2nd National Conference on Recent Innovation in Engineering, Science, Humanities and Management
REVA University, Yelahanka, Bangalore, (India)
29th-30th March 2019 www.conferenceworld.in ISBN : 978-93-87793-79-8

VIBRATION HEALTH MONITORING MODULE FOR GAS TURBINE ENGINE

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ABSTRACT

Vibration monitoring is widely recognized as an effective tool for the detection and diagnosis of failures of gas turbines. This paper represents a overview of vibration based methods for turbine blade. Blade faults and blade failures are ranked among the most frequent causes of failures in turbo machinery. This paper provides a review on the condition monitoring techniques and the most suitable signal analysis methods to detect and diagnose the health condition of blades in turbo machinery.

Compressor blades of a heavy industrial gas turbine need to undergo long period mechanical stress and vibration induced by high speed rotation and high pressure mass flow. High stress synchronized with erosion and corrosion damage during operation is the main reason for blade cracking. Early detection of blade anomaly and incipient crack is important to make sure blade and compressor health and minimize service disruption. In this paper we will introduce a blade health monitoring (BHM) system developed by GE Power.BHM sensors and data acquisition (DAQ) system are installed on the gas turbine to capture blade passing signals (BPS) and assess time of arrival (TOA) for each blade. Advanced signal processing algorithms process the signals locally to sum up key features that associated with blade health.

***Keywords:* Blade vibration monitoring, Blade tip-timing (BTT), Tip clearance (TC), Blade faults diagnostics, Tip clearance (TC), Vibration signal analysis techniques.**

I. INTRODUCTION

Heavy duty industrial gas turbines are widely used in power generation plants worldwide. Axial flow compressor is a key subsystem of the gas turbine. Due to inlet air flow aero dynamic load and rotor rotation, various mode displacement and vibration on the compressor blades are excited. Excessive vibration may accumulate high cycle fatigue and thermal mechanical stress on a rotor blade, and cracks may initiate and propagate over time. To detect and monitor blade cracks and state early warning before material liberation is the main focus for any blade health monitoring system. Blade tip sensing based approaches have been the primary method most commonly adopted for rotor blade vibration analysis and crack detection.

In this approach, one or multiple non-contacting blade tip sensors are inserted through drilled holes in compressor casing at an axial location directly above the trajectory of blade tips. The sensor can sense the approaching or departure of rotating blades and produce a pulse voltage when the blade passes the sensor midpoint. Two families of blade tip sensors are typically used, eddy current sensors (ECS) and variable reluctance magnetic sensors (VRS). Both sensor types operate on concept of the principal of perturbed magnetic field caused by blade passing. ECS sensor uses special circuit to extract an active magnetic field, while the VRS sensor uses permanent magnet to produce a static magnetic field. In comparison, the other one is comparatively less expensive since no complex circuit and signal conditioning is required to maintain the active field. On the other hand, ECS sensor can operate for blades of various conductive materials, whereas VRS mainly works with ferrous materials. Other sensing system is that acoustic pressure sensor and bearing vibration sensor have also been studied.

One central based blade health monitoring system (BHM) which was developed by Bhattacharya et al (2011) at GE in recent years. BHM uses about two VRS sensors for every compressor rotor stage to note blade passing signal. The BHM system regards configurable 1-3 or 1-6 stages 24x7 continuous monitoring to GE F fleet units. Both the BPS data from the VRS probe and once-per-rev signal from Keyphasor are captured in DAQ for TOA calculation. The once-per-rev signal can be used as reference point to mark the blade number. In this system, two data sources are employed in blade health calculation: a local DAQ is installed to accumulate TOA data, and turbine operation data initiating from turbine control system is logged in an on-site monitor (OSM) computer. Both data streams will be transferred as data files to a central calculation server for feature extraction and anomaly detection.

