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# Power Optimization of NACA 0018 Airfoil Blade of Horizontal Axis Wind Turbine by CFD Analysis

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## ABSTRACT

The country or region where energy production is based on imported coal or oil will become more self-sufficient by using alternatives such as wind power. Electricity produced by the wind produces no $CO_2$ emissions and therefore does not contribute to the greenhouse effect. Wind energy is relatively labour intensive and thus creates many jobs. Wind energy is the major alternative of conventional energy resources. A wind turbine transforms the kinetic energy in the wind to mechanical energy in a shaft and finally into electrical energy in a generator. The turbine blade is the most important component of any wind turbine. In this article is considered the single airfoil National Advisory Committee for Aeronautics (NACA) 0018 and a computational fluid dynamics (CFD) analysis is done at different blade angles 0º, 10º, 15º, and 30º with a wind velocity of 4 m/s. The analysis results show that a blade angle of 10º gives the best possible power and pressure and velocity distributions are plotted for every case.

## KEYWORDS

Air Density, Airfoil, Angle of Attack, Blade Angle, CFD, Drag, Lift, NACA, Power Of Wind, Wind Speed

## INTRODUCTION

Reducing carbon dioxide emissions is a major contributing factor in alternative energy proposals. In the United State (US) average fuel mix; about 1.5 pounds of $CO_2$ are emitted for every kilowatt-hour that is generated. Electricity consumption accounted for more than 2.3 billion tons of $CO_2$ in 2006. This accounted for 39.5 percent of the total emissions from human resources, according to the US Department of Energy. Coal-fired plants alone released over1.9 billion tons, which is one-third of the US total. The US Department of energy also projects that $CO_2$ emissions from power generation will increase by 19 percent between 2007 and 2030. This is due to new or expanded coal plants. A single 750 KW wind turbine produces roughly 2 million kilowatt hours of electricity annually (James, 2009). Generation of power from renewable energy resources has been extensively increased in several countries due to environmental issues and fossil energy trouble. In which the high generation level of renewable resources gives new opportunities and challenges for power sector (Alhelou et al., 2015; Alhelou & Golshan, 2016). One problem is that wind energy can only be produced when nature supplies sufficient wind. This is not a problem for most countries, which are connected to big grids and can, therefore, buy electricity from the grid in the absence of wind. It is, however, an advantage to know in advance what resources will be available in the near future so that conventional power plants can

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adapt their production. Now a days in upcoming smart grids, keep the sense of balance among the electrical demand and production. Electric energy would be the main concern due to the uncertainties of both requirement and production of electrical energy from renewable resources (Alhelou et al., 2018; Makdisie et al., 2018). Reliable weather forecasts are desirable since it takes some time for a coal-fired power plant to change its production. Combining wind power with hydropower would be perfect since it takes almost no time to open or close a valve at the inlet to a water turbine and water can be stored in the reservoirs when the wind is sufficiently strong (Spera, 1994). Wind machine has adopted the technology developed for the construction of airplane wings and airplane propeller blades and added some ingenious ideas of their own leading to a new and unique specialized technology. Wind machines operate in an environment totally different from the airplane wings characterized by continuously changing wind speeds and direction. Since the power contained in a moving air stream is proportional to the square of the rotor diameter and to the cube of the wind speed, the rotor blades must be carefully designed in order to optimally extract this power and convert it into torque that drives the electrical generator. Wind turbines come in different sizes and types, depending on power generating capacity and the rotor design deployed. Small wind turbines with output capacities below 10 kW are used primarily for residences, telecommunications dishes, and irrigation water pumping applications. The major responsibility of a power system is to constantly provide the demanded electric energy with a suitable value of service. When the production is lower/higher than the requirement, the frequency will go under/above the nominal value, to maintain the power balance the power system is used (Fini et al., 2016).

Main objective of this article is to obtain optimum power output. Wind energy presents several challenges in order to generate electricity. Power produced from the wind depends on wind velocity. So, at constant wind speed, constant power can be obtained. If constant wind speed is not there at that time constant power can be obtained by providing mechanism, i.e. by changing the blade angle up to certain limit. This work seeks to develop the design optimization for wind turbine rotor blade. By analysis of the rotor blade shows which blade angle give optimum power output. CFD simulation of blade helps to predict power, pressure distribution over the surface of airfoil and force acting on it. There are various blade simulation software's commercially available in the market. In this work Ansys CFX software was used for simulation.

## METHODOLOGY

Airfoil System - An airfoil is the shape of a wing, blade, 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. The nomenclatures of airfoil system are (Chandrala & Choubey, 2013) (Figure 1).

- Chord length - length from the Leading edge (LE) to the Trailing edge (TE) of a wing cross-section that is parallel to the vertical axis of symmetry.
- Mean camber line – halfway line between the upper and lower surfaces.
- LE - the front most point on the mean camber line.
- TE - the most rearward point on the mean camber line.
- Camber - maximum distance between the mean camber line and the chord line, measured perpendicular to the chord line.
- 0 camber or uncambered - means the airfoil is symmetric above and below the chord line.
- Thickness - the distance between the upper surface and lower surface measured perpendicular to the mean camber line.

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