ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 5, November 2012

Wear Debris Analysis of Automotive Engine Lubricating Oil Using By Ferrography

Om Prakash Sondhiya, Amit Kumar Gupta
ME Student (Design & Thermal Engineering), Institute of Engineering & Technology-DAVV, Indore (MP)

Abstract— ***Ferrography is a technique for analyzing the particles present in fluids that indicate mechanical wear. Ferrography provides Microscopic Examination and Analysis of Debris (particles) found in lubricating oils. These particles consist of metallic and non-metallic matter. The metallic particle is a wear condition that separates different size and shapes of metallic dust from components like all type of bearings, gears or coupling (if lubricated in path). Non-metallic particle consists of dirt, sand or corroded metallic particle. Analytical ferrography is among the most powerful diagnostic tools in oil analysis in tribology. When implemented correctly it provides a tremendous information on machine under operation. Yet, it is frequently excluded from oil analysis programs because of its comparatively high price and a general misunderstanding of its value. Performance may be improved through proper filtration of oil. Clean oil lubrication is always more effective. Adopting approach of oil replacement is expensive. A rapid centrifuged and/ or magnetic separator cleaning system helps cost cutting and disposal of used oil, as well. Ferrography also helps improving filtration efficiency and frequency for oil cleaning systems.***

Keywords — **Ferrogram, Ferrography, Wear Particles, Lubricating Oil, Bearings, Friction, Gears, Filter Paper, Particles Size, Piston, Magnetic Plugs.**

I. INTRODUCTION

Wear debris analysis is well-known in condition monitoring of tribosystems. The conditions of machine operation are related to the process of wear debris generation and finally to their morphology. Thus, classification of debris in different morphological classes provides valuable information on the current state of a tribosystem. Metallic wear debris are differentiated by their morphology (shape, texture and color) into several classes, e.g. rubbing, cutting, spherical, laminar, fatigue chunk and severe sliding wear particles. It has been found that each type has its own generation mechanism involving a specific wear process. For instance, cutting wear particles are produced by the penetration, plowing or cutting of mating bodies. The presence of severe sliding wear particles in a machine usually indicates a lubrication problem, as a result of lubricant film breakdown. Initially, the morphology of wear particles was examined visually by a trained expert. Nowadays, advances in computers and image recognition make automatic evaluation of the particle morphology possible. It may be characterized by a set of numerical features, and then appropriate classification methods can be used for wear particle identification. There are numerous papers that have considered wear debris morphology quantitatively is a good review), but practically all of them deal with problems of shape and texture. The reasons were that there were no simple techniques for color quantitative evaluation and no cost-efficient devices for color image acquisition. Only in the last decade color CCD cameras and appropriate computer hardware and software became common. Color is an important feature in wear debris analysis. If the shape and texture allow one to differentiate the wear particles according to their prehistory of formation, color may help to define debris composition. Composition of wear particles is determined by the materials of the worn surfaces, contaminants and products of tribochemical reactions. In lubricated metallic contacts we most often meet steel, copper, lead, tin, chromium, silver and titanium-contained particles. Ferrous oxides found in the lubricants usually can be divided into two groups: red or black oxides. Examination of color allows one to define the source of particle generation and the severity. This is a technique in use since 1970, it provides Microscopic Examination and Analysis of Debris (particles) found in lubricating oils. These particles consist of metallic and non-metallic matter. The metallic particle is a wear condition that separates different size and shapes of metallic dust from components like all type of bearings, gears or coupling (if lubricated in path). 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. Yet, it is frequently excluded from oil analysis programs because of its comparatively high price and a general is understanding of its value. The test procedure is lengthy and requires the skill of a trained analyst. As such, there are significant costs in performing analytical ferrography not present in other oil analysis tests. But, if time is taken to fully understand what analytical ferrography uncovers, most agree that the benefits significantly outweigh the costs and elect to automatically incorporate it when abnormal wear is encountered. Additionally, a lub system performance may be improved through proper filtrations of oil. Clean oil lubrication is always more effective. Adopting approach of oil replacement is expensive. A rapid centrifuged and/ or magnetic separator cleaning system helps cost cutting and disposal of used oil, as well. Ferrography also helps improving filteration efficiency and frequency for oil cleaning systems.

II. PROBLEM STATEMENT & METHADOLOGY

A. Problem Statement: A regular vibration-monitoring programme can capture higher vibration at much later stage of damage condition. More is the damage; more is the release of particles from component thereby, increasing the

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 5, November 2012

concentration of wear particles in lubrication oil tank. The choking of filters is next stage when operator comes to know impending failure of system. Regular monitoring of WPC (Wear Particle Concentration) thus alerts an operator earlier than any other damage symptoms. This in fact helps a maintenance engineer to schedule machine overhaul and / or be prepared for spares & replacement.

