FAILURE ANALYSIS OF MOBILE CRANES BASED CONDITION MONITORING

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ABSTRACT

In construction industry, maintenance costs accounts for 10-15% of the production cost. Maintenance affects the targets, quality and profitability of the plant. Mobile crane maintenance is one of important factor enhancing the productivity in construction plant. Mobile crane breakdown is responsible for high down time lost. To avoid unwanted down time maintenance programs should be capable to minimize breakdown. After analysis of existing maintenance procedure & maintenance cost of Hydraulic Mobile crane at different running hours at M/S ***Chauhan cranes*** *was found that some critical items of Mobile crane were failed before its life cycle. After failure analysis of some critical items of hydraulic mobile crane it was found that the failure of components takes place only due to lack of knowledge of maintenance procedure to the operator. Because operator play key role to maintain machine safe, reliable at minimum maintenance cost. This can only possible when the operator having full knowledge about safe operation, repair & maintenance procedure. The present work consists of failure analysis of some critical items of Mobile crane, their causes of failures & remedies. This work also covers as a systematic and collective approach to safe operation, Repair & maintenance procedure to Mobile crane operator to reduce maintenance cost, machine breakdown time & least rate of failures. Condition monitoring is much more than a maintenance scheduling tool and accordingly it should not be restricted to maintenance management. As part of an integrated, total plant performance management programme, it can provide the means to improve the production capacity, product quality and overall effectiveness of our manufacturing and production plants.*

Keywords*: Condition monitoring Engine, lubrication monitoring, wear particle analysis, Spectroscopy, microscope, Visual inspection, Vibration analysis, Temperature monitoring.*

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1. INTRODUCTION

Condition monitoring is a process of monitoring a parameter of condition in machinery, such that a significant change is indicative of a developing failure. Then the parameter will be regularly monitored so that the change of the parameter can be observed. Once a change is detected a more detailed analysis of the measurements will be conducted to determine what the problem is, and hence bring up a diagnosis of the problem. The parameters most often chosen to detect this change in condition are either vibration, which tends to increase as a machine moves away from a smooth running condition into a rougher mode with the development of a fault, temperature wear debris in lubrication oil on the quality of the lubricant itself. Condition monitoring is a major component of predictive maintenance. The use of conditional monitoring allows maintenance to be scheduled, or other actions to be taken to avoid the consequences of failure, before the failure occurs. It is typically much more cost effective than allowing the machinery to fail. James (1992) has defined condition monitoring as a maintenance philosophy that involves periodic measurement of the mechanical and process parameters that concerns a machine in order to gain a relative indication of the mechanical state of the machine[5]. The biggest use of condition monitoring is in confirming that the equipment is in good health. A machine in good health refers to a machine with a good level of availability and reliability; this translates to good and continuous financial returns. When a fault takes places, some of the machine parameters are subjected to change. The change in the machine parameters depends upon the degree of faults and the interaction with other parameters. In most cases, more than one parameter are subjected to change under abnormal condition. This standard defines the data processing and information flow needed between processing blocks in condition monitoring systems. Machine condition monitoring (MCM) is a vital component of preventive and predictive maintenance programs that seek to reduce cost and avoid unplanned downtime. MCM also contributes to health and safety by recognizing faults which may give rise to pollution or health hazards, and also by indication of incipient faults which could produce danger conditions. MCM setups include measurement hardware and software that acquire and interpret signals generated by the machine being monitored. Condition monitoring is taken to mean the use of advanced technologies in order to determine equipment condition, and to predict potential failure. It includes, but is not limited to, technologies such as visual inspection, vibration measurement and analysis, temperature monitoring, acoustic emission analysis, noise analysis, oil analysis, wear debris analysis, motor current signature analysis, and nondestructive testing.

