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A Review on “Condition Monitoring of Used Lubricating Oil”

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ABSTRACT. This paper is a review on the condition monitoring of used lubricating oil, in order to monitor the health of an engine. In automotive machine engine is subjected to high temperature and pressure during combustion. Lubrication of engines is a very important aspect of engine operations. The function of lubricating oil is to reduce friction, transfer heat, transmit power, protect against wear, prevent corrosion and seal for gases. So it is become very important to monitor the health of lubricating oil at regular interval. The used oil can be tested for its wear debris and analyzed to predict the engine parts failure in advance. Various methods such as spectrophotometric oil analysis, rotary particle depositor test, filter gram test, flash point fire point test, viscosity test, pH test etc. used by investigators to analyze used lubricant properties to determine the engine condition.

KEYWORDS: Condition monitoring, oil analysis, wear debris, spectrophotometric oil analysis, rotary particle depositor

I. INTRODUCTION

Condition monitoring is the process of monitoring condition in machinery, such that a notable change is symptomatic of a developing failure. It is a major part of Predictive Maintenance. By using condition monitoring techniques failure of machinery is stopped at early stage. Oil analysis is an important technique for engine maintenance. Which provide information about the condition of oil which is directly related to health of engine also provide the information of oil suitability for use and optimization of the oil change intervals.

Engine is the important and critical operating mechanism. Which needs to be lubricated with the proper lubricant in order to protect from early breakdown and maintain its performance? In present time oil analysis is done using a combination of physical and spectrochemical tests to monitor lubricant and component condition which follow various standard established by International Organization for Standardization, the American Society for Testing and Materials and the Society of Automotive Engineers. In previous work various researchers works on used oil analysis for which samples of oil are taken periodically to analyze wear rate. Data collected from various test useful forgetting information about condition of engine components.

II. TECHNIQUES FOR WEAR PARTICLES

2.1. Rotary Particle depositor test

It offers a rapid and simple method of debris separation. In rotary particle depositor test a measured volume of sample is applied, by pipette, to a glass substrate located on a rotating magnet assembly. Suspended debris particles are deposited radially as three adjacent rings by the combined effects of rotational, magnetic and gravitational forces. Which gives a stable well-separated deposit pattern ready for examination by optical or electron microscope.

2.2. Spectrometric oil analysis Programme

Spectrometric oil analysis Programme is a powerful technique for analysis of suspended structural metal and other contamination approximate up to 5 micron in size interred in used lubricating oil samples. Due to generation of wear metal and other particle in engine oil system can show changing the condition of various such as gears, bearing, oil pump, shaft, piston ring, valve, cylinder walls etc. it is a proactive condition monitoring techniques which helps to assess

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the rate of wear and its sources. Thus SOAP provide early warning of abnormal wear which tends to failure of any engine component. By carrying out analysis of used oil at specific intervals provide information which is used for identifying problems related to engine components based on the knowledge about the metals used for the construction of the engine. Such SOAP can also be used for comparison purposes & also to predict the possible failure of engine.

Possible sources of the element found in used oil analysis

Metal element	Possible sources
Iron (Fe)	Shafts, Gears, Piston rings, Cylinder Walls
Aluminum (Al)	Piston, Pumps, Bearings, Thrust Washers
Lead (Pb)	Anti- Wear Gears, Bearings
Chromium (Cr)	Piston Rings, Roller Bearings, Cylinder Walls
Tin (Sn)	Journal Bearing, Bearings Cages, Solder
Nickel (Ni)	Pumps, Gear Plating's, Valves
Silicon (Si)	Dirt, Airborne Dust
Copper (Cu)	Bearings, Bushings, Thrust Washers
Zn (Zn)	Anti- Wear Additive
Boron (B)	Anti- Corrosion in Coolants

2.3. Filter gram Analysis

Filter gram analysis is the microscopic examination of wear particles taken from oil sample. A filter gram can identify particles from 3μ to over 1000μ . A filter gram analysis of an oil sample can be a very useful addition to the more traditional methods of condition monitoring. The sample to examine is dissolved in Dimethyl Sulphate Oxide and filtered through a very fine membrane filter. The wear debris and other contaminants in the oil are captured on the membrane of filter paper. Which is examined under a high power microscope? The report gives an analysis of the size and composition of all the particles found as well as the wear mechanism which generated the metallic particles.