B Methodology

Determination of oil is collected from a four stroke – two wheeler engine (Honda CBZ). The condition of the oil is, it is used oil after running 1750km of bike after putting a fresh oil Quantity taken 100 ml. Test performed in CHOKSI lab Indore

III. LITERATURE SURVEY

There are six basics wear particle types generated through the wear process. These include metallic particles that comprise of Normal Rubbing Wear, Cutting Wear Particles, Spherical Particles, Severe Sliding particles, Bearing Wear Particle (Fatigue Spall Particles, Laminar Particles) and Gear Wear (Pitch Line Fatigue Particles, Scuffing or Scoring Particles) There do also exist sand and dirt particles responsible to generate wear particles in the system. The particles are classified to determine the type of wear and its source. White nonferrous particles, often aluminum or chromium, appear as bright white particles. They are deposited randomly across the slide surface with larger particles getting collected against the chains of ferrous particles. The chains of ferrous particles typically act as a filter, collecting contaminants, copper particles and babbitt. Copper particles usually appear as bright yellow particles but the surface may change to verdigris after heat treatment. These also will be randomly deposited across the slide surface with larger particles resting at the entry point of the slide and gradually getting smaller towards the exit point of the slide. Babbitt particles consisting of tin and lead, Babbitt particles appear gray, sometimes with speckling before the heat treatment. After heat treatment of the slide, these particles still appear mostly gray, but with spots of blue and red on the mottled surface of the object. Also, after heat treatment these particles tend to decrease in size. Again, these nonferrous particles appear randomly on the slide, not in chains with ferrous particles. Contaminants are usually dirt (silica), and other particulates which do not change in appearance after heat treatment. They can appear as white crystals and are easily identified by the transmitted light source, that is, they are somewhat transparent. Contaminants appear randomly on the slide and are commonly dyked by the chains of ferrous particles. Fibers, typically from filters or outside contamination, they are long strings that allow the transmitted light to shine through. Sometimes these particles can act as a filter, collecting other particles. They can appear anywhere on the ferrogram, however they tend to be washed towards the exit end. Ferrous particles can be broken down to five different categories, high alloy, low alloy, dark metallic oxides, cast iron and red oxides. Ferrous particles are identified using the reflected light source on the microscope. Transmitted light will be totally blocked by the particle. High Alloy Steel - particles are found in chains on the slide and appear gray-white. The distinguishing factor in the identification between high alloy and white nonferrous is position on the slide. If it is white and appears in a chain, it's deemed to be high alloy. Otherwise, it's considered white nonferrous. Low Alloy Steel - particles are also found in chains and appear gray-white but they change color after heat treatment. After heat treatment they usually appear as blue particles but can also appear pink or red. Dark Metallic Oxides - deposit in chains and appear dark gray to black. The degree of darkness is indicative of the amount of oxidation. Cast Iron - particles appear gray before heat treatment and a straw yellow after the heat treatment. They are incorporated in chains amongst the other ferrous particles. Red Oxides (Rust) - polarized light readily identifies red oxides. Sometimes they can be found in chains with the other ferrous particles and sometimes they are randomly deposited on the slide surface. A large amount of small red oxides on the exit end of the slide is generally considered to be a sign of corrosive wear. It usually appears to the analyst as a "beach" of red sand. Following are the images of few wear particles.

How is test conducted?

Analytical ferrography begins with separation of the wear particles by magnetic separation from the lubricating oil containing the wear debris on a ferrogram slide maker. The lubricating oil sample is diluted suitably with organic solvent to improved particle precipitation and adhesion. The diluted sample is allowed to flow from a glass slide called a ferrogram. The ferrogram rests on a magnetic bed, which attracts ferrous particles out of the oil. Due to the magnetic field, the ferrous particles align themselves in chains along the length of the slide with the largest particles being deposited at the entry point. Nonferrous or nonmagnetic particles and contaminants, unaffected by the magnetic field, travel downstream and are randomly deposited across the length of the slide. The deposited ferrous particles serve as a dyke in the removal of nonferrous particles. The absence of ferrous particles substantially reduces the effectiveness with which nonferrous particles are removed. After the particles are deposited on the ferrogram, a wash is used to remove any remaining lubricant. the wash quickly evaporates and the particles are permanently attached to the slide. The ferrogram is now ready for optical examination using a bichromatic microscope. Samples are examined under a microscope that combines the features of a biological and metallurgical microscope. Such equipment utilizes reflected and/or transmitted light sources. Different optical filters are deployed to classify sizing, composition, shape and texture of the particles. After classifying the composition of particles the analyst then rates the size of the particles using a micrometer scale on the microscope. Particles having size of 30 microns or greater are given the rating of "severe" or "abnormal." Severe wear is a definite sign of abnormal running conditions with the equipment being studied.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 5, November 2012