2. METHODS OF CONDITION MONITORING

2.1 Visual inspection

Visual monitoring can sometimes provide a direct indication of the machine's condition without the need for further analysis. The available techniques can range from using a simple magnifying glass or low-power microscope. Other forms of visual monitoring include the use of dye penetrants to provide a clear definition of any cracks occurring on the machine surface, and the use of heat-sensitive or thermo graphic paints. The condition of many transmission components can readily be checked visually. For example, the wear on the surfaces of gear teeth gives much information. Problems of overload, fatigue failure, wear and poor lubrication can be differentiated from the appearance of the teeth[6].

2.2 Vibration analysis

Modern condition monitoring techniques encompass many different themes; one of the most important and informative is the vibration analysis of rotating machinery. Using vibration analysis, the state of a machine can be constantly monitored and detailed analysis may be made concerning the health of the machine and any faults which may arise or have already arisen. Machinery distress very often manifests itself in vibration or a change in vibration pattern. Vibration analysis is therefore, a powerful diagnostic and troubleshooting tool of major process machinery. On-load monitoring can be performed mainly in the following three ways. Vibration signals are the most versatile parameters in machine condition monitoring techniques. Periodic vibration checks reveal whether troubles are present or impending. Vibration signature analysis reveals which part of the machine is defective and why. Although a number of vibration analysis techniques have been developed for this purpose, still a lot of scope is there to reach a stage of expertise[7]

2.3 Temperature monitoring

Temperature monitoring consists of measuring of the operational temperature and the temperature of component surfaces. Monitoring operational temperature can be considered as a subset of the operational variables for performance monitoring. The monitoring of component temperature has been found to relate to wear occurring in machine elements, particularly in journal bearings, where lubrication is either inadequate or absent. The techniques for monitoring temperature of machine components can include the use of optical pyrometers, thermocouples, thermography, and resistance thermometers.

2.4 Noise analysis

Noise signals are utilized for condition monitoring because noise signals measured at regions in proximity to the external surface of machines can contain vital information about the internal processes, and can provide valuable information about a machine's running condition. When machines are in a good condition, their noise frequency spectra have characteristic shapes. As faults begin to develop, the frequency spectra change. Each component in the frequency spectrum can be related to a specific source within the machine. This is the fundamental basis for using noise measurement and analysis in condition monitoring. Sometimes the signal which is to be monitored is submerged within some other signal and it cannot be detected by a straight forward time history or spectral analysis. In this case, specialized signal processing techniques have to be utilized.

2.5 Wear debris analysis

It is not possible to examine the working parts of a complex machine on load, nor is it convenient to strip down the machine. However, the oil which circulates through the machine carries with it evidence of the condition of parts encountered. Examination of the oil, any particle it has carried with it, allows monitoring of the machine on load or at shutdown. A number of techniques are applied, some very simple, other involving painstaking tests and expensive equipments. Presently, available lubricant sampling or monitoring techniques like rotary particles depositor (RPD), spectrophotometer oil analysis programme (SOAP), Ferro graphic oil analysis and recent software used techniques are available to distinguish between damage debris and normal wear debris. Every machine ever designed undergoes a process of wear and tear in operation, yet a battery of modern condition monitoring techniques is available to monitor this process and trigger preventive maintenance routines which depend on identifying any problem before it has the chance to develop to the point of final breakdown. Now recently, engineers have been able to extend their knowledge of conditions within operating machinery by studying the particles of metallic debris which can be found in lubricating oil from engines, gearboxes, final drive units and transmissions, or in hydraulic fluid, and recording the number, size, and type of these fragments of debris.

2.6 Acoustic emission analysis

Acoustic emission refers to the generation of transient waves during the rapid release of energy from localized sources within a material. The source of these emissions is closely associated with the dislocation accompanying plastic deformation and the initiation or extension of fatigue cracks in material under stress. The other sources of acoustic emission are melting, phase transformations, thermal stress, cool-down cracking, and the failure of bonds and fibers in composite materials. Acoustic emissions are measured by piezoelectric transducers mounted on the surface of the structure under test and loading the structure. Sensors are coupled to the structure by means of a fluid couplant or by adhesive bonds. The output of each piezoelectric sensor is amplified through a low-noise preamplifier, filtered to remove any extraneous noise and furthered processed by suitable electronic equipment.

