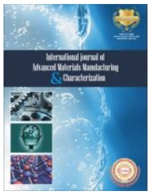

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Condition Monitoring of Steam Turbine through Ferrography

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A B S T R A C T

Power plants have many sensible equipments like pumps, turbine etc. For higher reliability and continuous generation of power, maintenance has to be done regularly. Many maintenance practices like preventive, predictive, corrective etc are being used. Predictive maintenance is most widely employed in practice. Condition monitoring is a type of predictive maintenance. Most rotating machine defects can be detected by such a system much before dangerous situations occur. It allows the efficient use of stationary online continuous monitoring systems.The machinery used in power plant is often operated continuously for many months; this machinery may fail by wear and tear if they are not having sufficient lubrication. The proper selection and use of lubricants, as well as the care and operation of lubricating systems, is an essential part of any power plant maintenance program.This Paper mainly concentrating on an analysis of used oil for contaminants by ferrogragh.

Introduction

Maintenance is a must every machine and for every person. Monitoring the condition of a machine is the basis of many maintenance techniques. They are as follows –

Types of maintenance:

Preventive maintenance: It is the planned maintenance of plants and equipments in order to prevent or minimize breakdowns and depreciation rates.
Preventive maintenance schedules are normally of the following two types:

i) Fixed time maintenance (FTM) schedule.
ii) Condition based maintenance (CBM) schedule.

Predictive maintenance: It is simply predicting the failure before it occurs, identifying the root causes for those failure symptoms and eliminating those causes before they result in extensive damage to the equipments.

Break down maintenance: Here repair is undertaken only after the failure of the equipment. The equipment is allowed to until it fails. During this period, lubrication and minor adjustments are done.

Proactive maintenance: We have those people who are healthy. They eat the right food and they get plenty of exercise. They know what is good for their body, they still visit their doctor to go through the tests just in case they do catch the odd virus. Their employers consider them to be very reliable. They rarely miss a day of work. This is akin to proactive maintenance.

Opportunistic maintenance: When equipment is taken down for maintenance/ changing of one or few worn out components, the opportunity can be utilized for maintaining/ changing other wearing out components, which are inaccessible for inspection

Routine maintenance: The simplest but very much essential form of maintenance practice is Routine Maintenance. This maintenance is carrying out minor maintenance jobs at regular intervals.

Condition monitoring

Condition monitoring is one of the predictive maintenance practices which are use most widely.

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Importance of condition monitoring:

The industries all over the world today demand high technology maintenance management in view of high power and speed of machines utilized in the complex process conditions. Approximately 20 -30 % of possible production time goes towards maintenance of equipment and this can be minimized through effective maintenance of equipment. Minimum downtime of machines and reduction in penalty costs are the pressing needs of every enterprise. These considerations are particularly true in the areas of advanced technology such as aircraft industries, oil well drilling, coal extraction, power plants and chemical industries etc. Condition monitoring helps to achieve the maintenance objectives in such highly capital intensive industries.

Definition:

"Condition Monitoring" is the art of monitoring the condition of equipment so that the health of the machine is known and gives understanding whether the health is stable or if it is deteriorating.

Advantages:

Condition Monitoring is considered as the reliable, cost effective and efficient technique for maintaining the majority of critical equipments such as engines, turbines, compressors etc used in most of the industries today.

Towards this aim Condition Monitoring plays an important role. Thus it is necessary to develop an appropriate monitoring system in the overall maintenance schemes for all machinery.

Condition Monitoring provides a powerful weapon in the maintenance armory. It provides early warning of many potential problems allowing planned maintenance and avoiding unscheduled outages. It gives a fast and accurate picture of what is happening in application. Condition Monitoring involves determining the health and performance of the machine. Both of which are very important. However, now that information is used as a part of production and maintenance decision process making is a separate issue.

Techniques:

Condition Monitoring is most frequently used as a predictive or condition based maintenance technique. Condition monitoring involves application of fault diagnosis techniques. A number of such techniques are available to identify the causes of impending trouble in machinery.
Some of the techniques used in condition monitoring discussed below:

- Vibration Analysis
- Lubrication Monitoring
- Infra-Red Thermograph
- Noise Monitoring
- Shock pulse measurement
- Spectroscopy
- Dissolved Gas Analysis
- Thickness Monitoring
- Corrosion Monitoring

Lubrication Monitoring: Oil and lubricants analysis is widely used in Condition Monitoring of lubricated machinery &hydraulic systems. Various tests are done depending upon the particular type of machine. These tests can be grouped in the following categories:

- Those that measure the properties of the oil itself such as viscosity, additive strength and flash point etc.
- Those that measure contaminants in the oil such particle concentration, fuel dilution and water dilution etc.
- Those that tell more about the machine through which the oil interface than about the oil itself such as wear metals & wear particles.

As mentioned above tests, Ferrography is used to for wear particle analysis.