Advantage of This Concept

Ferrography is a series of laboratory tests used to determine the condition of used Lubricants and equipment components, over a period. A trend of Wear Particle Concentration typically presents the opportunity for Maintenance programs from breakdown to be proactive. This need better understanding. The wear particles are either generated or captured in system through atmospheric dust/ dirt. The particles generating due to friction despite proper lubrication is an indication of damage to the system component. For example wear on gear teeth results in improper meshing, that means over a long period of such operation machine tends to consume more power for same throughput. Further operation under same loading condition leads to vibration, followed by noise radiation. A regular vibration-monitoring programme can capture higher vibration at much later stage of damage condition. More is the damage; more is the release of particles from component thereby, increasing the concentration of wear particles in lubrication oil tank. The choking of filters is next stage when operator comes to know impending failure of system. Regular monitoring of WPC (Wear Particle Concentration) thus alerts an operator earlier than any other damage symptoms. This in fact helps a maintenance engineer to schedule machine overhaul and / or be prepared for spares & replacement.

WEAR DEBRIS ANALYSIS: The primary reason for measuring the quantity of wear debris in used lubricants is usually to determine the wear rates of various components of a machine and in the course of time to measure changes in these parameters. However, an oil sample contains particles which have been produced at various times and it is not obvious how the instantaneous wear rate can be Determined or whether it is necessary to determine the instantaneous wear rate. Various models of lubrication systems (e.g. those of Lotan and of Bendiksen) have been used in the monitoring of aero plane engines using spectrometric oil analysis. Essentially these models take into account the loss of wear particles with oil usage or by the drainage and replacement of oil. These factors are of particular importance because of the high rate of oil use in aircraft and the small particle size; this is the size to which spectrometers are most sensitive. An alternative method is necessary for larger particle sizes and Anderson and Driver have suggested an oil system model for ferrography which takes into account particle loss by filtration and settling. The purpose of this paper is to present an oil system model developed at the National Centre of Tribology primarily for use with ferrography. It is of use in assessing instantaneous wear rates and in the comparison of debris analysis techniques. The basic principle of operation is simple. A representative sample of oil is tested through the following cycle.

1. Obtain an oil sample from a machine.
2. In the laboratory take a measured amount of the fluid and deposit into a clean beaker. The sample is then diluted with a solvent
3. Draw the sample through a membrane filter or use a magnetic separation technique such as the rotary particle depositor to separate the solids from the fluid.
4. The amount of ferrous wear is quantified by means of a debris analyzer such as the PQ2000 manufactured by Swansea Tribology Centre.
5. Visually analyze the debris at 100x magnification under a reflected light microscope quantifying the following parameters: These parameters are then trended in a custom designed software package and the diagnostician awards the unit a Health Status. The health status is a single parameter which gives the unit a level of threat. (Health status is a parameter between 1 -5 with 1 being a healthy machine and 5 being a machine which is imminently threatened with failure.)
6. Repeat the procedure at a decided time interval. Wear debris analysis is a relatively simple procedure not requiring a high skills level to perform.

WEAR MECHANISMS AND PARTICLES: 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. Cutting abrasive wear produces another particle type. These particles resemble most of all shavings from a metal shop. E.g.: Spiral, loops and threads. These presences of a few of these particles are not significant, but if there are several hundred, it is an indication of serious cutting wear. A sudden dramatic increase in the quantity of cutting particles indicates that the break down is imminent.

SURFACE FATIGUE: These wear mechanisms give plate particles a rough surface and an irregular perimeter. Small particles often develop in connection with roller bearings. Type of component, typical example nature of wear debris associated with failure Loaded, moving components in which load is concentrated in a non confirmed contact Rolling bearings, gear teeth, cams and tappets Ferrous particles of various size and shapes Loaded, moving components in which load is concentrated in a small area Piston rings and cylinders splines, gear couplings Ferrous flakes less than 150 mm across, and fine iron or iron oxide particles Loaded, moving components with the load spread over a large area Plain bearings, pistons and cylinders Usually very small and ferrous and non-ferrous flakes and particles, bearing fatigue can give rise to larger flakes Wear Metals Wear metals are caused by the relative motion between metallic parts. The motion is accompanied by friction and wear on the surfaces, which are in contact with one another. The metal particles are rubbed off due to friction and enter the lubricating oil; the degree of wear can be evaluated as being normal or abnormal. The wear metals

