An Overview of Wind Turbine Failure and Condition Monitoring

(Static and Fluid Analysis)

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Abstract- ***Our paper,"An Overview Of wind turbine Failure and Condition Monitoring"*** **intends to cite the causes of wind turbine failure and the necessity of condition monitoring. The future of the energy sector depends upon the efficient harnessing of non-conventional energy resources. The energy of rotation of blade can be harnessed upto 60%. Efforts are being made to increase this number. A test case of a wind turbine located 40ft above sea level is considered. For this wind turbine Static structural analysis is carried out and for the aerofoil profile of a wind turbine, Fluid Flow analysis is carried out.**

KEY TERMS-

Wind Turbine, Failure Diagnosis, FMEA, Condition Monitoring, CFD, ANSYS

INTRODUCTION

Like any piece of complex machinery operating under stress, wind-turbines also can undergo large damage. Without right care and protection policy, resultant claim can spiral out of control. For owners this can lead to lost revenue and operational downtime. Despite manufacturers best operational skills and guarantees wind turbines fail to operate successfully over the year.

1. Failure Of Wind Turbine

Failure of Wind Turbine majorly occurs due to:

1. Generator/Rotor Failure
   a) Design and manufacturing issues
   b) Operational issues
   c) Maintenance Practices
   d) Environmental Conditions

2. Bearing Failure:
   a. Over greasing
   b. Leakage from fittings
   c. Overheating
   d. Damage of bearing races
   e. Bearing collapsed in housing
   f. Lost Ball bearings

3. Gearbox Failure
   a) High variable load and speed
   b) Low gearbox safety factors
   c) Flexible foundation
   d) Operating as speed increases
   e) High Operating Temperature

4. Structural Failure
   Very Strong Wind
   Extreme temperature cycles
   Fractures in Foundation
   Strong Vibrations
   Rotational Fatigue

5. Environmental Failure
   a) Wind loading
   b) Thermal cycling

c) Contamination
d) Heavy storms

2. Detection Methods Of Gearbox Wear

Gearbox and Blades are classified as the most expensive and critical components of wind turbine. Moreover these are prone to high risk failure as compared to other parts of wind turbine. Various detection methods have been employed to to check the gearbox failure

1. Bearing inner race micropitting
2. Bearing race macropitting
3. Bearing roller scuffing
4. Bearing inner race axial cracks
5. Housing and planet bore wear
6. Planet gear retaining ring wear
7. Planet bearing shaft wear
8. Gear tooth micropitting

3. FMEA of Wind Turbine

Failure mode and effects analysis (FMEA) has been extensively used by wind turbine assembly manufacturers for analyzing, evaluating and prioritizing potential/known failure modes. However, several limitations are associated with practical implementation in wind farms. A failure mode is defined as the way in which a component, sub-system or system could potentially fail to perform its desired function. A failure cause is defined as a weakness that may result in a failure.

For each identified failure mode, their ultimate effects need to be determined, usually by a cross-functional team which is formed by specialists from various functions. A failure effect is defined as the result of a failure mode on the function of the system as perceived by the user. RPN is calculated as

RPN=OxSxD

Where;

O=occurance

S=severity

D=detection

FMEA rating for severity of detection

Rank	Description	Criteria
1	Certain failure	Monitoring conditions will always detect failure
2	High	Likelihood of failure
3	Low	Less possibility of failure
4	Impossible failure	Almost zero detection of failure

1. SOLIDWORKS and ANSYS ANALYSIS for locating critical parts of turbine blade

Wind farm with wind turbines exposed to average weather conditions and average wind speed (20 km/h) has been considered. Taking into consideration the height from sea level of the wind turbine following analysis has been done.