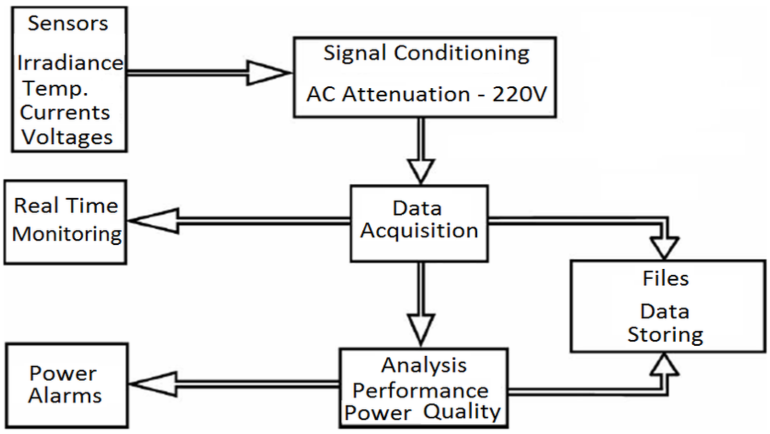

FIG 2.1 Block Diagram

II. LITERATURE REVIEW.

[1]) Ahmed Hafaifa “Fault diagnosis in gas turbine based on neural networks: Vibrations speed application” (Mar 2016): The diagnosis of faults and failures in industrial systems is becoming increasingly essential. This work proposes the improvement of a fault diagnostics system based on artificial intelligence technique, with neural networks applied to a GE MS3002 gas turbine. This technique with its generalization and memory skills which provides an effective diagnostic system for the examined system.

[2] Kouzou Abdellah, Djaidir Benrabeh, Ahmed Hafaifa “Vibration detection in gas turbine rotor using artificial neural network” (Mar 2016): The current development in surveillance methods as well new supervisory meets many requirements in the design and runing of industrial equipment. This article proposes the improvement of

vibration fault detection in gas turbines. Indeed, the presence of one or more defects of vibration in these machines results in the emergence of new usable frequency for monitoring these rotating machines. This work asks to implement an approach based on artificial neural network methods, combined with continuous wavelet technique for the building of fault diagnostic system based on the information data on the state of the tested gas turbine bearing.

[3] Guemana Mouloud ,Kouzou Abdellah, Abdelhafid Benyounes, Ahmed Hafaifa "Gas turbine modeling using adaptive fuzzy neural network approach based on measured data classification" (Jul 2017): The use of gas turbines is numerous in several industries such as; hydrocarbons, aerospace, power generation. However, despite to their many pros, they are tool to multiple exploitation problems that need to be solved. Indeed, the purpose of the present paper is to develop mathematical models of this industrial system with an adaptive fuzzy neural network inference system. Where the knowledge variables in this complex system are found from the real time input/output data measurements collected through the plant of the examined gas turbine. It is known that the advantage of the neuro-fuzzy modeling is to obtain robust model, which enable a decomposition of a complex system into a number of linear subsystems. On the other side, by looking through the membership functions for residual generator to get consistent settings based on the used data structure classification and selection, where the main agenda is to get a robust system information to make sure the supervision of the examined gas turbine.

[4] Attia Daoudi ,Ahmed Zohair Djeddi ,Ahmed Hafaifa "Fault detection and isolation in industrial control valve based on artificial neural networks diagnosis" (Sep 2013) : The industrial systems become more complex in older days; the raising complexity explains the need for a monitoring system performance, safe and reliable. This need for security and dependability requires the implementation of progressive diagnostic systems to report any fault in this industrial processes. In this paper, we innovate a supervision system based on artificial neural networks approach to produce defects indicators for our examined industrial control valve.

[5] Djaidir Benrabeh ,Kouzou Abdellah Ahmed Hafaifa "Faults detection in gas turbine rotor using vibration analysis under varying conditions" (April 2017) : Monitoring of rotating machines is very important task in most industrial sectors which needs a chosen number of performance indicators through the exploitation of these kind of equipments. Indeed for understanding the unrequited phenomena complexity of the industrial tools under operation, a dependable and a better accurate mathematical modeling is required to make sure the diagnosis and the control of these phenomena. This work proposes the improvement of a fault monitoring system of a gas turbine type GE MS 3002 based on vibration analysis technique using spectral analysis systems. The obtained results show the effectiveness of the represented monitoring system approach applied on the gas turbine, for rendering the operation under vibration mode and for generating normal performance during the exploitation of the gas turbine.

