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Research Article

Design and Fabrication of Fault Detecting System Using Robotic Mechanism for Wind Blades

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Abstract: Wind blade has to be inspected at regular intervals depends upon the sizes, inspection will be carried out for every two or four month time intervals. Wind turbine blades are generally built of fiber reinforced plastics and lightweight materials like plastic foam. High stress are developed in the wind blades due to uneven wind blow, however the inspections are limited by visual inspections and simple tapping tests. The techniques acquire high levels of experience and are not able to detect internal damages that are not visible at the surface of the blade. If any defects are found, blades are re-eraction from the towers by using cranes and maintenance work will carried out separately. Due to this over all maintenance and operating cost increases, also it requires more labour force and time duration to solve this problem. To develop a robotic system which inspection unit, locating actuator setup, lighting source, low speed motor, ultra sonic sensor with CRO interference. This robotic setup does work like fault preventing measures and fault identifying measures to avoid wind blade failure. The development of non – destructive testing techniques (NDT) for the use at wind turbine blades would help to make the inspection more reliable. However the testing equipment should be small and lightweight so that the inspection can be done in service and no need for re-eraction the turbine blades.
Keywords: Blade Failure, CATIA, Pneumatic Actuator, Servo Motor, Ultrasonic Sensor, Wind Blade

INTRODUCTION

Energy

Energy is the primary and most universal measure of all kinds of work by human beings and nature. Everything that happens in the world is the expression of flow of energy in one of its forms Energy is an important input in all sectors of a country's economy due to rapid increase in the population and standard of living [1]. Conventional sources of energy are increasingly depleted. Hence, Non Conventional energy sources have emerged as potential source of energy in India and world at large. Among the various non-conventional energy sources, wind energy is emerging as the potential major source of energy for growth [2].

Wind Power

Wind possesses energy by virtue of its motion. Any device capable of slowing down the mass of moving air can extract part of the energy and convert into useful work [3].

Following factors control the output of wind energy converter: -

- The wind speed
- Cross-section of the windswept by rotor
- Conversion efficiently of rotor
- Generator
- Transmission system
-

Fig-1: Wind Farm

A wind turbine is a machine that converts the energy of wind into rotational energy by means of vanes. A wind turbine is a device that converts kinetic energy from the wind, also called wind energy, into mechanical energy in a process known as wind power. If the mechanical energy is used to produce electricity, the device may be called a wind turbine or wind power plant [4].

The strength of wind varies, and an average value for a given location does not alone indicate the amount of energy a wind turbine could produce there. To assess the frequency of wind speeds at a particular location, a probability distribution function is often fit to the observed data. Different locations will have different wind speed distributions. Wind turbines are the most common turbine configuration used today. They consist of a tall tower, atop which sits a fan-like rotor that faces into or away from the wind, a generator, a controller, and other components. Most horizontal axis turbines built today are two- or three-bladed [5].

Wind turbine blades

Usually flat objects connected to a center shaft that converts the push of the wind into a circular motion in a wind turbine. Most wind turbines have three blades. Very small turbines may use two blades for ease of construction and installation.

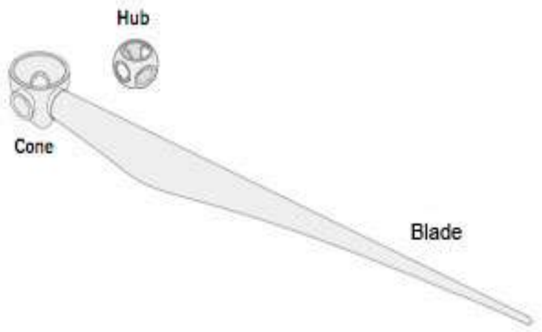

Fig-2:Wind Blade

List of wind blade manufacturers

- Vestas Wind Systems
- GE Energy
- Gamesa
- Enercon GmbH
- India's Suzlon Wind Energy Corp

In wind energy plants have to be inspected at regular intervals, depending on the size, every two to four years. Besides the tower and the mechanical parts like the gear, the turbine blades are part of these inspections. Due to the constant wind contact the blades are highly stressed parts of the turbine.

However the inspections are limited to visual inspections and simple tapping tests. These techniques acquire a high level of experience and are not able to detect internal damages that aren't visible at the surface of the blade. It shows an industrial climber roping from the rotor of a wind turbine to inspect critical areas of the blades.

