A REVIEW ON ROTOR BLADE OF THE WIND TURBINE AEROFOIL SECTION NACA 5510

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ABSTRACT

Owing to the fast development in the energy filed, the demand is increasing to improve energy efficiency and lifetime of wind turbine. Therefore, it's important to understand deeply the behavior of wind turbine under different load conditions.Meanwhile, this paper mainly aims to survey the most recent condition and performance monitoring approaches of wind turbines with the primary focus on blade, gearbox, generator, braking system, and rotor. Different methodologies of wind turbine condition monitoring, performance monitoring, and fault diagnosis reported in the literature are discussed. The main objective of this paper is to supply invaluable information for future researchers in escalating the ability as well as accuracy of wind turbine condition monitoring techniques. The evolution of wind technology is expected to continue over the next two decades resulting in a continued improvement in reliability and energy capture with a modest decrease in cost. The development of new and innovative rotors, drive systems, towers, and controls is expected to enable this continued improvement in the cost effectiveness of wind technology.

Keywords: blade, airflow, Aerofoil, pressure distribution, velocity distribution.

INTRODUCTION

Renewable energy is energy created from sources that do not deplete, such as solar, wind, hydropower and geothermal. Most renewable energy is consequent from direct or indirect way of exploiting. Renewable energy has two distinctive features, one is infinite reserve, and the second feature is proving clean energy (zero carbon monoxide emission) contrary to other sources of energy such as coal, natural gas, crude oil, and uranium that are harm the environment, because it produce toxic gases when burned, one of these gases is carbon dioxide gas causing a change in climate. Climate change has a major impact on the environment such as increased pollution, droughts, rising sea levels and rising temperatures. High temperatures cause changes in environmental integration.(Schubel & Crossley, 2012) So the pressing question today is that, besides providing enough energy for humanity, can it be able to ensure a safe world for the next generation? Thus, there should be a need to learn how to solve the use of alternative energy resources alongside traditional sources. For this reason, renewable and sustainable energy is of interest in the current study. Wind energy is an alternative to fuel, its play an important role in supplying the most industrialized countries with energy. Wind power production is growing rapidly annually; Figure 1 shows the Global capacity and annual additions of wind power.(Deisadze, 2013) Wind power is generated by wind turbines, the blades of wind turbine are most critical component of the wind turbine system. Loads of wind caused a deflection in the wind turbines blades, so the blade should have enough strength with light weight to avoid failure. The blades are characterized by specific strength and high rigidity. Therefore, strong and light materials are required in order to save the turbine from fatigue failure and reduce the overall weight of the wind turbine system.(Deisadze, 2013)

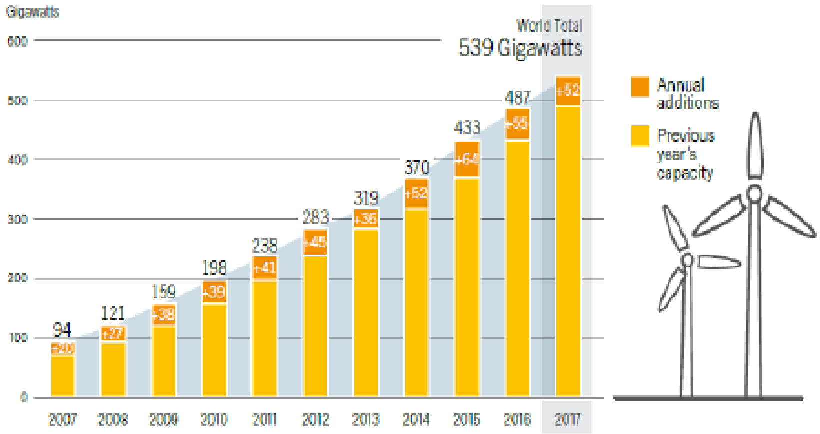

Figure 1: Global capacity and annual additions of wind power, 2007-2017

India's Market Overview of Wind Energy

India has a vast supply of renewable energy resources. India has one of the world's largest programs for deployment of renewable energy products and systems 3,700 MW from renewable energy sources installed.(Tong, 2009)