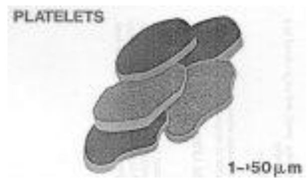
ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 5, November 2012

have the same chemical composition as the components from which they come, and type of wear metal can provide information on which part being worn. Increased quantities of iron are common, since many parts are composed of iron, while an increase in content of less common metals such as silver can often indicate precisely which component is being worn abnormally. The size and shape of wear material will differentiate between the following wear mechanisms. Visual and microscopic examination of the sample is as important a source of information as the regular testing of the debris samples. Prior to filtering the sample, examination of the sample visually within the sample bottle gives useful information. Water present within the oil sample can clearly be seen either in the form of emulsification or as a distinct water layer. The general cleanliness level of the oil may also be determined. Once filtered the debris should be visually examined prior to microscopic examination. The presence of water within the lubricant can be detected from the filter paper. This is seen in the form of light circular areas on the filter paper. Water also sometimes oxidizes the ferrous material, and the presence of rust indicates the ingress of water. Water affects the viscosity of the lubricant, considerably reducing the effect of the lubricant, increasing wear rates and should be avoided. Frequently gearboxes become contaminated with mineral particles such as silica, coal and shale. These produce fine abrasive wear particles normally only observed under the microscope. The unchecked presence of mineral particles specifically quartzite with it's high hardness should be avoided. The mineral particles in suspension act as a grinding medium and produces excessive bearing wear which leads to loss of gear and shaft location which further accelerates the wearing process.

The various debris testers available do not respond to non magnetic materials such as:

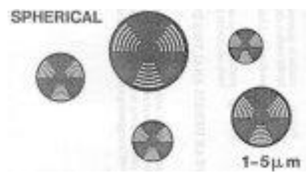
Chromium	Brass	Coal
Tin	Bronze	Copper Minerals
Antimony	Phosphor bronze	Aluminum
Aluminum bronze		Molybdenum disulphate

These are often clearly visible on the filter paper, and should be carefully looked for because even though they may be present in quantities no indication would be given by the debris tester.

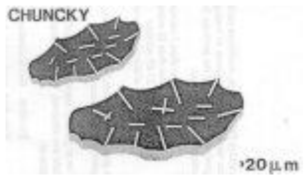


1. "Normal" Rubbing Wear

2. Cutting Wear



3. Bearing Fatigue, Overheating



4. Gear Fatigue

Fig. 1: Diagrammatic Illustration of Particle Types

The sizing (both average, maximum particle size and the particle size distribution) is one of the more important aspects of testing. In general the damage state of a gearbox is proportional to the size of the particles. In it's simplest form of application four classes of size classification are used:

Fine	less than 5 microns
Small	less than 25 microns
Medium	25-60 microns
Large	above 60 microns

As a general rule, which has exceptions, particles over 25 microns indicate a potentially dangerous damage state for the unit. The wear particle shape gives an indication as to the damage mechanism by which that particle was removed. The wear shape characterization being used is shown in Fig.2 and consists of:

Platelets	Two dimensional particles produced by metal to metal sliding.
Spherical	Produced by bearing fatigue or by lubrication failure resulting in local overheating.
Spirals	similar in appearance to machining swarf, and are produced by a harder surface abrading into a softer
Chunky	Produced by a fatigue mechanism
Fretting	Produced by an oxidation mechanism where small intense cyclic loads are present

The gearboxes in underground coal mining equipment have long been a maintenance problem. Traditional techniques of failure analysis, quality assurance and control have only gone part of the way to solving this problem. In 1986 Condition Monitoring Services was involved in suggesting a predictive rather than a reactive maintenance philosophy for these units. to date a number of wear debris analysis mini laboratories have been installed and have monitored underground coal mining equipment with considerable success.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 5, November 2012

Firstly	To the large debris size and quantity naturally generated in these units.
Secondly	To the problems associated with taking conventional condition y monitoring tools into fiery mines.
Thirdly	To the logistical problems of monitoring large numbers of gearboxes within a very hostile environment.

Since the early days of 1986 debris analysis has become a widespread and generally accepted technique of condition monitoring. Examples of some of the successes achieved with debris analysis are:

- Failure prevention in diesel engines used in haul trucks.
- Failure prevention in long wall mining and continuous miner gearboxes.
- Failure prediction on a large selection of both surface and underground mining equipment used in the gold mining industry.
- Contamination control in surface gold mining process equipment.
- Grease and oil selection through comparative lubricant trials.
- Condition monitoring of critical coal milling gearboxes in the power generation industry.
- Failure investigations of critical bearings in ball mills used in the gold mining industry.

New Developments in Debris Analysis: There have been two innovative local developments of debris monitoring. These are Contamination Control. A simple technique for monitoring and reporting on levels of solid contamination within a system has been developed. Previously monitoring of contamination to the accepted codes has either been time consuming or required an expensive investment in equipment. Now users are able to set contamination limits for their equipment and simply monitor whether they are within these limits.