2.7 Motor current signature analysis

Motor current signature analysis (MCSA) is a novel diagnostic process for condition monitoring of electric motor-driven mechanical equipment (pumps, motor-operated valves, compressors, and processing machinery). The MCSA process identifies characterizes, and trends overtime the instantaneous load variations of mechanical equipment in order to diagnose changes in the condition of the equipment. It monitors the instantaneous variations (noise content) in the electric current flowing through the power leads to the electric motor that drives the equipment.

2.8 Nondestructive testing

The principle of nondestructive testing (NDT) is to be able to use the components or structure after examination. The inspection should not affect the item involved, and must therefore, be nondestructive. NDT includes many different technologies, each suitable for one or more specific inspection tasks, with many different disciplines overlapping or complimenting others. Thus the best technique(s), for any one application, should be decided by an expert eddy current testing, electrical resistance testing, flux leakage testing, magnetic testing, penetrant testing, radiographic testing, resonant testing, thermographic testing, ultrasonic testing, and visual testing are some of the different NDT techniques.

3. EXPERIMENTAL INSTRUMENT

3.1 Rotary Particles Depositor (Rpd)

Rotary particle depositor is the low cost method of separating the debris particle from the sample of engine oil by the use of Millipore filter. That this result in the collection of all the contaminants in the lubricant sometimes tends to confuse matters. The concentration of wear particles is measured with an instruments called as Particle Quantifier or Debris Tester, which utilize the eddy current principles to measure small quantities of ferrous particles. The Interpretation of the information gathered, particularly that on characteristics such as shape and size, require a degree of expertise that can be generated through the supplementary techniques such as Ferrography or Rotary particle depositor.

The RPD combines magnetic and centrifugal separation. It is faster than both the AF and DRF techniques and presents an oil sample ready for microscopy in about 6 minutes. Additionally, unlike DRF technology, the RPD Rotary Ferrograph does not require the sample to be diluted and does not suffer from interference due to carbonaceous material in the sample. Removal of the lubricant by solvent washing and drying gives a stable well-separated deposit pattern ready for examination by optical or electron microscope.

3.2 Working

The RPD Rotary Ferrograph offers a rapid and simple method of debris separation and particle size analysis. A measured volume of lubricant sample is filled in the burette. Then switch on the power of RPD machine. When magnet and glass slide (substrate) assembly start to rotate at desired speed start allowing drop by drop lubricating sample oil on the glass slide by the means of nozzle fitted on burette. Keep the machine turn on till the end of lubricating oil in the burette. Particles of debris are deposited radially as three concentric rings by the combined effects of rotational, magnetic and gravitational forces. It should be noted that lubricating oil sample is well shacked before filling in burette[3].

Carefully removed the glass slide from magnet assembly and analyzed with the help of compound microscope and finally capture the image of slide. This image of slide contains the important information about the oil sample which is to be used for the investigation. This process is applied for all oil lubricating oil samples. Glass slide should be well cleaned with the help of benzene or other suitable chemical.

