DECLARATION

"I hereby declaration that I have read through this thesis and found that it has comply the partial fulfillment for awarding the degree of Bachelor Mechanical Engineering (Structure and Material)

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"I hereby declaration that this thesis is my original work except for questions and citations, which have been fully acknowledgement

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Date : 8/05/2009

VIBRATION ANALYSIS OF TURBINE GENERATOR BASED ON ONBOARD DATA

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Abstract

Turbines generator today are required to run for well beyond their intended lifetimes. Opening up machines for inspection is expensive, and owners need to consider all relevant information in making the decision. The forces and resultant vibration caused by inadequately balanced rotors destroy bearings and seals, damage foundations, transmit noise and increase maintenance costs can be detected and monitored using condition monitoring by Vibration analysis.This report is produced to make analysis of chareteristic vibration on steam turbine generator and to diagnosis the factor that cause the vibration during during full speed based load.In vibration analysis, a spectral or signals from the tested machine are gauge using electronic probe and sensor such as Commtest Analyzer. The signals will be recorded in computer memory. Each of the samples of recorded signals will be analyze to predict the vibration of the machine. From the data onboard, the condition of the machine either it is normal or having problems was specified. Usually, the prediction from data will refer to the ISO standard. The ISO standard that are widely used for machines above 15kW is ISO 10816-3/BS 7854-3

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Chapter 1

Introduction

1.1 General

Industrial vibration analysis is a measurement tool used to identify, predict, and prevent failures in rotating machinery. Implementing vibration analysis on the machines will improve the reliability of the machines and lead to better machine efficiency and reduced down time eliminating mechanical or electrical failures. Vibration analysis programs are used throughout industry worldwide to identify faults in machinery, plan machinery repairs, and keeps machinery functioning for as long as possible without failure. Vibration analysis data provides valuable machine information on whether a machine has been correctly serviced and meets specific vibration tolerances .This type method is used considerably on turbine generator such as Steam Turbines and other rotating machineries.

Turbine is a rotary engine that extracts energy from a fluid flow. Claude Burdin (1788-1873) coined the term from the Latin turbo, or vortex, during an 1828 engineering competition. Benoit Fourneyron (1802-1867), a student of Claude Burdin, built the first practical water turbine.The simplest turbines have one moving part, a rotor assembly, which is a shaft with blades attached. Moving fluid acts on the blades, or the blades react to the flow, so that they rotate and impart energy to the rotor. Early turbine examples are windmills and water wheels.

Almost all electrical power on Earth is produced with a turbine of some type. Very high efficiency turbines harness about 40% of the thermal energy; with the rest exhausted as waste heat. Turbines are often part of a larger machine. Turbines can have very high power density (i.e. the ratio of power to weight, or power to volume). This is because of their ability to operate at very high speeds

Generator always related to electricity generation. In electricity generation, an electrical generator is a device that converts mechanical energy to electrical energy, generally using electromagnetic induction. The reverse conversion of electrical energy into mechanical energy is done by a motor, and motors and generators have many similarities. A generator forces electric charges to move through an external electrical circuit, but it does not create electricity or charge, which is already present in the wire of its windings. The source of mechanical energy may be a reciprocating or turbine steam engine, water falling through a turbine or waterwheel, an internal combustion engine, a wind turbine, a hand crank, the sun or solar energy, compressed air or any other source of mechanical energy

1.2 Objective

The objective of this research is to study, analysis and discuss the abnormalities in the vibration characteristics detect in turbine generator using vibration analysis based on onboard data method.

1.3 Scope of Study

1 To do literature study on the background of steam turbine generator base on the type, capacity, and performance of the turbine generator.
2. To do literature study on the problem, breakdown or maintenance activity on turbine generator
3. To carry out the vibration measurement and analysis on turbine generator
4. To analyze the characteristic vibration of turbine generator.
5. To analyze the dynamic vibration characteristic during Full Speed Base Load (FSBL)
6. To study and discuss problem solving.

1.4 Problem statement

Every machine with fault that can ultimately result in failure, secondary damage, and downtime, will vibrate in characteristic ways. If this information can be learned, the damage on the turbine can be preventing from it to become more serious. Thus the machine may require less maintenance and become more reliable. Vibration analysis is one among the method that can help solving this problem.