Grease Analysis: A program for the routine monitoring of greases using debris analysis has been going on for over a year now. Ale major problem concerning grease is separating the wear debris from the solids occurring within the grease's additive assembly. As no generally accepted standard method existed, this had to be developed and refined into a meaningful technique. There has now been a buildup of data showing that not only can debris analysis be performed on greases but the technique is sensitive to mechanical health.

Data Management Processing and Reporting: Today more and more importance is being placed on the collection, control and effective use of information as a management tool. This is particularly appropriate in the field of maintenance management where so much can be gained or lost through effective action at the appropriate point in time. To facilitate using information as a powerful management resource, the CMS machinery health monitoring system has been developed.

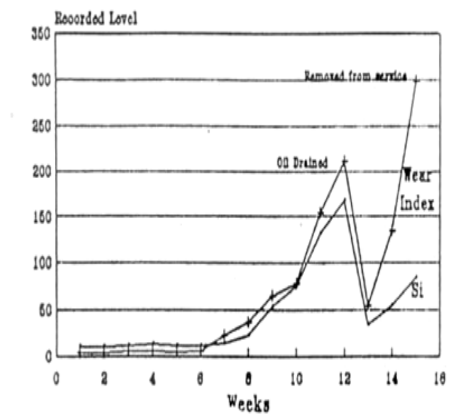


Fig 2. the Wear Index and Si Level Plotted Against Time of Sampling for an Industrial Gearbox.

In addition the program has the ability to record maintenance details and costs, previous performance histories and has the facility to build in intelligence such as threshold values and acceptance limits. From the data stored within the computer it will be capable of producing management reports such as:

- Plant status summary reports
- Plant status exception reports
- Problem follow up reports
- Cumulative machine history reports
- Specific machine history reports
- Cumulative fault summary reports
- Cumulative equipment summary report

Side Benefits of Instituting Wear Debris Monitoring Programs: Beyond the main concern to prevent unexpected failures which most users of such systems have, there are a number of side benefits that have been experienced. These side benefits are easily overlooked but all contribute to instigating better use of machinery and reducing the running costs for users. Some of the hidden benefits are:

- Regular sampling ensures that there is lubricant in the gearbox
- The oil is in a state whereby it will serve the required function
- Reduction or elimination of unexpected failures allows better use of manpower
- Extension of the life of mature machines
- Allowing slightly degraded machines to be run until they can be conveniently rectified, whereas previously this machine may have been immediately taken out of service with resultant loss of availability.
- Due to the reduction in failures, the high costs of transport, storage and handling of spares and sub assemblies

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 5, November 2012

is greatly reduced. In the UK coal mining industry this figure is estimated to be as high as 22% of the life cycle costs of machines.

- By sampling a unit immediately prior or after entering service an indication of the quality and workmanship during maintenance is obtained. At one mine this has led to an improved standard of maintenance both within the mine and by external contractors. The size and shape of wear material will differentiate between the following wear mechanisms. The particle material will pin point to the source and therefore deteriorating component-wearing race, rolling element or cage, rubbing scales, gear teeth etc.

IV. TYPES OF WEAR PARTICLES

There are six basic particles type generated through the wear process. These include ferrous and non-ferrous particles and comprise of:

1. Normal Rubbing Wear: Rubbing wear particles are generated because of normal sliding wear in a machine and result from exploitation of particles of the shear mixed layer. Rubbing wear particles consists of flat platelets, generally 5 microns or smaller, although they might range up to 15 microns depending upon equipment associations. There should be little or no visible texturing of the surface and thickness should be 1 micron or less

2. Cutting Wear Particles: Cutting wear particles are generated as 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 soft surface. The particle generated this way is coarse and large, averaging 2-5 microns wide and 25-100 microns long. Hard abrasive particles in the lubrication, either as contaminants such as sand or wear debris from another part of this system, may become embedded in soft wear surface (two body abrasion) such as Lead/Tin alloy bearing. The abrasive particles protrude from the soft wear surface and penetrating the opposing wear surface. The maximum size of cutting wear particles generated in this way is proportional to the size of abrasive particles in the lubricant. Very fine wire-like particles can be generated with thickness as low as 25 microns. Cutting wear particles are abnormal. Their presence and quantity should be carefully monitored. If the majority of the cutting particles in a system are a few micrometers long and a fraction of micrometers wide the presence of particulate contaminants should be suspected. If a system shows increased quantity of large (50 microns long) cutting wear particles, a component failure is potentially imminent.

3. Spherical Particles: These particles are generated in the bearing cracks. If generates their presence gives an improved warning of impending trouble as they are detectable before any spalling occurs. Rolling fatigue generates few spheres over 5 microns in diameter while the sphere generated by welding, grinding and corrosion are frequently over 10 microns in diameter.