2.4. Flash Point and Fire Point Test

The flash point is often used as a detailed characteristic of liquid fuel and it is also used to help characterize the fire hazards of liquids. The flash point of a volatile liquid is the lowest temperature at which it can vaporize to form an ignitable mixture in air. At the flash point, the vapor may cease to burn when the source of ignition is removed. The fire point is a higher temperature defined as the temperature at which the vapor continues to burn after being ignited. Neither the flash point nor the fire point is related to the 0020 temperature of the ignition source or as the burning liquid which are much higher. To find out the flash and fire point of oil samples here the Pensky Martens apparatus is used. Which is closed up textures? Where the vapors above the liquid are not in temperature equilibrium with the liquid. The oil samples are poured into cup. The cups of apparatus are sealed with a lid through which the ignition source can be introduced. When oil reaches its flash point it gives the flash when an ignition source is read at its neck. After some time oil reaches its fire point at which it gives the flame of fire for a few seconds. These temperatures are carefully noted.

III. LUBRICATING OIL ANALYSIS

Amit Jain, R.S. Rajput [1], investigated on used gear oil of Maruti Wagon R. There were so gear oil samples that were collected from the gear boxes of private vehicles. These samples were collected from the gear boxes of different vehicles. For that different condition monitoring techniques such as spectrometric oil analysis, flash point fire point test, viscosity test, Total acid number analysis, rotary particle depositor test, pH test, litmus paper test, Filter gram test, Sulphur test, Water content test, were performed on used gear oil. According to the observation various wear modes were observed. Researcher concluded that used oil analysis is known to be a very effective tool for health monitoring and as a proactive maintenance technology. Which extracts the relevant information about the physical aspects of used oil and the wear condition of the parts from the gearbox of vehicle?

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B. J. Roylance [2], has introduced the science and application of ferrography embraces both the engineering and medical fields and this has led to new and exciting ways of understanding the associated phenomena and how to extract the best information for the advancement of the subject matter. The purpose of this special issue is to provide an overview of some of the principal developments that have taken place over the past three decades, thereby placing on record what is widely acknowledged to be one of the most significant development in the field of wear debris technology. This overview of past developments in ferrography would not be complete without some speculation about the future. There is a need to continue to develop methods that can remove the tedium of manual operation in preparing and analyzing samples. Some laboratories that experience large throughputs of samples incorporate automated procedures. With increased rate of staff turnover in many industries, it is important to provide good interpretative material backed up by through training of operating personnel. The enlarged use of computerized procedures for recording information, performing analysis, assisting with training programmes, and in gaining subsequent „on-the-job“ experience, is already available and will continue to develop as maintenance personnel become more computer-orientated and dependent. In setting down an overview of three decades of development and achievement in ferrography, it is far from being an exhaustive treatment of the subject matter. However, it is to be hoped that it has provided some insight into the way the story has unfolded so far and makes a fitting tribute to the originators of ferrography, without whom none of it would have been possible. The contributions of the other participants in this special issue will bring the story up to-date as they describe the more recent developments that are helping to ensure that ferrography continues to remain in the forefront of wear-related condition-based maintenance techniques.

Amit Jain, R.S.Rajput, Ajay kumarTaneja[3], stated that spectrometric oil analysis techniques of used gear oil provide the information about the gear part which are under the various condition of wear. In such test information of suspended particles were interrelate metal of gear part from which it made. Thus it provides the useful information about the health of gear box. And it is helpful for proactive maintenance.

