An Overview of Steam Turbine Blade Vibration Monitoring System (BVMS)

Pratik Dalvi¹, Devidas Barge², Hrishikesh Dhandha³

¹, ², ³ Department of Mechanical Engineering, Datta Meghe College of Engineering, Airoli, Navi Mumbai, Maharashtra, India

Abstract—This paper describes an overview of blade health monitoring system used for steam turbine. Alternative of conventional blade vibration measurement system, a non-contact measurement technique is investigated. The blade vibration can be detected by measurement of tip timing since the blade timing will slightly differ from the passing time calculated from the turbine rotor speed in the presence of the vibrations. The operation of blade vibration monitoring system and the components required for its operation has been presented. Vibrations of last stage free standing blades of low pressure steam turbine can cause high cycle fatigue, which damages the blades and reduces blade life. The operational risks associated with high-cycle fatigue failures as well as other failure like stress corrosion cracking, blade root failure etc. can be observed by using non-contact type monitoring system known as Blade Vibration Monitoring System.

Keywords—Steam Turbine, Vibration Measurement, Blade Vibration Monitoring System, Turbo-machine, Optical Sensors, Condition Monitoring, Data Acquisition.

I. INTRODUCTION

The Steam turbine consist various components, blades are especially important among all. While rotating, turbine blades experience vibration which generate stress and cause the damage of the system. The blade vibration amplitude and frequency have a profound impact on integrity, operations, performance and fatigue life. The accurate estimation of blade vibration is crucial issue. The various incrementing technologies are being discuss related to blade vibration measurement, damage signatures, and monitoring system for all blades.

Continuous availability of steam turbine in a power plant directly related to its performance under distinct operating conditions. In the recent past Low Pressure Turbine free standing stage blades failure experienced in many of large capacity steam turbines. Statistics shows that LP Turbine free standing blades are more susceptible to failure compared to those of HP & IP Turbine blades.

The operational risks associated with high-cycle fatigue failures as well as other failure like stress corrosion cracking, blade root failure etc. can be effectively monitored by the use of a non-contact Blade Vibration Monitoring System (BVMS) where the health of each blade can be assessed during actual running of a turbine.

BVMS refers to measurements made on rotating machinery using sensors that do not make contact with the rotor blades. A BVM system has a number of advantages over the traditional turbo-machinery measurement method (strain gages): data for each blade is acquired in a measured stage, and the instrumentation is non-contacting, which means that no slip rings or telemetry systems are required and the sensors can be replaced, if necessary, without dismantling the machine or even stopping the machine in some installations. Blade vibration monitoring system (BVMS) monitors the vibration behaviour of all the number of blades in a stage during actual running of the turbine. BVMS provides real time data of all the various parameters associated with the operation of Steam turbine power plant. All the various parameters can be analysed and related with each other in order to find the optimal operating condition for steam turbine at reduced vibrations.

II. OVERVIEW OF THE BVM SYSTEM

BVM System shown in figure 1, consists of different types of probes, Signal conditioning unit, timing system and a data acquisition system to analyse the data. For higher amplitude resolution i.e. for maximum trigger accuracy optical sensors are preferably used.

Light beam of He-Ne laser of 633nm, 8mW is used whose light is guided to probe by means of an optical single mode fibre. The light extends in parallel with the blade edge, when the blades pass the light beam with their tips; the intensity of the reflected light rises rapidly. At the same time, the extension of the illuminated spot along the edge allows averaging over any scratches present on the blade surface.

Sensors i.e. probes generate analogue pulses each time a blade passes in front of them. A remotely powered preamplifier is located near the rotor under test and connects to the sensors. For optical sensors, a laser and photodiode are contained in the preamplifier. The preamplifier receives
power and sends buffered signals through a long cable to Blade Vibration Sensor Interface (BVSI) unit. In addition to providing the preamplifier with power, the BVSI also triggers on each blade pulse, creating a digital signal, which is precisely timed. The data console operates with Blade Data software. This software allows the user to easily configure the conditioning and triggering parameters of each sensor signal, configure the software to view blade vibration, clearance, and blade stagger and set visual and acoustic alarms. For more detailed off-line analysis and report generation, Analyse Blade Vibration software can be used. It is also possible to monitor tests remotely via the internet.

