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Wear Debris Analysis of Internal Combustion Engine by Ferrography Technique

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Abstract

IC engines are typically used for the auto vehicles. These engines are necessary for the auto as just like the heart for soul. Because the heart of soul is fail whole system of body additionally fail. Same issue is additionally applicable in automobile because the engine of the vehicle did not develop power, driver cannot run the vehicle. Maintenance is the most vital side for increasing Engine life that successively increases the life time of vehicle. Engine performances are directly depends upon the health of its parts for example piston, cylinder, cylinder head, crankshaft, cam shaft, connecting rod etc... Engines behavior are mostly depend upon its lubricating oil.

Keywords: Wear, Ferrography, Lubricating Oil, Debris Analysis particles size.

Introduction

IC engines are typically used for the auto vehicles. These engines are important for the automobile as just like the heart for soul. Because the heart is fail whole system of body additionally failed. So for successful operation of vehicle engine ought to perform its intended function properly. There are many of techniques are available for the monitoring of engines performance such as vibration monitoring, acoustic monitoring, oil monitoring etc. This work is totally based on oil monitoring. Oil monitoring is a key component of successful condition monitoring programs. It can be used as a predictive and proactive tool for judjing the wear modes of rubbing parts and diagnose the faults in machinery.It is a technique of predicting the health of equipment in a non-intrusive way, by the study of wear particles. The continuous trending of wear rate monitors the performance of engine /engine parts, and provides early warning and diagnosis. Oil condition monitoring can sense danger earlier than other techniques. This technique holds good for both oil and grease samples. By dissection the oil sample, the residual life of used oil is determined and a fault in the machine can be diagnosed before the machine has to be prematurely shut down.

Sliding adhesive wear particles are generally found in most lubricating oils. They are an indication of normal wear. They are produced in large numbers when one metal surface moves over another. The particles are seen as thin asymmetrical flakes of metals with highly polished surfaces.

The 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.

Wear debris Analysis

There are many techniques for analyzing wear debris in lubricating oil
Few of these are given below:

- Spectrometric oil analysis programs
- Rotary particle depositor
- Litmus paper test
- Sulpher test
- Filtergram analysis
- Ferrography technique

Ferrography is the most important technique for analyzed wear particles in the lubricating oil. In this project work only ferrography technique used for wear debris analysis of internal combustion engine oil.Ferrogram D7690 is used for analytical ferrography and D5185 is used for wear metals in lubricant oil. In analytical ferrography by microscopic analysis we tell about size, shape, color, texture and orientation etc.

Ferrography

Ferrography is a powerfull tool used foroil analysis. It involves separating out solid particles from a lubricant and examining them under a microscope checking characteristic like particle size, concentration, composition, morphology and surface condition of the ferrous and non-ferrous wear particles. This testing is commonly called ferrography.

Ferrography consist of two main activities:

1. Quantitative analysis

What is wear particle concentration means the count of number of particles in unit volume of oil sample is considered as wear particle concentration (WPC). We also offer weight particles in unit volume of oil samples for trending.

2. Qualitative analysis

Analytical ferrography is among the most powerful diagnostic tools used in oil analysis now a days. The technique of wear debris analysis(Analytical ferrography) is gaining popularity in the field of machine condition based maintenance system. To perform analytical ferrography the solid debris suspended in a lubricant is separated and and systematically deposited onto a glass side. The slide is examined under a microscope to distinguish particle size, shape, morphology and surface condition of the ferrous and non-ferrous wear particles. The particles present in a lubricating fluid carry detailed and important information about the condition of the machine component
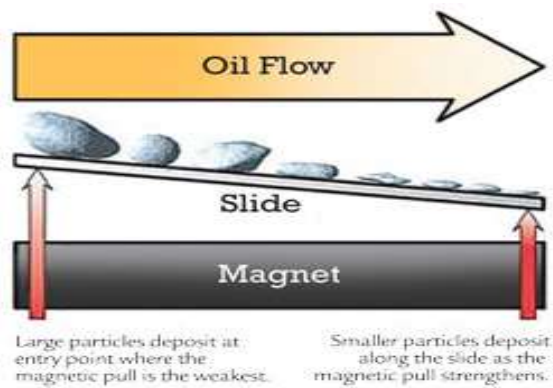

Fig1: Ferrogram maker

Investigation and Data Collection

For effective monitoring of the engine health, accurate sampling of its lubricant is necessary. Oil analysis gives important information about the engine health; it will give information that where the wear rate is high or where its rate slow and also give the reasons behind such wear. It also tells about mechanism of wear particle like as cutting, rubbing severe sliding etc. in which parts of the engine wear So that carefully data collection is important to get accurate result.