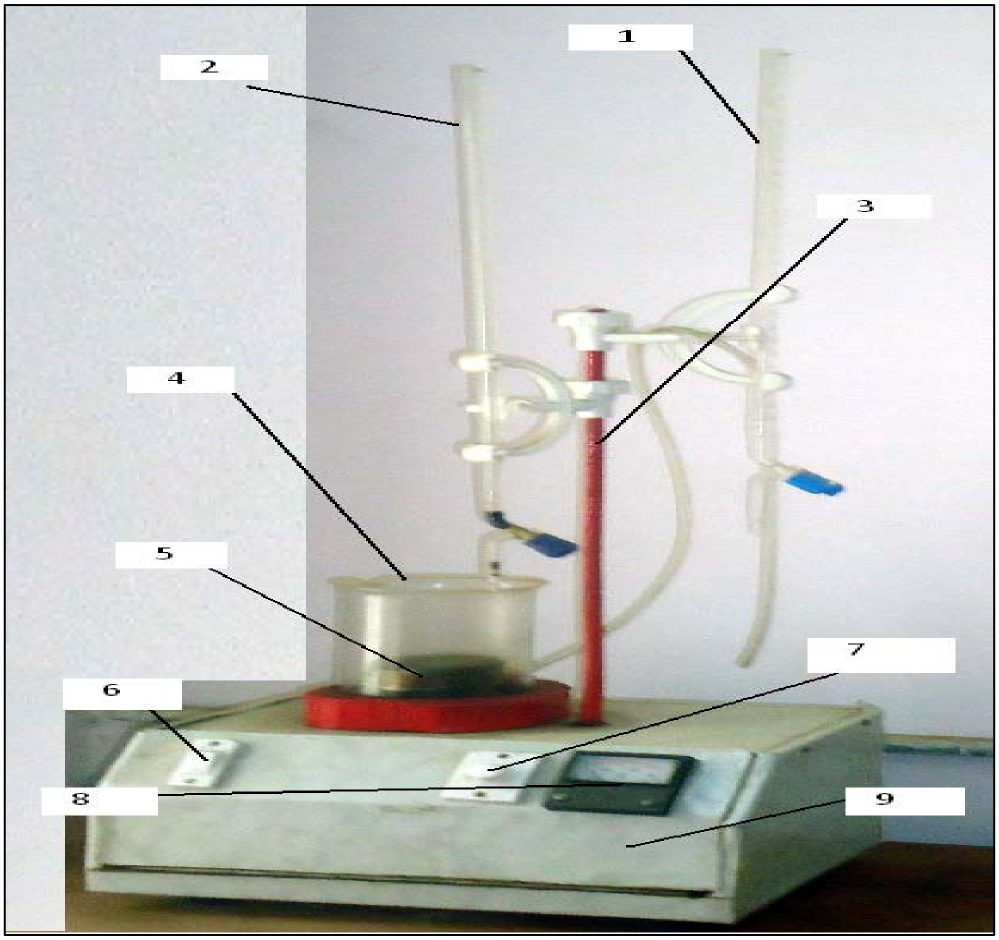


Figure 3: Rotary Particle depositor apparatus

Where

1= burette for lubricant oil,

2= burette for benzene,

3= stand, that is provided for hold the burette,

4= beaker,

5= magnet,

6= on/off switch,

7= regulator switch for regulate the speed of motor/rpm of the motor,

8= meter that shows the speed/rpm of the motor,

9= wooden box that cover the motor

4 DATA COLLECTION

All data of sample are collected from the ***Chauhan cranes***, and these all sample are belongs to the engine oil of Tire Mounted Crane of all samples are described below : Details of engine components are given in

4.1 Specifications of Tire Mounted Crane-

Name of Machine:	**Tire Mounted Crane**
Maximum Load carrying capacity	20 Tones
Make/ Model & HP of Engine	MITSUBISHI,16DI4WT
Model& Serial No.	RK200/1036
Punj No. of Engine	MC0010
Serial No. of Engine	279589
Weight of Machine	22.96 Tones
Length	10.195 Meters
Width	2.49 Meters
Height	3.48 Meters

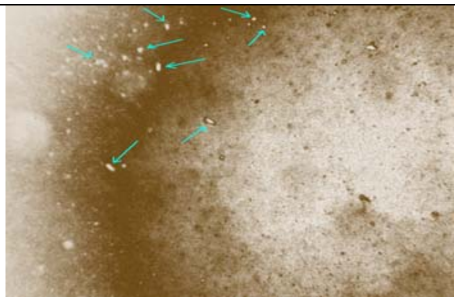
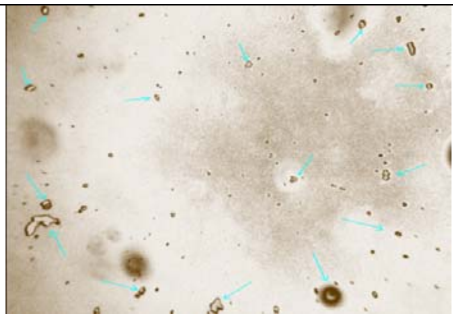
Following Table 1: shows the all the details of oil (in terms of hours) which are used for the investigation.