A. Static Structural Analysis

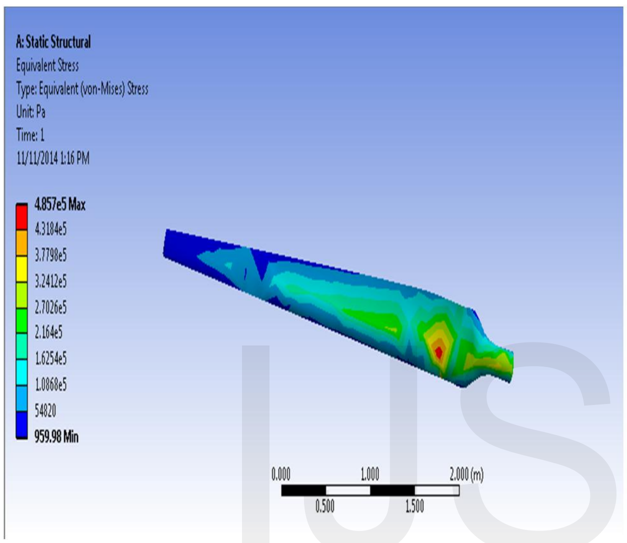

Fig 1(a) stress analysis

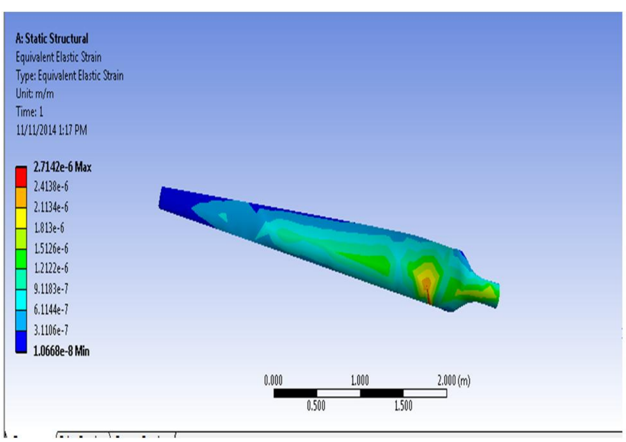

Fig1 (b) strain analysis

A maximum strain of 2.7142e-006 m/m and a maximum stress of 4.857e+005 Pa has been developed in the turbine blade.

B. Modal Analysis

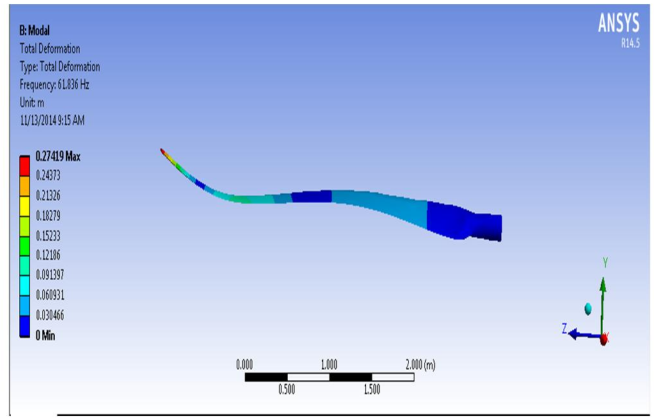

Fig2. Modal Analysis of turbine blade

After performing the modal analysis on the wind turbine blade a maximum displacement of 0.279m has been observed

C. Harmonic Analysis

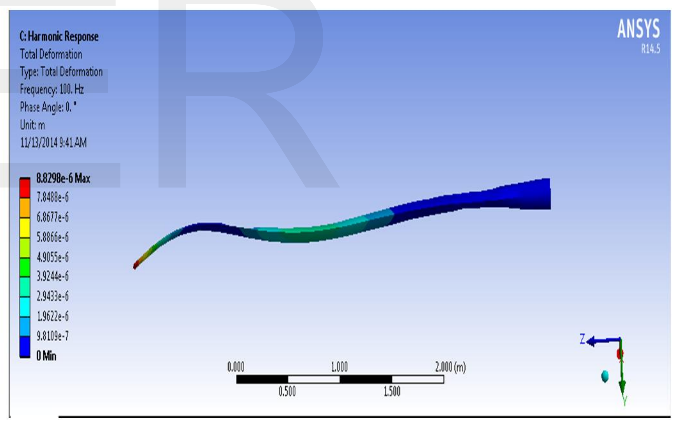

Fig 3(a) Harmonic response

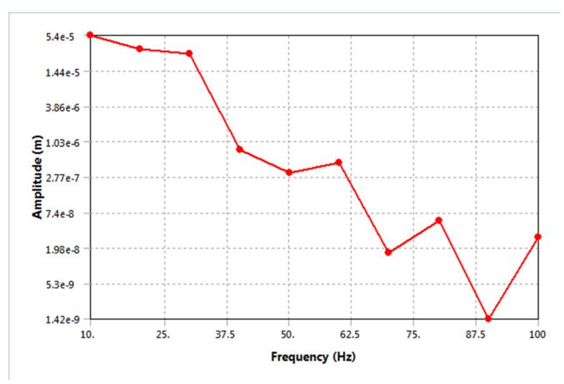

Fig 3(b) harmonic response plot

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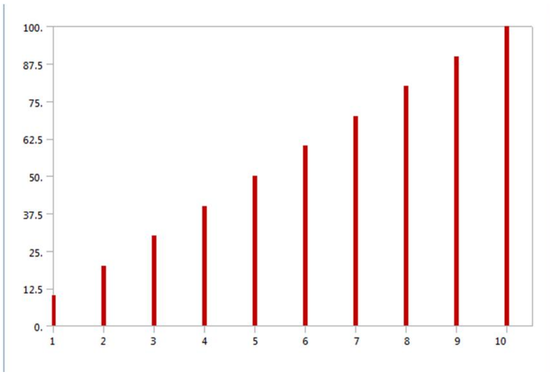