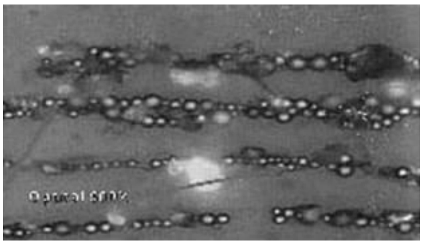


Fig 3 Spherical Particles

4. Severe Sliding: Severe sliding wear particles are identified by parallel on their surfaces. They are generally larger than 15 microns, with the length-to-width thickness ratio falling between 5-30 microns. Severe sliding wear particles sometimes show evidence of temper colors, which may change the appearance of the particle after heat treatment.

Fig 4. Severe Sliding

5. Bearing Wear Particles: These distinct particle types have been associated with rolling bearing fatigues. Fatigue spall particles constitute actual removal from the metal surface with a pit or a crack is propagated. These particles reach a maximum size of 100 microns during the microspalling process. Fatigues spalls are generally are flat with a major dimension-to-thickness ratio of 10 to 1. Laminar particles are very thin free metal particles with frequent occurrence of holes. They range between 20 to 50 microns in major diameter with a thickness ratio of 30:1. These particles are formed by the passage of wear particles through a rolling contact. Laminar particles may be generated throughout the life of a bearing. Rubbing, Surface-Fatigue, Corrosion, Sliding, Cutting. The particle material will pin point to the source and therefore deteriorating component-wearing race, rolling element or cage, rubbing scales, gear teeth etc. Spherical particles can be heat generated if there is insufficient lubrication or there is a depletion of extreme pressure additives in high load or high stress conditions. Spheres are also produced by fatigue (cavitation erosion) of rolling element bearings. Fatigue spherical particles formed within bearing fatigue cracks range in size from 1 to 10 microns. A marked increase in spherical particles indicates possible equipment distress.

V. SIGNIFICANT OIL CONTAMINENTS

Lubricating oil used in engine may possibly include concentration of such elements as iron chromium, copper, lead, tin, antimony, borated silver, silicon. A list of common contaminants and their possible origins is given in table 2.

1. Aluminum Pistons, bearings
2. Boron Coolant leak
3. Copper Bearings, bushings, washers etc.
4. Iron Piston rings, ball and roller bearings

5. Lead Bearings, bushings Iron concentration usually rises as a consequence of higher wear rate of cylinder liners or piston rings (or of piston where these are of ferrous materials). A common cause is that of piston rings stuck in their grooves with consequent blow-by of combustion gases and burning of the oil film adding to scuffing and piston seizure.

Iron and silicon together in high concentration suggests linear and ring wear from dust in the intake air. This could be caused by inefficient or chocked air filters. Air filter filled relatively low in the body of a vehicle may choke and allow direct to enter.

VI. USED OIL CONTAMINATION TIME TRENDS

The quantity of each contaminant reflects the extent of surface wear of the components of a machine under normal conditions; wear rate is small and uniform so that oil contamination collects slowly. As large surface defects develop, abnormal wear occurs and contamination increases. A curve typical of the change of the iron concentration with time as shown in figure initially, when the machinery is now or recently overheated, a sharp rise in metallic concentration occurs from A to B as the parts wear in. Once this phase is completed, the concentration should remain steady, the oil shouls then be changed. the physical analysis of the wear debris that has been generated by the deterioration of the moving parts within the system, a diagnosis of the wear mechanisms and extent of the damage to components is made using the following parameters. The test package includes:

Wear index: A measurement of the amount of ferrous wear within a system.

Particle Quantifier Index (PQ): A measurement of the wear debris filtered from the used oil.

Magnetic Separation Index (Mag I): A measurement of ferrous wear debris magnetically separated from other debris.

Contamination Index (Contamin): A measurement of the amount of metallic contamination.

Average Size: The average size of the particle size of the wear debris.

Maximum Size: The maximum particle size of the wear debris.

Density Index (Density): A measurement of the density of the largest wear particles.

VII. WEAR PROCESS MONITORING TECHNIQUES

The method of wear process can be classified into three main types, which are shown in fig.

1. Direct detection method: Wear debris in the lubricant is detected in the machine by arranging for the oil flow through a device, which is sensitive to the presence of debris.
2. Debris collection methods: Wear debris is collected in a device, fitted to the machine which is convenient to remove, so that the debris can be extracted for examination.
3. Lubricant Sample Analysis: A sample of lubricant is extracted from the machine and analyzed for wear debris contamination. These methods are normally used to monitor the conditions of components lubricated by a circulatory oil system. When applying a wear debris monitoring method to any machine for the first time there is an initial learning period required, partly to gain experience in using the equipment, but mainly to establish wear debris characteristic levels which indicate normal and incipient failure conditions. This learning period can take up to 2 Yrs. During this time it will also be necessary to establish the inspection and sampling intervals for intermittent monitoring methods such as debris collection and lubricant sampling. This time interval will depend on the application but fortnightly or monthly is probably a reasonable choice for an industrial application in the absence of more precise guidance. Debris collection and lubricant sampling can also indicate the nature of the wear problem and engineers carrying out monitoring need to be given a regular feedback of information on the accuracy of their diagnosis. A scattering of black particle fragments (whiskers) is seen. An unacceptable coating is visible. This indicates abnormal wear. A sample of lubricant is extracted from a machine and analyzed for wear debris contamination. There are two most widely used methods. They are:

