Oil Debris Analysis for Condition Monitoring of an IC Engine

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Abstract: Condition monitoring is a process of monitoring one or more parameters from the machine, such that a significant change in these parameters can give information about the machine health. Condition of the IC engine could be done by gaining the information based on engine oil debris analysis. Breakdown of an IC Engine is unpredictable and regular maintenance of it would totally depend on mileage or duration of time the system had been used. The objective of this dissertation work is to determine actual wear conditions in IC engine by studying all the debris particles suspended in oil sample. The effectiveness of wear debris analysis in condition monitoring will be studied for machinery maintenance. Wear debris analysis is a method of predicting the health of machine in a non-intrusive manner by studying wear particles present in lubricating oil.

Keywords: wear debris analysis, condition monitoring, ESEM, EDS.

1. INTRODUCTION

Since development of the world getting progressively, there is growing involvement in the studies of condition of machineries components. Greater machineries in industry are growing faster than their operator. In this situation, growing importance of predictive maintenance led us to the development of large number of machine condition monitoring techniques. The internal mechanical parts which widely contribute to major breakdown in engines, On the other hand, lubricants are another factor to be considered as to ensure the performances of engines are within optimum operating conditions. Any unscheduled breakdown can increase the maintenance cost, and can cause human casualty. Therefore to minimize any unscheduled breakdowns, a proper maintenance strategy and condition monitoring systems be essential to detect faults in the early stages and offer attentive notification to notify the operator. The capabilities of Condition Monitoring Systems provided that if it has been conducted correctly it can extend the life duration of the engines. These could also reduce the maintenance expenditure and avoid disastrous breakdown to the engines.

Importance of predictive maintenance leads to the development of a large amount of machine condition monitoring techniques. Vibration and oil analysis be the two different methods in determining mechanicals failures into common components of machines, such as engines, gearboxes and generators. As it is difficult to monitor wear conditions by measuring vibration because of its complex sources, multi phasic interference and low frequency, due to that oil analysis becomes the main method for monitoring various machinery parts. Oil analysis can be categorized into three fluids analysis methods that are property, fluid contamination and wear debris analysis. Condition monitoring of machinery through analysis of wear debris is now extensively applied as a tool in diagnostic technology. Wear debris analysis is a method of predicting the health of machine in a non-intrusive manner by studying wear particles present in lubricating oil.

2. LITERATURE REVIEW

Isa et al. [1] presents the ferrographic analysis of wear particles contained in used lubricant oil samples that collected from the engines, gearboxes and generators of a commercial marine ship. Flash point, viscosity measurement, ferrography analysis and energy dispersive X-ray analysis (EDX) had been employed to extract the relevant information about the physical condition of used oil and the wear situation of the parts from generator, gearbox and main engine. Their study showed that the application of wear debris analysis and ferrography in particular is an effective means to identify and respond to maintenance requirements of marine ships machineries.

Ebersbach et al. [2] investigated the effectiveness of combining both vibration analysis and wear debris analysis in incorporated machine condition monitoring maintenance program. A series of studies was conducted on a spur gearbox test rig. The information provided by wear debris analysis was compared with vibration analysis spectrum in order to enumerate the usefulness of vibration analysis and wear debris analysis in predicting and diagnosing machinery failures. They discussed the use of mathematical approach for wear debris analysis, facilitated by the use of a laser scanning confocal microscope (LSCM). The co-relation between wear debris and vibration analysis techniques is discussed, and the usefulness of

mathematical descriptors for wear debris analysis is evaluated.

Peng et al. [3] had given the co-relation of vibration analysis and wear debris analysis. An investigational test rig consists of worm gearbox driven by means of electric motor was set up to inspect the co-relation of both the techniques under different wear conditions. Oil sample and vibration information were collected regular intervals. Wear debris analysis includes the study of particle size distribution and no. of particles, the inspection of particle morphology and types to find out possible wear mechanism and analysis of chemical composition to assess wear sources. Fault revealing in the vibration signature is compared with particle analysis. The results from this paper have given more understanding on the dependent and independent role of vibration analysis and wear debris analysis in machine condition monitoring and defect identification.

R.K. Upadhyay [4] monitored used CH415W40 engine oil under bichromatic microscope to observe the contamination and surfaces wear. According to the observation, rubbing, cutting, fatigue, corrosion, abrasive and scuffing wear modes were observed.

Allison et al. [5] explained wear debris analysis is an effective technique designed for determining wear modes and observing failure progression in this manner provides extensive lead times for maintenance remediation. Applications utilizing this technology has seen significant success along with early warning on disastrous failure, improved operational uptime, extended intervals between scheduled repair, decreased maintenance costs, etc. Packaging and automating the procedure allows this technology to become a repeatable and reproducible condition-monitoring tool which can be used in any laboratory or easily employed for in-service maintenance support for at-line condition estimation.

3. METHODOLOGY

In this research work the effectiveness of wear debris analysis for condition monitoring will be studied for machinery maintenance. Preliminary investigations will be carried out on oil sample from engines of selected vehicles to find their wear rate. Different engines from different manufacturers will be selected. These engines will comprise similar age and performing under the same type of services. Spectrometric and microscopic measurements will be carried out in engine oil analysis laboratory. Wear debris analysis will include the study of debris particle number and particle size distribution, the examination of particle morphology and types is used to determine possible wear modes and wear condition.