1.5 Outline of research

1. Literature review
   Information of many sources is collected as reference of this project
2. Equipment preparation
   Equipment is borrowed and method of measuring vibration is guided by AFCM Company
3. Data collection and analysis
   The Data taken will be analyzed using vibration analysis based on onboard data during full speed base load (FSBL) condition and steady state condition
4. Discussion
   Discussions on the abnormalities characteristic vibration of the turbine generator

1.6 Expected result

In the end of this project, we will produce a report that explains the type of abnormalities of vibration, the method used during analysis and the problem solving for each of the problem. This report can be reference for student that willing to involve in condition monitoring field.

Chapter 2

Literature Review

2.1 Steam turbine generator

Electrical generating plants commonly run with steam power. In such plants, the burning of coal, oil, or natural gas or the energy derived from a nuclear reactor is used to boil water. The steam thus produced is then used to drive a turbine which, in turn, propels a generator. Because the turbine generates rotary motion, it is particularly suited to be used to drive an electrical generator - about 80% of all electric generation in the world is by use of steam turbines.

A steam turbine consists of a stationary set of blades, often called nozzles and a moving set of blades called buckets, or rotor blades. In a steam turbine, hot steam at a pressure above atmosphere is produced by a boiler, then, expanded in the nozzle where the heat energy is converted to kinetic energy.

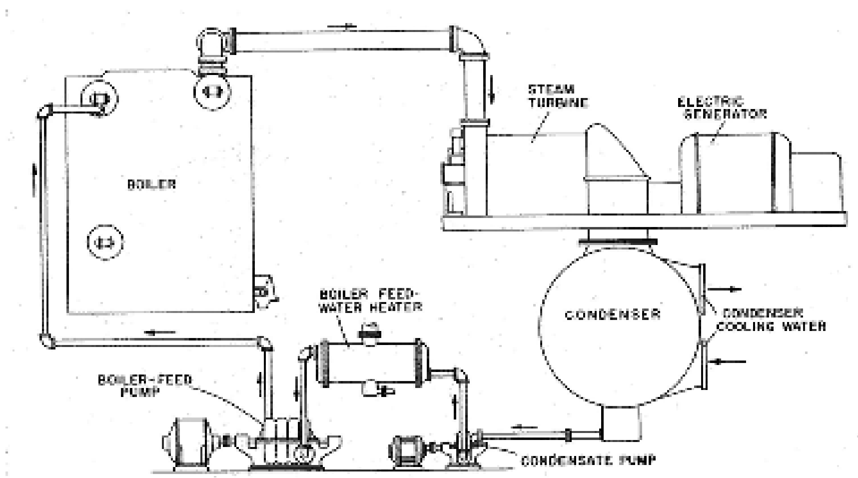

Figure 2.1-A typical steam turbine operating system

This kinetic energy is then converted into mechanical energy in the turbine. If the nozzles are fixed and the jets directed at the movable blades, the impulse from the force of the jets pushes the blades. If the nozzles are free to move, reaction of the jets pushes against the nozzles forcing them to move in the opposite direction.

The stationary and rotating blade components act together to provide torque to the rotor assembly, which is transmitted through the shaft to the load (figure 2 Illustrates the typical arrangement of impulse and reaction turbine blade designs).

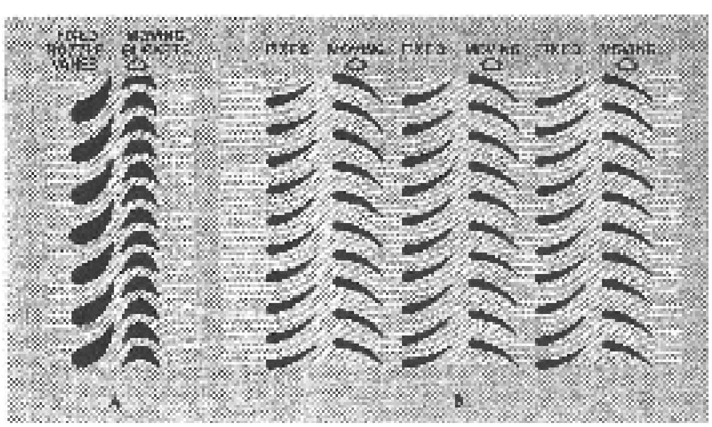

Figure 2.2- A. Impulse turbine design. B. Reaction turbine design.

Steam turbines are built in a number of different configurations to suit the needs of industrial process, compression, or power plant electrical generation installations. They may be of double (compound), or single cylinder design. Turbines with single cylinder design are either a condensing or a back pressure (non-condensing) machine.