Fig 3(c) Distribution Plot

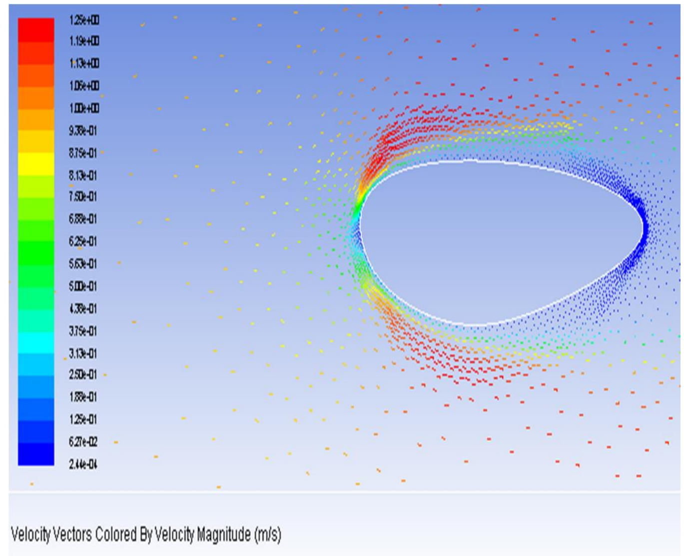

Fig 4(b) Plot of Velocity Vectors by order of magnitude

The above plot demonstrates the actual travel direction of fluid particles. We can infer that maximum fluid is flowing past the aero foil profile and only a part of it is sticking and continuing to flow as a single fluid.

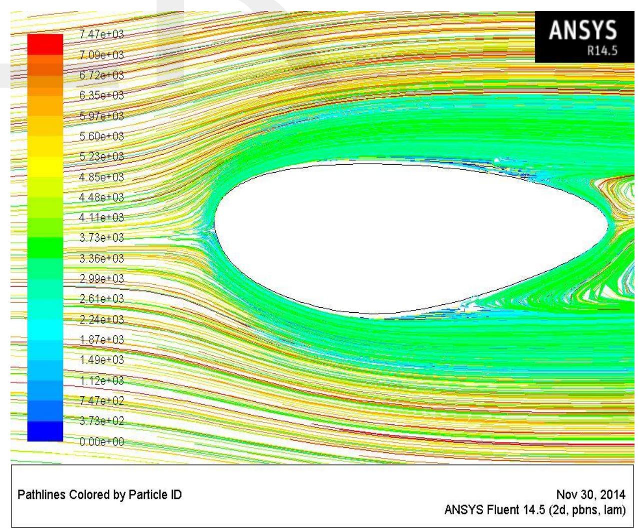

Fig 4(c) Pathlines demonstrating wake formation around aerofoil

CFD Analysis of a Wind Turbine Blade

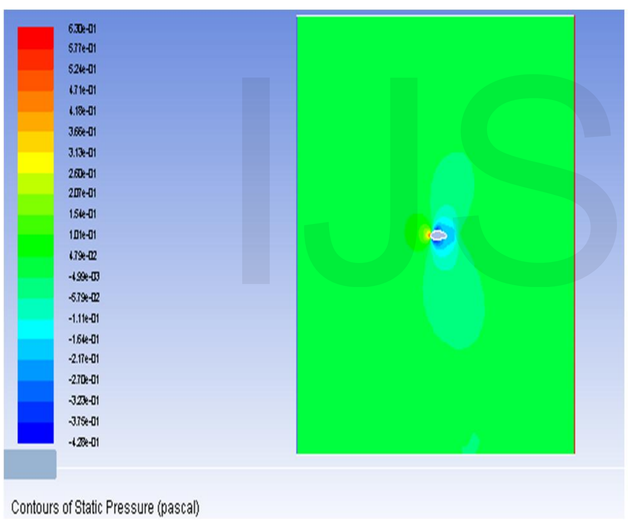

Fig 4(a) Pressure Plot of aerofoil

From the pressure plot we infer that as we go away from the aero foil profile the pressure is uniformly distributed in the bounding box. Near the profile slight pressure variation of fluid is observed.

The CFD analysis has been carried out for a wind turbine blade spanning about 50 ft. and material Fibreglass. At a certain distance from the aero foil end the path-lines break away forming a wake. It indicates the turbulence zone.

The wind turbine is horizontal axis. The wind speed observed during the time of supervision is about 20 km/hr.

Condition Monitoring in Wind turbines

Condition monitoring systems (CMS) comprise combinations of sensors and signal processing equipment that provide continuous indications of component (and hence wind turbine) condition based on techniques including vibration analysis, acoustics, oil analysis, strain measurement. On WTs they are used to monitor the status of critical operating major components such as the blades, gearbox, generator, main bearings and tower. Monitoring may be on-line (and hence provide instantaneous feedback of condition) or off-line (data being collected at

Condition Monitoring Techniques

1. Vibration analysis
2. Acoustic Emissions
3. Ultrasonic Techniques
4. Oil Analysis
5. Strain Measurement
6. Radiographic Inspection
7. Thermography

Limitations of condition monitoring

1. Overall condition monitoring is difficult to achieve in large windy terrains and places which experience rapid weather changes
2. Condition monitoring has drawback where predictability is concerned.
3. Condition monitoring is a costly technique and cost reduction needs to be achieved
4. Increased number of parts eg sensors make the system bulky.

9. References

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