Sample Code	**Total Runs (hours)**
1.	0 (unused)
2.	200
3.	300
4.	500
5.	800
6.	1000

5. RESULTS

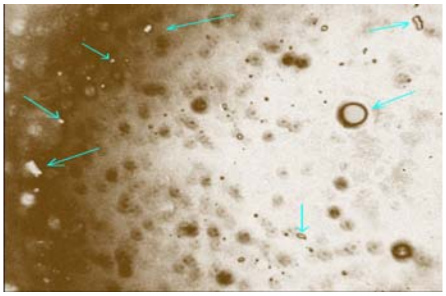
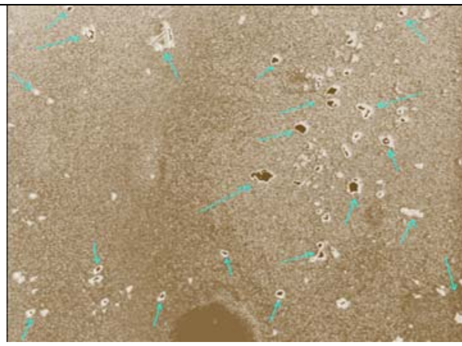
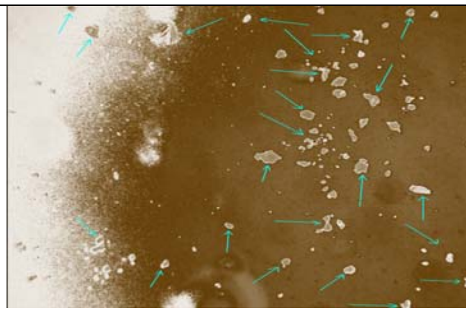
When the slide of samples which was made by using of RPD machine is investigated by microscope following result was came which is shown in table[1].

Table 2: RPD test analysis

Sample code	**Photograph**	**Comment**
1.		No particle
2.		Particle of small size
3.		More samll partcle are spread over the slide as compaire to previous slide.

Where

Arrow shows the particles

Sample code	Photograph	Comment
4.		medium size particles has increased.
5.		More medium size particle has shown in the slide.
6.		Bigger particle has shown in the slide.

Where

Arrow shows the particles

It is clear from above experiment that rate of debris particles increases as the Tire Mounted Crane runs, i.e. wear rate increases with the Tire Mounted Crane life**.**

6. CONCLUSION

Sliding adhesive wear particles are found in most lubricating oils. They are an indication of normal wear. They are produced in large numbers when one metal surface moves across another. The particles are seen as thin asymmetrical flakes of metals with highly polished surfaces. These presences of a few of these particles are not significant, but if there are several hundred, it is an indication of serious wear in the Engine. A sudden dramatic increase in the quantity of wear particles indicates that the break down is imminent. A consequence of periodic stresses with very high local tension in the surface, which occurs, with the meshing of years. These wear mechanisms give plate particles a rough surface and an irregular perimeter.

Oil analysis is the most effective techniques for monitoring the health of engine. They offer complementary strengths in root cause analysis of engine failure, and are natural allies in diagnosing engine condition. They reinforce indications seen in each technology, and have unique diagnostic strengths in highlighting specific wear conditions.

The following few conclusions could be highlighted:

- ✓ In *RPD* analysis, presence of ferrous and non ferrous particles is increased with respect to Tire Mounted Crane runs. These particles rate are continuously increased with the Tire Mounted Crane life, which decreased the quality of engine oil.

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