Z. Peng, N.J. Kessissoglou, M. Cox [4], has describes that vibration and wear debris analyses are the two main conditions monitoring techniques for machinery maintenance and fault diagnosis. These two techniques have their unique advantages and disadvantages associated with the monitoring and fault diagnosis of machinery. When these techniques are conducted independently, only a portion of machine faults are typically diagnosed. Vibration analysis and oil analysis are the most effective techniques for monitoring the health of machinery. They offer complementary strengths in root cause analysis of machine failure, and are natural allies in diagnosing machine condition. They reinforce indications seen in each technology, and have unique diagnostic strengths in highlighting specific wear conditions. In this study, two condition monitoring techniques, namely wear debris analysis and vibration analysis, have been used to identify wear in a worm gearbox under various controlled experimental conditions. Wear mechanisms include the detection of rubbing, metal-to-metal contact, and boundary lubrication breakdown. Results have shown that these two independent condition monitoring techniques, a more reliable assessment of the condition of the test rig can be made. Meanwhile, the two techniques have their individual advantages. Wear debris analysis provides further insight on the wear rate and mechanism of the gears. Vibration analysis has provided quick and reliable information on the condition of the bearings. Integration of these two condition monitoring techniques in all tests conducted on the worm gearbox resulted in a comprehensive diagnosis of the machinery condition. Future research is planned to further examine the relationship between the two techniques during active machine faults, and examples from other machinery and components that are commonly encountered in industry.

KIM S.S., Hwang [5], explained that there were so lubricant oil samples that collected from the engines, generators and gearboxes of a commercial marine ship. Flash point, viscosity measurement, Ferrography analysis and energy dispersive X-ray analysis (EDX) have been employed to these techniques are conducted independently, only a portion of machine faults are typically diagnosed. Vibration analysis and oil analysis are the most effective techniques for monitoring the health of machinery. They offer complementary strengths in root cause analysis of machine failure, and are natural allies in diagnosing machine condition. They reinforce indications seen in each technology, and have unique diagnostic strengths in highlighting specific wear conditions. In this study, two condition monitoring techniques, namely wear debris analysis and vibration analysis, have been used to identify wear in a worm gearbox under various controlled experimental conditions. Wear mechanisms include the detection of rubbing, metal-to-metal contact, and

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M. Lukas and R. J. Yurko[6], stated that Oil analysis spectrometers have been in use for the analysis of wear metals, contaminants and additives in lubricating oils for almost 50 years. They have become the mainstay and primary analytical tool of most machine condition monitoring programs based on oil analysis. Spectrometers have evolved from large instruments that take up the better part of a laboratory, to smaller table top instruments. Analysis times have decreased from hours to seconds and no longer have to be operated by experts to obtain excellent analytical results.

X. L Wang and G. N. Zhang [7], stated to investigate the behavior of failure and recycling of lubricating oils, three sorts of typical 10w-40 lubricating oils used in heavy-load vehicle including the new oil, waste oil and regeneration oil regenerated by self-researched green regeneration technology were selected. The tribology properties were tested by four-ball friction wear tester as well. The results indicated that the performance of anti-extreme pressure of regeneration oil increase by 34.1% compared with the waste one and its load-carrying ability is close to the new oil; the feature of wear spot are better than those of the waste oil and frictional coefficient almost reach the level of the new oil's. As a result, the performance of anti-wear and friction reducing are getting better obviously.

Syazuan Abdul Latipa, Salmiah Kasolanga and others [8], proposed that Traces of wear metals in used operating lubricant by principal vary in origin and its concentration value. These wear metals concentration obtained from the used lube provide vital information regarding the cause and level of the deterioration existed and progressed in operating mechanical component. It has been affirmed that the occurrence of severe wear metals appeared to act as a catalyst that could speed up the degradation of a particular lubricant used during operation. It has been well recognized that, spectrometric analysis is exceedingly practical for the reason of quantitatively and qualitatively evaluate the elements of additives, contaminants and wear metallic particles presence in lubricating oil. From this study researcher concluded that, the occurrence of wear by product of these elements presence in the mechanism can be classified as benign wear and the presence of wear particles on both mission profiles considered as normal wear particle mode and within the accepted wear severity limitation. many abnormal wear debris in used lubricating oil that severe abrasive wear, sliding wear, and adhesive wear occurred and resulting in the decrease of anti-wear performance thus the oil has been difficult to play a lubricating role. The existence of a large number of abrasive grains destroyed the lubricating oil film thus the boundary lubrication condition was coming for Friction pairs and the wear degree aggravated. So, the wear types in the experimental process may be normal sliding wear and mild abrasive wear and reached the lubrication performance of new one.