Table 1: States with strong potential: (potential MW /installed MW)

States with strong potential	Potential MW	Installed MW
Andhra Pradesh	8285	93
Gujarat	9675	173
Karnataka	6620	124
Madhya Pradesh	5500	23
Maharashtra	3650	401
Orissa	1700	1
Rajasthan	5400	61
Tamil Nadu	3050	990
West Bengal	450	1

HAWT Advantages

- Variable blade pitch, which gives the turbine blades the optimum angle of attack. Allowing the angle of attack to be remotely adjusted gives greater control, so the turbine collects the maximum amount of wind energy for the time of day and season.
- The tall tower base allows access to stronger wind in sites with wind shear. In some wind shear sites, every ten meters up, the wind speed can increase by 20% and the power output by 34%.
- High efficiency, since the blades always move perpendicularly to the wind, receiving power through the whole rotation. In contrast, all vertical axis wind turbines, and most proposed airborne wind turbine designs, involve various types of reciprocating actions, requiring airfoil surfaces to backtrack against the wind for part of the cycle. Backtracking against the wind leads to inherently lower efficiency.

LITERATURE REVIEW

(Thresher & Robinson, 2008)observed Wind energy is one of the fastest-growing electrical energy sources in the United States. The United States installed over 5,200 MW in 2007 and experts are forecasting for as much to be installed in 2008. The United States cumulative installed capacity as of Dec. 31, 2007, was 16, 596 MW. Wind turbines have evolved rapidly over the past 20 years and the turbines have grown in size from 100 kW in the early 1980s to over 2.5 MW today. The evolution of wind technology is expected to continue over the next two decades resulting in a continued improvement in reliability and energy capture with a modest decrease in cost. The development of new and innovative rotors, drive systems, towers, and controls is expected to enable this continued improvement in the cost effectiveness of wind technology. Wind energy can supply 20% of the United States' electricity needs by 2030 and will be a significant contributor to the world's electricity supply.

(Schubel & Crossley, 2012) reviewed the current state-of-art for wind turbine blade design is presented, including theoretical maximum efficiency, propulsion, practical efficiency, HAWT blade design, and blade loads. The review provides a complete picture of wind turbine blade design and shows the dominance of modern turbines almost exclusive use of horizontal axis rotors. The aerodynamic design principles for a modern wind turbine blade are detailed, including blade plan shape/quantity, aerofoil selection and optimal attack angles. A detailed review of design loads on wind turbine blades is offered, describing aerodynamic, gravitational, centrifugal, gyroscopic and operational conditions.

(Rehman, 2018)analyzed that among renewable sources of energy, wind is the most widely used resource due to its commercial acceptance, low cost and ease of operation and maintenance, relatively much less time for its realization from concept till operation, creation of new jobs, and least adverse effect on the environment. The fast technological development in the wind industry and availability of multi megawatt sized horizontal axis wind turbines has further led the promotion of wind power utilization globally. It is a well-known fact that the wind speed increases with height and hence the energy output. However, one cannot go above a certain height due to structural and other issues. Hence other attempts need to be made to increase the efficiency of the wind turbines, maintaining the hub heights to acceptable and controllable limits. The efficiency of the wind turbines or the energy output can be increased by reducing the cut-in-speed and/or the rated-speed by modifying and redesigning the blades. The problem is tackled by identifying the optimization parameters such as annual energy yield, power coefficient, energy cost, blade mass, and blade design constraints such as physical, geometric, and aerodynamic. The present paper provides an overview of the commonly used models, techniques, tools and experimental approaches applied to increase the efficiency of the wind turbines. In the present review work, particular emphasis is made on approaches used to design wind turbine blades both experimental and numerical, methodologies used to study the performance of wind turbines both experimentally and analytically, active and passive techniques used to enhance the power output from wind turbines, reduction in cut-in-speed for improved wind turbine performance, and lastly the research and development work related to new and efficient materials for the wind turbines.

