratio for Reynolds number of $Re=1.10^6$. In this paper the k-omega SST, the k-epsilon RNG, the Spalart-Allmaras using these models we study simulate air flow around airfoils. Lift, drag, pressure coefficient, lift to drag ratio, chord,twist distribution and power output of the airfoils are calculate, airfoil simulated and results are compared initially. There is a range of angle of attack where the lift coefficient varies linearly at some point, further increase in angle of attack a lift coefficient reaches maximum value. This referred to as stall, there is a region having a lowest value of lift coefficient. Outside of this range it increases again sometimes rapidly for both of airfoils. Good agreement of all these model with experimental data from angle of attack between -5 to 5. The ultimate parametric study was conducted to determine if the airfoil had an appreciable effect on the efficiency of the turbine. Based BEM theory it was confirmed that changing the airfoil could have an appreciable effect on the turbine efficiency. Through this experiment shows that the NACA2412 airfoil have a higher efficiency at tip speed ratio of 7 and also have higher maximum power output than the NACA0012.In choosing between the two airfoils, it is clear that the NACA 2412 creates a more efficient turbine blade than the NACA 0012. Additionally, continuation of this analysis would include analyzing different airfoils such as the S-Series airfoils created specifically for wind turbine blades.

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