Actuators

Actuators are constituent components of mechatronic systems An actuator refers to a device or component that provides the driving action to a mechanism or a plant to perform an intended task [6]. In robotics, it may be used, for example, to move the joints or in the grasping mechanism (hand) for picking parts. In a more general case of mechatronic systems, actuator may refer to a driving device that receives an input signal that represents a motion command and produces a corresponding motion.

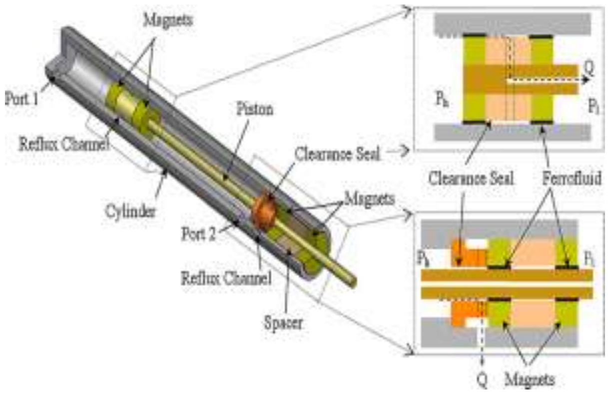

Fig-3:Pneumatic Actuator

Ultrasonic Testing

It is a non-destructive testing (NDT) method in which beams of high frequency sound waves that are introduced into the material being tested are used to detect surface and sub-surface flaws. The sound waves travel through the materials with some attenuation of energy and are reflected at interfaces. The reflected beam is detected and analyzed to define the presence and location of flaws [7].

Ultrasonic waves are almost completely reflected at metal gas interfaces. Partial reflection occurs at metal liquid or metal solid interfaces, with the specific percentage of reflected energy depending mainly on the ratios of certain properties of the matter on opposite sides of the interface.

Cracks, laminations, shrinkage, cavities, bursts, flakes, pores, bonding faults and other discontinuities that can act as metal-gas interfaces can be easily detected. Inclusions and other in homogenities in the metal being inspected can also detected by causing partial reflection or scattering of the ultrasonic waves, or by producing some other detectable effect on the ultrasonic waves.

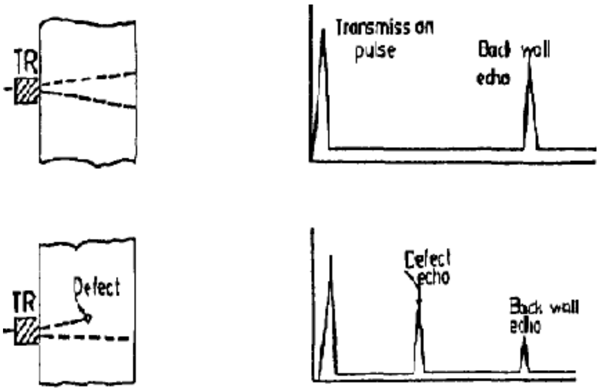

Fig-4:Defect Identification

PROBLEM IDENTIFICATION

Factor For Failures

The turbine blade has to stand great forces and is degraded by the constant wind. During common wind conditions the blade tips reach velocities up to 300 km/h. Therefore the leading edge of the turbine blade often shows erosion due to small particles like dust that hit the turbine blade with very high velocities.

If the gel coat is eroded UV-radiation and water can infiltrate and degrade. The trailing edge is highly stressed by the constant stall. Typically delamination can be observed here. Other damages due to fatigue are for example delamination within the laminates, stress whitening or de-bonding of matrix and fibers.

Erosion of the leading edge is decelerated by protection films that are sticked onto the gel coat. The load on the trailing edge is reduced using diverse vortex generators to cause an earlier stall.

At the moment several condition monitoring systems for new wind energy plants using embedded sensors are being developed to detect symptoms of fatigue at an early stage. For existing turbines the conventional inspection techniques have to be used.

Other Major Failure In Wind Blades

1. Tip failure
2. Root failure
3. Tower structure failure
4. Turbine and maintenance failure

In our project we are taking blade failure. We shall coordinate with wind care India pvt Ltd. To develop a robotic system to prevent the blade failure by early identification of further internal cracks to avoid blade failures

METHODOLOGY [8-10].

Components used for setup

- Double acting pneumatic actuators
- Camera
- Rotating plate
- Low speed motor
- Ultrasonic testing sensor
- Microcontroller
- FRL unit
- 8.5/3 manually operated directional control valve
- Connecting hose
- Actuator controlling & mounting accessories

Double acting pneumatic actuators

A double-acting actuator is a actuator in which the working fluid (compressed air) acts alternately on both sides of the piston. It has a port at each end, supplied with hydraulic fluid for both the retraction and extension of the piston. Stroke length double acting pneumatic actuators is about 50 mm of Figure 5 shows Double acting pneumatic actuators .