(Deisadze, 2013) studied the potential for installing roof-mounted vertical axis wind turbine (VAWT) systems on house roofs. The project designed several types of VAWT blades with the goal of maximizing the efficiency of a shrouded turbine. The project also used a wind simulation software program, WASP, to analyze existing wind data measured on the roofs of various WPI buildings. Scale-model tests were performed in the WPI closed- circuit wind tunnel. An RPM meter and a 12 volt step generator were used to measure turbine rotation speeds and power output at different wind speeds. The project also studied roof mounting systems for turbines that are meant to dissipate vibrations to the roof structure. Turbine vibrations were measured during the wind tunnel tests and in impact tests on a scale-model house. Recommendations were made for future designs of roof-mounted VAWTs.

(Zuheir et al., 2019)examined that owing to the fast development in the energy filed, the demand is increasing to improve energy efficiency and lifetime of wind turbine. Therefore, it's important to understand deeply the behavior of wind turbine under different load conditions. This research paper provides an approach to study and analyze the stresses and deformations under the steady-state condition. Also, it was investigated the vibration characteristics of the NREL offshore 5-MW blade (HAWT) with a long of (61.5 m) and with rotor diameter (126 m). The 3D model of wind turbine blade was created by using SOLIDWORKS and then exported to ANSYS/Workbench19 in order to achieve the numerical simulation based on Finite element method. The steady-state analysis of the selected wind turbine blade was performed at maximum rated power (maximum rotation velocity =12.1 rpm). In this work, three different materials (E-glass fiber, Kevlar, and Carbon fiber reinforced plastic) were selected to build the body of the wind blade parts. The results presented the von-Mises stresses, total deformations, first ten natural frequencies and mode shapes of NREL 5-MW wind turbine blade. In steady-state analysis, it was found that the optimum material was (CFRP) where the minimum level of stresses occurred. In vibration analysis, it was found the material that has a higher structural stiffness is CFRP material which avoids high frequencies and mode shapes.

(Zhang et al., 2019)analyzed that currently in the process of wind farm inspection, wind turbine blade appearance inspection mainly adopts the telescope or high-definition cameras, low detection efficiency, labor intensity and the precision is limited, in order to solve this problem, a kind of wind turbine blades defect recognition system based on image array is proposed. Through the joint of array camera and image processing server, the functions of the image acquisition, processing, and defect recognition and detection results output are implemented. The software of artificial intelligence deep learning based on neural network algorithm is used to identify the defects of blade image, and output quality analysis report, to realize automatic detection of wind turbine blade surface defect. The field measurement results show that the system greatly improves the efficiency and accuracy of wind turbine blade defect detection.

(Bin & Kashem, 2020)observed Wind power generation is playing a pivotal role in adopting renewable energy sources in many countries. Over the past decades, we have seen steady growth in wind power generation throughout the world. This article aims to summarize the operation, conversion and integration of the wind power with conventional grid and local microgrids so that it can be a one- stop reference for early career researchers. The study is carried out primarily based on the horizontal axis wind turbine and the vertical axis wind turbine. Afterward, the types and methods of storing this electric power generated are discussed elaborately. On top of that, this paper summarizes the ways of connecting the wind farms with conventional grid and microgrid to portray a clear picture of existing technologies. Section-wise, the prospects and limitations are discussed and opportunities for future technologies are highlighted. It is envisaged that, this paper will help researchers and engineering professionals to grasp the fundamental concepts related to wind power generation concisely and effectively.

CONCLUSION

Fundamentally, the main purpose of this paper is to provide a widespread view over recent approaches in the area of condition monitoring and fault diagnosis of wind turbine systems in order to guide the future research activities. It is expected that the given information in this paper could lead to some major directions for future researches.For reasons of efficiency, control, noise and aesthetics the modern wind turbine market is dominated by the horizontally mounted three blade design, with the use of yaw and pitch, for its ability to survive and operate under varying wind conditions. Minor changes to blade shape may then occur as manufacturers incorporate new aerofoils, tip designs and structural materials. A conflict of increased aerodynamic performance in slender aerofoils versus structural performance of thicker aerofoils is also evident.

The review provided in this study will be very useful to researchers, academicians, students, and consultants who are planning to work on wind turbine efficiency enhancement, optimization and its performance evaluation.

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