Wear Particle Analysis/Ferrography

Ferrography is a technique that provides microscopic examination and analysis of wear particles separated from all types of fluids. Developed in the mid 1970's as a predictive maintenance technique, it was initially used to magnetically precipitate ferrous wear particles from lubricating oils.
This technique was used successfully to monitor the condition of military aircraft engines, gearboxes, and transmissions. That success has prompted the development of other applications, including modification of the method to precipitate non-magnetic particles from lubricants, quantifying wear particles on a glass substrate (Ferro gram) and the refinement of our grease solvent utilized in heavy industry today. Three of the major types of equipment used in wear particle analysis are the Direct-Reading (DR) Ferro graph, the Analytical Ferro graph and the Ferro scope.

Direct Reading (DR) Ferro graph

The DR Ferro graph Monitor is a trending tool that permits condition monitoring through examination of fluid samples on a scheduled, periodic basis. A compact, portable instrument that is easily operated even by non-technical personnel, the DR Ferro graph quantitatively measures the concentration of ferrous wear particles in lubricating or hydraulic oil. The DR Ferro graph provides for analysis of a fluid sample by precipitating particles onto the bottom of a glass tube that is subjected to a strong magnetic field. Fiber optic bundles direct light through the glass tube at two locations where large and small particles are deposited by the permanent magnet. At the onset of the test, before particles begin to precipitate the instrument is automatically "zeroed" with a microprocessor chip as the light passes through the oil to adjust for its opacity. The light is reduced in relation to the number of particles deposited in the glass tube, and this reduction is monitored and displayed on a LCD panel. Two sets of readings are obtained: one for Direct Large >5 microns (DL) and one for Direct Small <5 microns (DS) particles. Wear Particle Concentration is derived by adding DL + DS divided by the volume of sample, establishing a machine wear trend baseline.

Figure-2.1: Direct Reading Ferro graph

Machines starting service go through a wearing in process, during which the quantity of large particles quickly increases and then settles to an equilibrium concentration during normal running conditions. A key aspect of ferrography is that machines wearing abnormally will produce unusually large amounts of wear particles indicating excessive wear condition by the DR Ferro graph in WPC readings. If WPC readings are beyond the normal trend a Ferro gram sample slide is made with the fluid for examination by optical microscopy.

The Analytical Ferro graph

Additional information about a wear sample can be obtained with the Analytical Ferro graph system, instruments that can provide a permanent record of the sample, as well as analytical information. The Analytical Ferro graph is used to prepare (Ferro gram) a fixed slide of wear particles for microscopic examination and photographic documentation.
The Ferro gram is an important predictive tool, since it provides an identification of the characteristic wear pattern of specific pieces of equipment. After the particles have deposited on the Ferro gram, a wash is used to flush away the oil residue or water-based lubricant. After the wash fluid evaporates, the wear particles remain permanently attached to the glass substrate and are ready for microscopic examination.

Figure-2.2: Ferrogram Maker

The Ferro scope: Ferro grams are typically examined under a microscope that combines the features of a biological and metallurgical microscope. Such equipment utilizes both reflected and transmitted light sources, which may be used simultaneously. Green, red, and polarized filters are also used to distinguish the size, composition, shape and texture of both metallic and non-metallic particles, which is a key component to proper diagnosis.

Figure-2.3: Ferroscope

Results and Discussions

After caring out the above mentioned tests for different samples of lubricating oil the mechanical impurities (wear particles) can be summarized below.

Types of Wear Particles

There is six basics wear particle types generated through the wear process. These include ferrous and nonferrous particles a comprises.

Normal Rubbing Wear: Normal-rubbing wear particles are generated as the result of normal wear in a machine and result from exfoliation of parts of the shear mixed layer. Rubbing wear particles consist of flat platelets, generally 5 microns or smaller, although they may range up to 15 microns depending on equipment application. There should be little or no visible texturing of the surface and the thickness should be one micron or less.

Figure-3.1: Cutting Wear

Cutting Wear Particles: Cutting wear particles are generated as a result of one surface penetrating another. There are two ways of generating this effect. A relatively hard component can become misaligned or fractured, resulting in hard sharp edge penetrating a softer surface. A particle generated this way is generally coarse and large, averaging 2 to 5 microns wide and 25 microns to 100 microns long.

Hard abrasive particles in the lubrication system, either as contaminants such as sand or wear debris from another part of the system, may become embedded in a soft wear surface (two body abrasion) such as a lead/tin alloy bearing. The abrasive particles protrude from the soft surface and penetrate the opposing wear surface. The maximum size of cutting wear particles generated in this way is proportional to the size of the abrasive particles in the lubricant. Very fine wire-like particles can be generated with thickness as low as .25 microns. Occasionally small particles, about 5 microns long by 25 microns thick, may be generated due to the presence of hard inclusions in one of the wearing surfaces.