Fig-5: Double acting pneumatic actuators

Camera

The camera rotates in 360 degree by using rotational movement of AC servo motor. Electricity is supplied from the wind turbine. Camera is interfaced with a computer by USB port from this camera know about progress working inside the wind blade. Resolution of camera is about 1mega pixel.

Manually Operating 5/3 Directional Control Valve (DCV)

Directional control valves they allow compressed air into different paths from one or more sources. Manually operated valves work with simple levers or paddles where the operator applies force to operate the valve. A pneumatic operated 5/3 DCV works at much higher pressure range up to 10 bar. Figure 8 shows the manually operated 5/3 Directional control valves.

Fig-7: Manually Operating 5/3 DCV

Rotating Plate

The rotating plate is made of poly vinyl material because of to reduce the weight of the overall setup. Thickness of plate is 5 mm.plate is coupled with AC servo motor. The camera and ultra sonic sensor is mounted on this plate.

Fig-8: Rotating Plate

Low speed motor

The motor is rotate around 10-25 rpm either it works on AC/DC.This setup carrying the rotating plate and their mounting accessories.

Ultrasonic testing sensor

The technique is used to detect the bonding areas through several centimetres of GFRP. An ultrasonic pulse is sent into the material. The waves are reflected at material changes or at the back wall. The echo will be very strong and will arrive earlier if there is no bond between shell and spar. If shell and spar are linked very well the clear echo will move to later arrival times or will vanish completely.

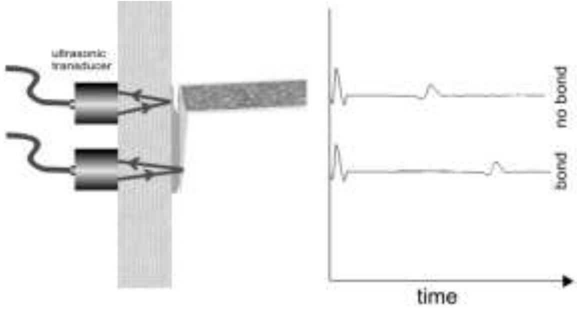

Fig- 8: Ultrasonic testing sensor

FRL unit

FRL stands for filter, regulator, and lubricator. This system remove contaminated fine particles present in the compressed air, regulate it our desired range of pressure up to 1-10 bar and provide proper lubrication at higher pressure ranges. Figure 9 shows FRL unit.

Fig- 9: FRL unit

Actuator controlling & mounting accessories

When the accurate positioning and movement of the actuator mounting device like L-clamps are required. for controlling the actuator, pneumatic gate valves, union, male T-connectors, pressure reducing switches are used. Pneumatic 6"hose used for transmitting the compressed air.

Fig-10: Pneumatic air hose

Fig-11: Pneumatic accessories

WORKING, ASSEMBLY AND DESIGN

Working

When setup properly hangs inside the blade by means of hand winch. The switch of ultra sonic sensor is activated, sensor continuously passing ultra sonic waves through transmitting end it may strike wind blade, if any cracks are identified in blades receiving end engages with some pulse loss or gain shows waveform in CRO from which the actual size of crack is identified. These are all activities are watched by camera. If cracks are very tiny means the pneumatic actuators actuated to close looking of stall. Actuators are used to proper positioning the setup.AC motor used to rotate the sensor mounted rotating plate. Microcontroller used to interface between computer and sensor.

Assembly

Assembly of the lower plate

Sensor, camera are mounted on the lower plate. When motor rotates at speed of 10-25 rpm ,due to movement of motor the whole setup rotates in 360 degree from which cracks identified in blades. Assembly of lower plate is very important one.

Assembly of the upper plate

The upper plate consists of pneumatic actuators on the top side. Bottom side low speed motor is mounted with bolts. Actuators mounted by L-clamps for no deflections. When assembly of upper plate weight balance must taken care.

Control panel

In this place the FRL unit, Manually Operating 5/3 Directional Control Valve, pneumatic air hose connections are mounted from which place all the controls are activated. Four directional control valves are placed in the control panel.