Steam turbines are made in a variety of sizes ranging from small 1 hp (0.75 kW) units (rare) used as mechanical drives for pumps, compressors and other shaft driven equipment, to 2,000,000 hp (1,500,000 kW) turbines used to generate electricity. There are several classifications for modern steam turbines [Wikipedia]

2.1.1 Steam turbine capacity

Steam turbines are made in a number of different arrangements to suit the need of various power plant or industrial installations. Turbines up to 40-60MW capacity are generally single-cylinder machine. Larger unit in size up to 1250MW are usually of compound type. Compound type is the steam is partially expanded in one cylinder then passed to one or more additional cylinder where expansion is completed.

2.1.2 Steam Turbine Lubrication

The primary lubricated components of steam turbines are the journal and thrust bearings and depending upon the design and application of the turbine, a hydraulic governor control system, seals, accessory gear drive, flexible coupling and turning gear may also require lubrication.

Where a generator, compressor or other device is driven by the turbine, the central lubrication system usually lubricates the bearings and auxiliary components of the driven machinery. According to Paul E.mix in his book it state that the lubricant used in steam turbines must be premium quality recirculation oil with excellent thermal and oxidation stability, in order to prevent varnish and sludge formation at bearing oil temperatures that may occasionally reach 200ºF (94ºC). In addition, the lubricant must have high quality rust and corrosion prevention characteristics and must readily shed the water that may enter steam turbine systems.

2.2 Troubleshooting Steam Turbines

Steam turbines are prone to problems requiring the initiation of maintenance. These problems include conditions affecting lubrication, alignment problems, imbalance conditions, vibration, bearing problems, operational errors, steam contamination and problems affecting the efficiency of the turbine blades themselves, such as stress cracking, corrosion, pitting and erosion. In addition, erratic governor operation or worn governor parts will cause poor turbine performance

2.2.1 Vibration Troubleshooting

1. Bearing Problem

Bearing problems in steam turbines are related to such conditions as wear, incorrect clearances or the internal frictional qualities of the lubricant.

2. Alignment problem

Alignment problems can be caused by cracked or damaged foundation mounting pads bent or deformed base plates, damaged or worn drive couplings, loose, missing or damaged hold down bolts and brackets.

3. Imbalance problems

Imbalance problems may be created by damage to turbine blades caused by such conditions as erosion, pitting or corrosion

2.3 Maintenance of turbine

Maintenance is a very important to the power plant. By applying maintenance to turbine generator, the condition of the turbine can be monitor in every period of time (6 month) detect a problem early and save a lot of money by from bigger damage on turbine. There a various maintenance method:

1. Breakdown maintenance
2. Preventive
3. Predictive
4. Reliability centered (Proactive)

2.3.1 Breakdown maintenance

It is also known as "run to failure" maintenance. It is the practice of allowing machine to fail rather than taking any preemptive action. The advantage of this method is that no cost related to condition monitoring and machines are not over-maintained. This method leads to very high repair cost and loss of production if the failure is detected later.

2.3.2 Preventive maintenance

In this method, the maintenance is performing early before it needs to avoid failure to the machine. Therefore there are fewer failures and less interruption to production. The disadvantage on this method is this method can cause more harm to the machine by frequently repaired when there was no problem detected.

2.3.3 Predictive maintenance

This method is also known as "condition based maintenance". This method is the best method in prevent failure on the machine at the same time improve quality performance and increase machine safety. This is because the maintenance is only performed when convenient. This method is used to predict when a machine will fail, determine health status and predict failure mode. The advantage is that it cost instrument, system, services for monitoring. Vibration analysis is categorized in this method.

2.3.4 Proactive maintenance

This method also known as “reliability centered maintenance” and “precision maintenance”. In this method the root cause of the failure is finding early to reduce the chance of failure. It changes machine design, purchasing and maintenance procedures to reduce failures and increase machine reliability. The disadvantage, this method requires additional skill and additional time invested up front.

2.4 Technology in detecting vibration on turbine

There are several technologies that can be used in maintenance for detect failure or vibration and monitor the condition of turbine generator.