1. Spectrometric oil analysis program (SOAP)
2. Ferrography

These methods are normally used to monitor the conditions of components lubricated by a circulating oil system. Two main lubricating sample analysis methods are:

1. Analysis of the sample to determine the concentration of the chemical elements it contains.
2. Analysis of the sample to determine the amount, size and shape of contaminant particles contained in it.

SOAP: It is a maintenance tool which is used to check the condition of the oil lubricated mechanical systems (Examples: Motors, Gear boxes, Hydraulic systems). The systems can be kept under surveillance without dismantling them. Abnormally worn compounds can be localized and replaced before a catastrophic failure occurs. The quantity and type of wear metals in sample of lubricating oil is determined. The quantity can indicate something about the magnitude of the wear and the type of wear metals can reveal which component is wearing out.

- Emission Spectroscopy An emission spectrometer is an optical instrument where the sample is burned is in a spark between two electrodes. The energy is absorbed by the metal in the sample, and they emit light with wavelengths, which are characteristic for each element in the sample. The intensity of light is proportional to the concentration of the metal in the sample.
- Atomic Absorption Spectroscopy In this, the sample is burned in a gas flame, where the metal compounds are transferred into atoms that can absorb light at wavelengths, which can characteristic for each metal. If one wishes e.g. to determine the quantity of fuel copper, then light with a wavelength characteristic for copper is send through the flame, where the copper atoms absorb a part of light . The

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 5, November 2012

quantity of absorbed light is proportional with the quantity of copper in the sample. Only particle under certain size can be measured, which is of the order of 0-10Ã, Âµm. With emission spectroscopy somewhat larger particles can be measured.

Limitations: - Users of the SOAP claim that they find that a large proportion of the defects which would lead to the breakdown. This method provides no indication of: Large particles (E.g. bearings can breakdown due to few large particles) Defects which occurs quickly (E.g. due to the lack of lubricating oil or due to bearings which burn up) Defects where no wear metals are formed.(E.g. breakdown due to metal fatigue).

VIII. APPLICATIONS

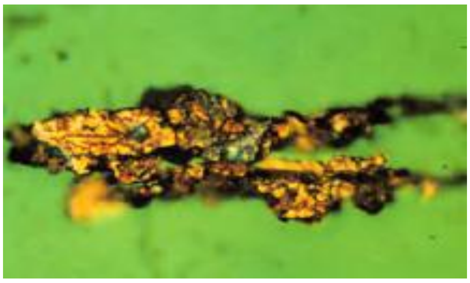
1. It is used in situation s where breakdowns are catastrophic or expensive.
2. It is widely used in the military services.
3. In US, it is used by the Air force, Navy and the Army.
4. It is used for many civil aviation companies.

Ferrography: It is a technique which is based upon the systematic collection of oil samples from oil- lubricated machines. The method identifies, isolate and classify wear particles from machine parts. A magnetic field is used to sort the wear particles in the flowing oil. This technique was used successfully to monitor the condition of military aircraft engines, gear boxes and transmissions. Three of the major types of equipments used in wear particle analysis are the Direct Reading (DR) ferrorgraphy, the analytical ferrograph system and Ferrogram scanner. Registration of the quantity of large and small wear particles is used to monitor the development of process between checks. Abnormal wear is revealed when there is a change in distribution of the particles called wear index of the oil.

Ferrograph Analysis Apparatus: Here the particles are separated on a treated object glass where due to its displacement in a special magnetic field (with a very high field gradation) causes the particle should be sorted according to size. The largest particles are deposited first while smaller ones travel farther with the flowing oil. The density i.e. the concentration of particles at a single location on the ferrogram is measured with a optical densitometer by allowing light to pass through it.

1. DR Ferrography This is a quick method for which direct reading of the index SD can be achieved in about 5 minutes. In this apparatus, a controlled flow of oil passes through a calibrated glass tube which is mounted in a specially designed magnetic field. The separation causes the particles to be sorted by the size of the bottom of the tube. The apparatus uses photocells to convert the measured light intensities attained by passing light to the tube to electric signals. The measured region of the apparatus is 0 -190 DR units, where maximum value is 190 DR corresponding to the cases where the bottom of the tube is completely covered with metal particles.