The Samples of the investigated engine oil is collected carefully and mark the no on every bottle according to corresponding vehicle runs.

The samples for investigation are collected from the Hero agency in indore. It is the largest service centre of two wheeler vehicles in indore Region. And Feroography test of collected samples was conducted at specto lab delhi.

Details of the investigated samples

Investigation works for this dissertation are carried out on Hero HF Deluxe bike. Following Table shows the details list of all samples or engine oil are used for the investigation. It is to be noted that vehicles runs are in approximation.

Table 1: Detail of Samples

SAMPLE CODE	TOTAL RUNS (in Km)
1	520
2	2800
3	5156
4	9500
5	10144

Specification of the vehicle:

Table2 shows the technical specification of the vehicle which is used for investigation. This specification helps to understands more about the vehicle which is used for the investigation.

Table 2: Technical Specification

NAME	HERO HF DELUXE BIKE
Engine type	Air Cooled, 4-Stroke, Single Cylinder
Displacement	97.2 cc
Maximum Power	5.74 KW at 7500 RPM
Maximum Torque	8.04 N-m at 4500 RPM
Bore	50mm
Stroke	49.5 mm
Compression	9:1
Fuel Tank Capacity	10.5 Litres
Reserve	1.8 Litres
Oil Tank Capacity	1 Litre

Figure 2: Engine of HF Deluxe bike

Results and discussion

The following results are obtained after the wear debris analysis of lubricating oil for ferrous and non-ferrous wear particle
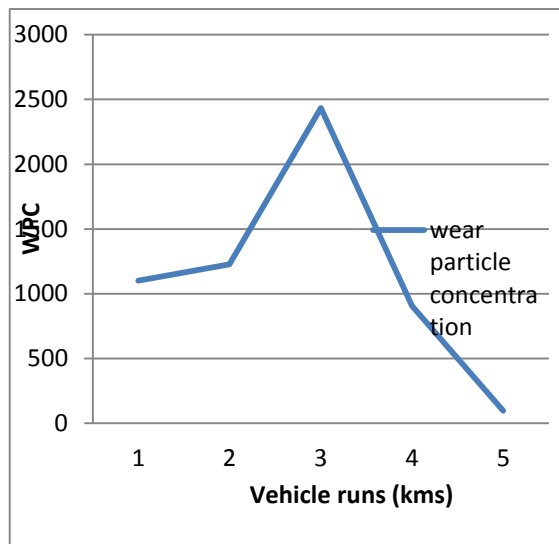
For ferrous wear particles.

Figure 3: Graph between WPC and Vehicle runs

Wpc in sample2 and sample3 increases because in sample1 the wear debris max. size is large as seen 248 micron of case hardened steel , in next sample this case hardened steel particle max. size reduced uo to 6o micron and in sample3 small size of 30 micron seen which increases the concentration of wear particle. Means as vehicle runs the particles size is reduced and number of particles increases and after that as vehicle runs in sample4 and sample5 max. size as well as wpc is decreased.
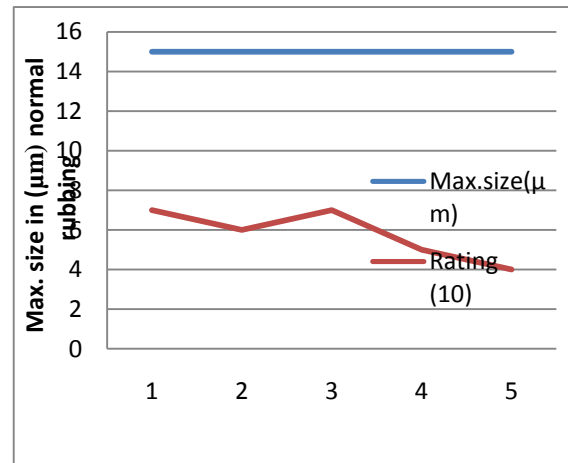