R.K. Upadhyay [9], proposed that Engine oil is an important and the most essential part of machine system. Oil monitoring is tool determine lubricant useful life. Lubricating oil analysis can be made for performance testing or engine condition monitoring. Knowledge of system's failure modes is helpful for cost-effective analysis. Contamination occurs by mating contact inside the engine chamber. According to the observation, rubbing, cutting, fatigue, corrosion, abrasive and scuffing wear modes were observed. Researcher uses analytical ferrography technique to analyze the wear particles present in used oil. This technique involves passing a volume of fluid over a slide which is supported over a magnetic field. Permanent magnet arranged to create a varying strength over the length of the substrate. Debris deposited over slide serves as a media for optical analysis. Researcher concluded that used oil analysis is known to be very effective tool health monitoring and as a proactive maintenance technology.

Om Prakash Sondhiya, Amit Kumar Gupta [10], stated that Ferrography is a technique for analyzing the particles present in fluids that indicate mechanical wear. Ferrography provides Microscopic Examination and Analysis of Debris

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(particles) found in lubricating oils. Analytical Ferrography is among the most powerful diagnostic tools in oil analysis in tribology. When implemented correctly it provides tremendous information on machine under operation. Performance may be improved through proper filtration of oil. Clean oil lubrication is always more effective. Adopting approach of oil replacement is expensive. Ferrography also helps improving filtration efficiency and frequency for oil cleaning systems.

M.C. Isaa, and N.H.N. Yusoff[11], stated that the application of wear particle analysis and Ferrography in particular is an effective means to identify and respond to maintenance needs of marine ships machineries. Ferrographic analysis of wear particles contained in used lubricant oil samples that collected from the engines, generators and gearboxes of a commercial marine ship. Flash point, viscosity measurement, Ferrography analysis and energy dispersive X-ray analysis (EDX) have been employed to extract the relevant information about the physical aspects of used oil and the wear condition of the parts from generator, gearbox and main engine.

SretenPerić, BogdanNedić, DraganTrifković, MladenVuruna [12], were performed tribological tests that are part of the oil analysis and are used to access the condition of the system. Furthermore, the results of experimental research on the tribological characteristics of the oil sampled from engines and gear transmissions of the vehicles are shown. All of this road vehicle was in regular use by the Serbian armed forces. The performed research has revealed some significant changes in the tribological characteristics of oil for engine and gear transmission lubrication. These changes directly depend on the condition of the entire engine and transmission elements, i.e. depend on their functional characteristics. The presented method of oil analysis should contribute to an early detection of failures due to friction and wear processes in vehicle engines and reduce the need for preventive maintenance.

IV. CONCLUSION

Final conclusion on lubricating oil analysis from researchers work as below

1. Used oil samples contain so many abnormal wear debris which results in the decrease of performance of lubricating oil.
2. Oil monitoring is tool determine lubricant useful life which can predict future breakdown
3. Analytical Ferrography is among the most powerful diagnostic tools in oil analysis in tribology.
4. Wear particle analysis is an effective means to identify and respond to maintenance needs of marine ships machineries.
5. Spectrometric oil analysis techniques are used for the analysis of wear metals, contaminants and additives in lubricating oils.
6. Use of regeneration oil is more beneficial than use of new oil.
7. Wear metals concentration obtained from the used oil provide vital information regarding the cause and level of the deterioration existed and progressed in operating mechanical component.
8. The method of oil analysis reduces the need for preventive maintenance.

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