1. Vibration analysis
2. Oil analysis
3. Wear particle analysis
4. Thermography
5. Ultrasound

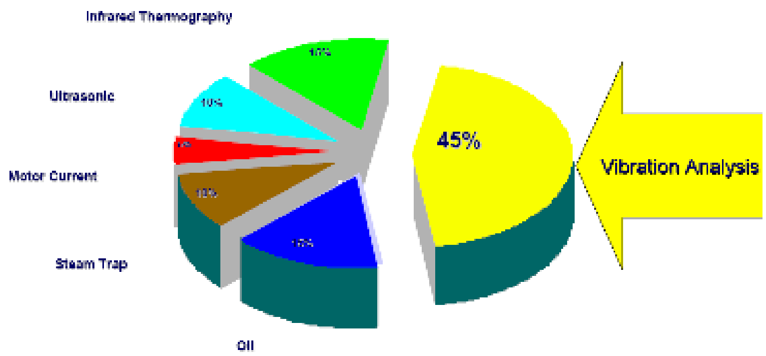

Figure 2.3 Percent of total method used in Vibration monitoring

2.4.1 Thermography

All mechanical systems generate thermal energy during normal operation. This excessive heat can be generated by friction, cooling degradation, material loss or blockages. This technique allows for the monitoring of temperatures, thermal patterns and evaluates their operating condition while the turbine is online and running under full load.

Thermography is more useful for locating a problem area than for indicating the root cause of the overheating. The heat is usually produced within a component that is not visible directly to the camera. That heat must conduct up through the material and present itself as a pattern on the surface of the object in order for the infrared camera to sense it [20].

In turbine section, thermography is use to locate high lube oil temperature, high bearing temperatures, faulty stop/control valve operation, uneven metal temperature , leaking shaft seals identify misalignment in couplings [41]. Thermography examination can help in using other tools, such as vibration analysis, more effectively. If a thermal anomaly is found, then the other tools can be employed to help isolate the cause of the problem.

2.4.2 Oil analysis

Rotating machinery need correct lubricant to perform well. Incorrect lubricant or contaminated lubricant will result in increasing wear and components failure. In rotating machine bearing is the part that completely related to the oil. The used of incorrect lubricant can cause the bearing to wear and causing vibration to the system.
To avoid this from happening, this technology was tested on oil and grease. The test gives information if the lubricant is still able to perform its job in top quality, whether there are any contaminants and early warning of wear on machine component.

2.4.3 Wear particle analysis

This technology is applied to lubricated equipment to exanimate particles suspended in the lubricant by providing accurate insight into the condition of a machine's lubricated. It analysis based on particle shape, composition, size distribution, and concentration to indentify abnormal wear-related condition at an early stage. Analysis on oil can be done either in-house or off-site of plant.

2.4.4 Ultrasound

An ultrasonic detection device is an excellent tool as a power plant's first line of defense in predictive/preventive maintenance. This technology used to quickly locate problems in a wide range of components, equipment, and systems, enabling them to make informed decisions as to what further actions are needed to solve the problems. Technicians use ultrasound when they first suspect a problem.

Ultrasonic technology allows the technician to gather information rapidly. In power plants, ultrasonic technology is unique in its ability to detect and pinpoint leaks in air and steam systems, condensers, boiler tubes, and water walls - something infrared and vibration analysis cannot do.

In the case of bearings, ultrasound can not only "tell" the operator if the bearings are over- or under-lubricated or are out of round, ultrasound can pinpoint which bearings need immediate attention[31]. Ultrasonic technology is a quicker method to investigate suspect bearings, gears, check valves, and other critical components in any rotating equipment in the facility [48].

2.4.5 Vibration Analysis

Vibration analysis is the method or technique that uses instruments to monitor and analyze machine vibration to determine if the machine is working properly [7]. Vibration is also use to look for the patterns, change in motion and detect a problem early enough to act [9]. The result gained from the measurement give information about the nature of the problem and the status or condition of fault [12]. The data and information gained from this method can help to improve maintenance practices on the machine thus the machine will become more reliable
Vibration

There are many general meaning of vibration. According to Wikipedia vibration refers to mechanical oscillations about an equilibrium point (1). Vibration also can be defined as the act of vibrating, or the state of being vibrated. The vibrating object moved in different way. The vibration characteristics can be determined by the movement speed of the object.

2.5 Principle of vibration

Piers Clement in his article 'The great principle of vibration' said that "Nothing rests; everything moves; everything vibrates."He state that vibration exists at every level from the microscopic to the macroscopic, and at every level harmony is sought and conflict is resolved

In physics vibration is often called oscillation - either a movement back and fro as in the swing of a pendulum or random vibrations as are exhibited in the Brownian movement. It can be described by three factors: the amplitude (size), the frequency (rate) and the speed.