Methodology used for this work is shown in following flow chart. According to following flow chart experiment will be carried out.

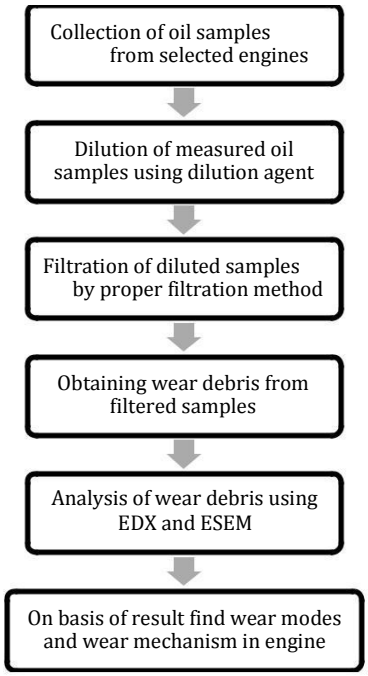

Fig.1 Flow chart of methodology

4. EXPERIMENTATION

A lubricant flow in engine is shown in Figure 2, and will contain filters for cleaning the lubrication oil of debris. If, the debris particles we want to monitor is absorbed by the filter and restricted to pass, we must monitor the wear particles at a point in the flow-line between the machine operating point and the filter. If the debris particles flow through the filter, then the position of debris monitoring point is not critical. However, even small debris particles will not be certainly to pass throughout the filter and it is normally desirable to monitor at the point shown in following figure.

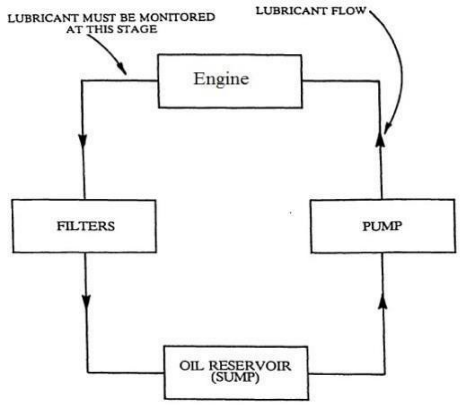

Fig.2 block diagram of lubricant flow system of a typical engine

All the oil samples are taken at the point shown in above fig.2. First samples are taken at specific time interval of operation, up to maximum run of selected engine. Then different engines from different manufacturers performing same operation and having similar age are selected to compare their wear rate.

All the collected samples are then diluted using n-Hexane as dilution agent. Then it is filtered using whatman filter paper. As a result of filtration, required wear debris is collected in filter paper. The filtration process is carried with set up as shown in following figure.

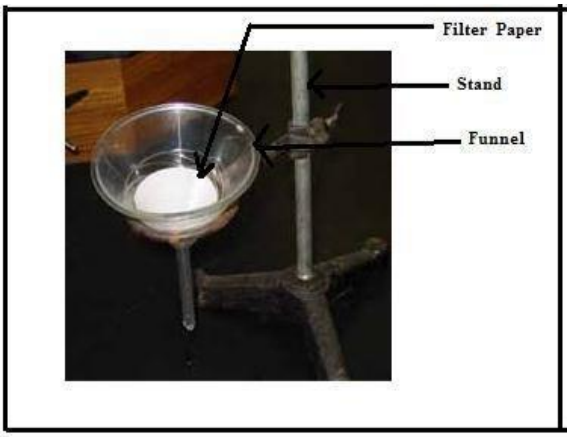

Fig.3 Image of experimental set up for filtration process

To collect this debris first filter papers are dried. To obtain wear particles these filter papers are then burned on crucible to get ash less powder of it. The powder with debris particles is shown in following figure.

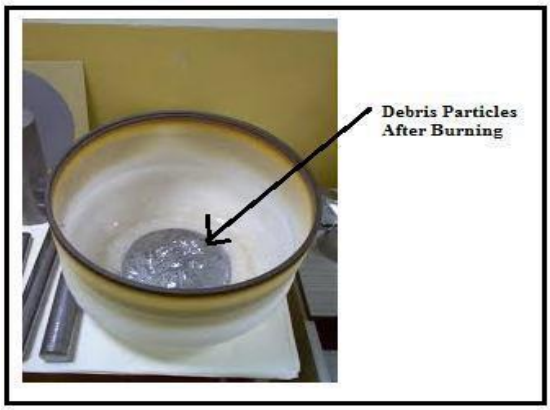

Fig.4 Image of debris particles after burning

The samples of debris in the powdered form will be tested in laboratory. As studied in literature survey and by referring different Oil Analysis Handbooks, it is found that for testing of concentration and composition of debris in the samples Energy Dispersive X-ray Spectrometer (EDS) should be used; and for microscopic inspection of size and morphological analysis Environmental Scanning Electron Microscope (ESEM) should be used.

The testing work mentioned above is within the process with the help of and at SAIF, IIT Bombay. Based on the result obtained from this analysis diagnosis of engine condition will be done.

5. CONCLUSION

The studies have shown that the analysis of wear debris is important tool to detect critical stages of accelerated wear that results in costly and dangerous component failures. With the information regarding size, pattern and composition of wear particle the sources of wear can be identified.

The main advantage of this wear debris analysis for condition monitoring of IC engine is that, the oil samples can be taken from machines which are still in operation, instead of dismantling the machines to study and analyses of the surface damages in it.

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