III. PROBLEM DEFINITION

The gas turbine engine includes several concentrically mounted components, such as shafts, bearings and gears, each rotating at a slightly different and known frequency.

ISBN : 978-93-87793-79-8

Machinery having massive rotating components, such as jet aircraft engines, may experience shaft, bearing, and/or gear failures. In addition, these rotating components may become unbalanced and impose loads upon the bearings and engine housing well beyond acceptable specifications.

These problems are a result of any type of causes which contains, manufacturing defects, design defects, wear, misuse, accidental damages and the like. In the case of in-flight aircraft, failure of these engine components can lead to, not only engine loss, but a catastrophic loss of aircraft and crew.

IV. METHODOLOGY

- The monitoring systems provide certain diagnostic and predictive information about existing and developing fault conditions.
- By analyzing previous performance data, monitoring systems can be built so that failures are predicted and thereby the removal and inspection of the relevant component can be planned.
- This results in the reliability and safety of the complex machinery being improved significantly.
- In addition considerable savings in the maintenance cost due to the avoidance of having to locate faults in various components.
- This model is based on analytical redundancy methods.
- The main advantage of the proposed method is its simplicity. It can be applied with the present health monitoring system without any modification of existing instrumentation.

Method for monitoring bearing vibration levels associated with a rotating component and establishing an alarm setting therefore, the method comprising the steps of

a) measuring an operating parameter and a corresponding set of vibration amplitudes for a rotating component during a period of operation, the rotating component including a plurality of bearings and at least one sensor for measuring vibration amplitudes

b) selecting a bearing to be monitored from the plurality of bearings of the rotating component.

V. SOFTWARE IMPLEMENTATION

An interface for instant monitoring of the status of the aircraft engine has been designed in MATLAB Simulink. Any performance degradation that may occur in the aircraft’s gas turbine engine can be easily detected graphically or by the engine performance deterioration value. Also, it has been indicated that it could be a new indicator that informs the pilots in the event of a fault that they monitor while flying.

Software packages integration • MSL, SPAN/Simulink

• Multi-platform application

MATLAB SIMULINK is used for; the development and running of state-space, or real-time, engine models (RTEM) and analysis of Engine Health Monitoring Data.

In order for our system to work instantly, we need to design an interface in the MATLAB Simulink environment with the best ANN (Artificial Neural Network) model as a result of the experiments.

VI. CONCLUSION

As future work, expansion and enhancement in BHM feature extraction can further enhance the detection capability. The main advantage of the proposed method is its simplicity. It can be applied with the present health monitoring system without any modification of existing instrumentation.

Advantages of Blade Vibration Monitoring:

> Detection and analysis of blade vibrations

> Detection of unfavorable impact parameters and avoidance of dangerous operating ranges

Information support for avoiding more complex monitoring procedures such as TipTiming

> Extensive support for analysis, diagnosis and evaluation by our Diagnostic Centre.

Limitations:

The available resolution is sufficient to estimate blade vibration frequency and identify the vibration mode. Developed methods are capable to warn about the excessive level of blade vibrations as well as about frequency change of the synchronous blade vibrations caused by fatigue cracks.

(1) The need of domain expertise and advanced knowledge of BTT signals analysis due to severe under-sampling,

(2) That the traditional BTT method can only say whether there is a drawback in the blade but it cannot judge the severity of the defect. Thus, how to overcome the above cons has become a big challenge. Aiming at under-sampled BTT signals, a feature learning method using a convolution neural network (CNN) is introduced.

At the same time, it is found that tip clearance (TC) is also very sensitive to the blade state, specially regarding defect severity.

Applications:

Neural networks and fuzzy logic.

Model based analysis and other techniques.

VII.ACKNOWLEDGEMENT

No study can be done in a single day but it is a result of long experimentation and observation where the required environment consisting of many people play a major role in initializing and completing a work.

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