2. The Analytical Ferrograph additional information about a wear sample can be obtained with the Analytical Ferrograph system, instruments that can provide a permanent record of the sample, as well as analytical information. The Ferrogram 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 Ferrogram, a wash is used to flush away the oil 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. Ferrogram Maker Instrument Wear-Debris analysis made easy The EDAX Eagle Micro-Probe EDXRF system provides a fast and simple method for the component identification of wear-debris particles



.

Fig 5 Copper particles

Fig 6 Babbitt particle

High alloy steel EDAX has led the way in the development and supply of elemental analysis instrumentation based on the method of energy-dispersive (X-ray) spectrometry (EDS). The EDS method utilizes the simple spectral information produced as a result of electron transitions deep within an atom. These X-ray spectra (so called because of their energy/ wavelength) obtained from a sample under investigation within a suitable analysis instrument, provide unique information about the type and quantity of the elements present. EDAX introduced the first commercially available EDS system for electron microscopy applications The EDS technique is a familiar elemental analysis attachment to a scanning electron microscope (SEM) where electrons are used as the primary energy source to excite the X-ray spectra. SEM-EDS methods are used for wear-particle analysis for both their morphological and compositional properties, and are particularly useful where the study of very small particles (approximately five microns or less) is necessary. On the other hand, the radiation output from an X-ray tube may also be employed as an energy source. The resultant benefits for systems using an X-ray energy source include greatly simplified specimen handling/presentation needs, less sophisticated instrumentation, simpler and faster

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 5, November 2012

operation and lower cost. Such a standalone system is called an energy-dispersive X-ray fluorescence spectrometer (EDXRF), of which the EDAX Eagle is a specialized example. the EDS technique is a familiar elemental analysis attachment to a scanning electron microscope Ease of analysis:- The magnetic plugs are degreased prior to the transfer of the debris on to a clear sticky tape (the traditional method used for debris archiving and/or optical examination) Without the need for any further sample preparation, the tape/debris is presented to the spectrometer for analysis where, in typically less than two minutes, its analysis may be obtained. Also the measured spectrum can be compared (using spectral pattern-recognition methods) to stored reference spectra of the monitored assembly's component parts and hence to identify the component that has worn or been damaged.

IX. RESULTS AND DISCUSSIONS

The Result of this analysis is that I found the wear debris in oil is dark brown in colour which shows the presence of Dark metallic oxides

X. CONCLUSION

- The wear debris monitoring method access the nature of the particles generated when components wear.
- They can indicate exact nature of the machine problem
- The methods of wear debris analysis used as an indication of machine conditions are:

Indication from the amount of debris present
Indication from the size distribution of debris
Indication from the physical form of debris
Application of chemical analysis of debris

REFERENCES

[1] Moreton, G and Yardley, E D - The Use Of Wear Debris Analysis to Monitor Gear Transmissions Under ground. Proc. of the Conf. on Condition Monitoring, 1984, p491.

[2] Lester M F and Brooks A - Debris Testing Progress and Further Developments. Proc. of the Conf. on Condition Monitoring 1987

[3] Fogel A G and Wright G J - Case Study: The Application of wear Debris Analysis for Monitoring Under ground Continuous Coal Miners. Conf. Proc. of "Tribology 86".

[4] Fogel A G and Wright G J - Refining Wear Debris Monitoring as a useful Applied Technology in Maintenance Management. Conf. Proc. of "Tribology 88".

[5] Venkatraman.a, senthilvelan.t, winter school on recent trends in diagnostic maintenance..

[6] Prabhu.b.s, workshop on plant engineering and industrial tribology..

[7] Reference: http://seminarprojects.com/thread-wear-debris-analysis-full-report#ixzz2af9kpj3p.

AUTHOR'S PROFILE

Om Prakash Sondiya is a M.E. student at Mechanical Engg. Deptt. Of Institute of Engineering & Technology, Devi Ahilya University Indore, India. He received his B.E. Degree in 2009 in Mechanical Engineering from the SGSITS INDORE (M.P.), India. He is currently working on WEAR DEBRIES ANALYSIS OF AUTOMOTIVE ENGINE LUBRICATING OIL USING BY FERROGRAPHY
E-mail address: om.prakash1961@gmail.com

Mr. Amit Kumar Gupta obtained his B.E. degree in Mechanical Engineering from IET-DAVV Indore (M.P.), India. He received his M.E. in "Computer Integrated Manufacturing" from S.G.S.I.TS., Indore, India. He is presently working as Assistant Professor in Mechanical Engineering Department, Institute of Engineering & Technology, Devi Ahilya University, and Indore, India. His areas of interest are fields related to CAD/CAE/FEA and Acoustics of Muffler.
E-mail address: amitgupta1507@yahoomail.com