III. COMPONENTS of BLADE VIBRATION MONITORING SYSTEM (BVMS)

i. Sensors: The first step in any measuring system is to sense the quantity to be measured which is done by a device known as a sensor. Sensors are the devices which convert one form of energy (e.g. speed, temperature, vibration etc.) into electrical signals for their recording, storage or analysis purpose. There are various types of sensor which are used for monitoring blade vibration. They are classified based on their working principles, such as the passive eddy current sensor, capacitive sensor, DC biased capacitive sensor, and AC biased capacitive sensor, microwave tip clearance sensor and the optical sensor. Let us look in detail the Passive Eddy current sensor and the Optical Sensor.

   a. Passive Eddy current sensor: This type of sensor works on the principle that eddy current forms when a moving or changing magnetic field intersects a conductor or vice versa. The principle of operation is to create a permanent magnetic field through which the rotor blades pass, and disturbing the field as shown in figure 2. If the blades are electrically-conductive (not necessarily ferrous), rapid eddy currents in the passing blade, disturb the permanent magnetic field. This field disturbance is sensed by a coil within the probe.

   b. Optical sensor: These types of sensor works on the principle of transmission and reflection of light passing through optical fibre. These sensors are non-contact type of sensors where in these sensors are placed strategically in the outer casing flush to the inner surface. First the laser is emitted over the tip of the blade through the laser diode and then the reflected laser is captured by the photodiode for its analysis and to determine the vibration of blade shown in figure 4.

The following list of elements is used throughout this application:

1. Coil
2. Core
3. Magnet
4. Connector
5. Potting compound
6. Barrel
7. Case wall
8. Shield
9. Rotor blades
10. Winding axis
11. Mounting hardware

These sensors are placed on the turbine casing wall (shrouds) in such a way that the rotating blade should first pass the permanent magnet and then the Ferro magnetic coil. The orientation of the sensor should be as shown in the figure 3.

![Fig. 3. Orientation of the Sensor](image)

Another type of optical sensor uses a reflective tape attached to a stationary vane and the rotary vane acts as a shutter which blocks the reflecting laser coming back to the photo diode. The pattern in which the reflected signal is
disturbed is calibrated directly to give the vibration of the rotary blade as shown in figure 5.

![Figure 5: Orientation of Laser Diode and Reflective Tape](image)

**ii. Preamplifiers:** These are the devices which help in boosting the weak signal its processing. Strengthening the signal not only makes it noise tolerant but also improves its transmissibility thereby increasing the overall quality of the signal. These signals are then transmitted to power amplifiers to increase its amplitude. Analogue sensors usually require preamplifiers. It should be placed near to the sensor to eliminate the chances of noise and interference.

**iii. Data Acquisition Console:** These devices are similar to storage devices but they have an additional feature of recording the data with its time. This timed data is very useful for analysis of changes in various parameters with respect to time.

**IV. CONCLUSION**

The present study can conclude that lot of development work has been done in vibration measurement field and an attempt has been made to report about various components required for the operation of Blade Vibration Monitoring System which includes different types of sensors such as passive eddy current sensor and optical sensor. Mostly optical sensors are preferred because of their compactness and it gives vibration data on all blades, they are fast and cost effective in operation. Also the numbers of optical sensors required are less. This paper also provides overview of the working of blade vibration monitoring system.

It is observed that a non-contact Blade Vibration Monitoring System (BVMS) is effective technique for condition monitoring of turbine. It gives capability to identify the required system. The expected benefits of this type of studies are an easier implementation of the monitoring system and a more complete vibrational control of all turbine blades.

**REFERENCES**