Design

SOFTWARE: Catia V5 r17

Design of the lower plate

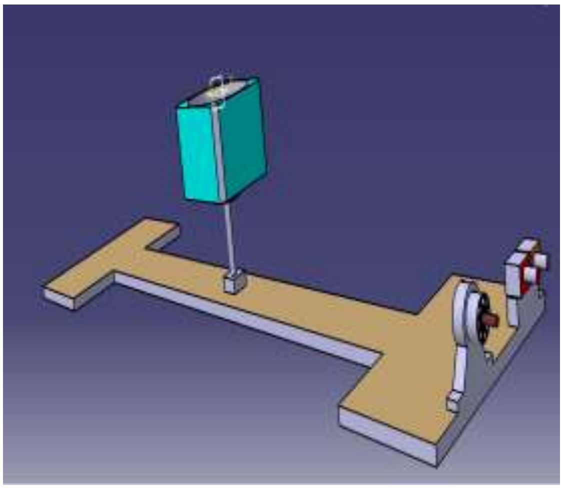

Fig-12: Design of the lower plate

Design of the upper plate

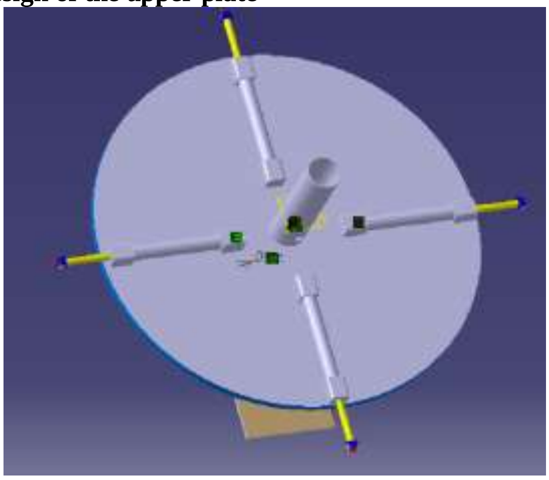

Fig-13: Design of the lower plate

Setup

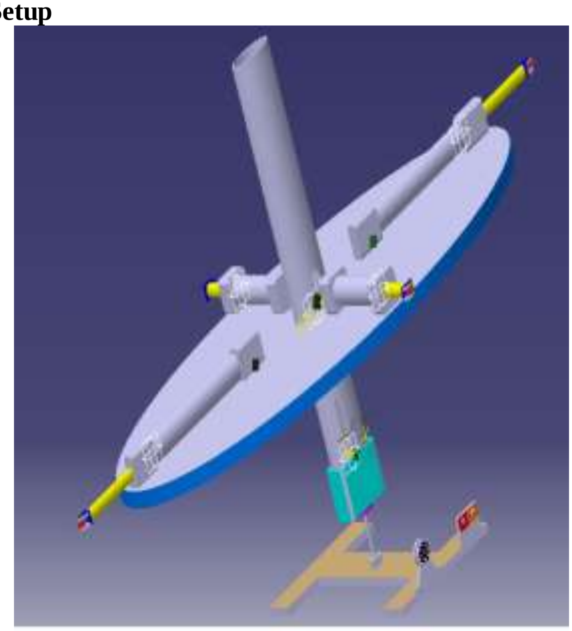

Fig- 13: Design of the overall setup

RESULT

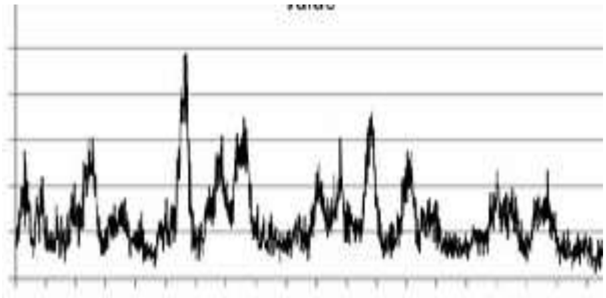

Fig-14: Crack identification graph

The above mentioned graph indicates crack present over wind blade guided by ultrasonic sensor. High amplitude values of graph indicated intensed crack and low amplitude graph shows defect free area.

CONCLUSION

Using this setup prior identification of faults, foreign materials and defects in the wind blade can easily in less time consumption. This technique has been using to predict possible internal and blow holes in the power produce wind turbine blade structure. The setup has to reduce the inspection time so easy for maintenance people. The cracks are identified as early as possible so remedy actions are taken out. It avoids some short of eraction work because inspection done at nacelle. It partially eliminates dependability of crane so overall maintenance cost will reduce. The huge setup is not required for inspection. This method will give more accurate possible prediction of cracks and holes by using ultrasonic sensor and eliminate manual inspection errors.

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