Cutting wear particles are abnormal. Their presence and quantity should be carefully monitored. If the majority of cutting wear particles in a system are around a few micrometers long and a fraction of a micrometer wide, the presence of particulate contaminants should be suspected. If a system shows increased quantities of large (50 micrometers long) cutting wear particles, a component failure is potentially imminent.

Spherical Particles: These particles are generated in the bearing fatigue cracks. If generated, their presence provides an early warning of impending trouble as they are detectable before any actual spalling occurs. Rolling bearing fatigue is not the only source of spherical metallic particles. They are known to be generated by welding or grinding processes (contamination). Spheres produced in fatigue cracks may be differentiated from those produced by other mechanisms through their size distribution. Rolling fatigue generates few spheres over 5 microns in diameter while the spheres generated by welding, and grinding are frequently over 10 microns in diameter.

Severe Sliding: Severe sliding wear particles are identified by parallel striations on their surfaces.

These striations are parallel to each other and the long axis of the particle.

They are generally larger than 15 microns, with the length-to-with thickness ratio falling between 5 and 30 microns. Severe sliding wear particles sometimes show evidence of temper colors, which may change the appearance of the particle after heat treatment.

Bearing Wear Particle: These distinct particle types have been associated with rolling bearing fatigue: Fatigue Spall Particles constitute actual removal from the metal surface when a pit or a crack is propagated.

These particles reach a maximum size of 100 microns during the micro-spalling process Fatigue spalls are generally are flat with major dimensions-to thickness ratio of 10 to 1. They have a smooth surface and a random, irregularly shape circumference.

Laminar Particles are very thin free metal particles with frequent occurrence of holes. They range between 20 and 50 microns in major dimension with a thickness ratio of 30:1. These particles are formed by the passage of a wear particle through a rolling contact. Laminar particles may be generated throughout the life of a bearing, but at the onset of fatigue spalling, the quantity generated increases. An increasing quantity of laminar particles in addition to spherical wear is indicative of rolling-bearing fatigue micro-cracks.

Gear Wear: Two types of wear have been associated with gear wear: Pitch Line Fatigue Particles from a gear pitch line have much in common with rolling-element bearing fatigue particles. They generally have a smooth surface and are frequently irregularly shaped. Depending on the gear design, the particles usually have a major dimension-to-thickness ratio Between 4:1 and 10:1. The chunkier particle result from tensile stresses on the gear surface causing the fatigue cracks to propagate deeper into the gear tooth prior to spalling.

Scuffing or Scoring Particles is caused by too high a load and/or speed. The particles tend to have a rough surface and jagged circumference. Even small particles may be discerned from rubbing wear by these characteristics. Some of the large particles have striations on their surface indicating a sliding contact. Because of the thermal nature of scuffing, quantities of oxide are usually present and some of the particles may show evidence of partial oxidation,

That is, tan or blue temper colors. Many other particle types are also present and generally describe particle morphology or origin such as chunk, black oxide, red oxide, corrosive, etc. In addition to ferrous and non-ferrous, contaminant particles can also be present and may include: Sand and Dirt, Fibers, Friction polymers, and Contaminant spheres.

Contaminant particles are generally considered the single most significant cause of abnormal component wear. The wear initiated by contaminants generally induces the formation of larger particles, with the formation rate being dependent on the filtration efficiency of the system. In fact, once a particle is generated and moves with the lubricant, it is technically a contaminant.

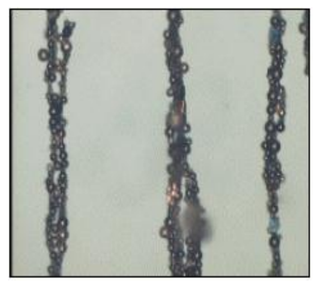

Figure-3.2 Fatigue Spalling Eminent

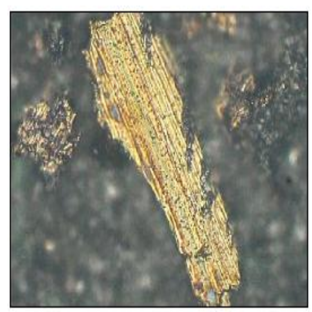

Figure-3.3: Severe Sliding

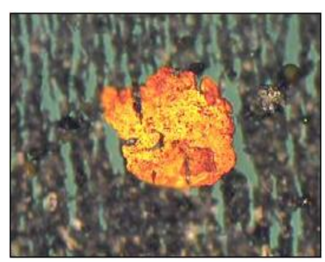

Figure-3.4: Bearing Wear

Figure-3.5: Gear Wear

Conclusions:

- To determine the condition of oil during the usage to facilitate a decision for oil change once it has reached beyond the limits of its usefulness.
- .To knows the health of the machine and minimizes the risk of unexpected shutdown or failure.
- It saves on the cost of maintenance**.**
- All these testing parameters will decide when to remove equipment from service for maintenance & replacement of oil.

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