Figure 4: Graph between Maximum Size in Normal Rubbing and Vehicle Runs

In normal rubbing seen that the wear particles found in marginal quantities of same max. size 15 micron. And rating in sample1 ,2, and 3 is in marginal condition but after some time or as vehicle runs it is in normal condition.
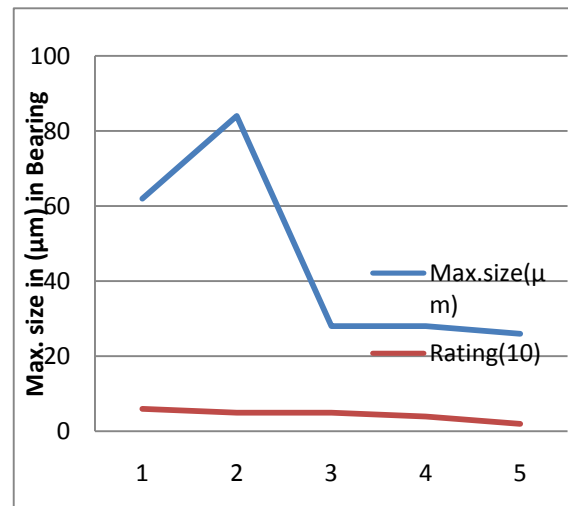

Figure 5: Graph between Maximum Size of wear particle in bearing and vehicle runs

These distinct particle types have been associated with rolling wear fatigue. These particles max size do not exceed 100 micron. Fatigue spall particles constitute actual removal from the metal surface with a pit or a crack is propagated.max size 84 micron is observed in sample2. As vehicle runs

the size of particles reduced up to 28 micron and in sample5 these are found in small quantity.
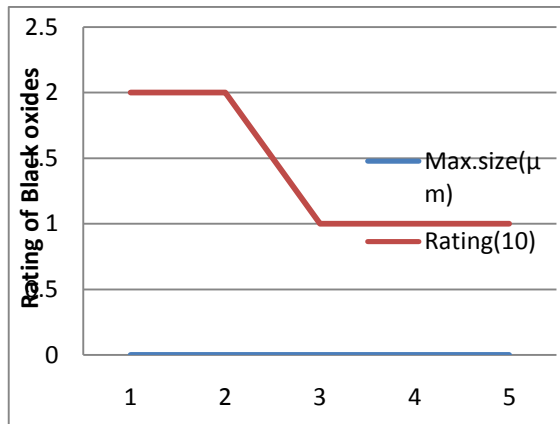

Figure 6: Graph between Rating of black oxides and vehicle runs

Dark metallic oxides deposit in chains and appear dark gray to black. The degree of darkness is indicative of the amount of oxidation. Very fine particles of negligible size are seen oil. Rating of these particles are ranging between 1 to 2 hence condition is normal.
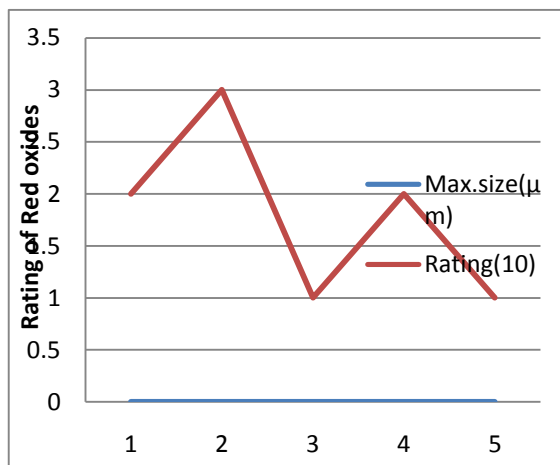

Figure 7: Graph between Rating of red oxides and vehicle runs

Red oxides (Rust) polarized light readily identify the red oxides. Sometimes they can be found in chains with the other ferrous particles and sometimes they are randomly deposited on the slide surface. They usually appears as a beach of red sand. Very fine particles in normal rating are in oil samples.
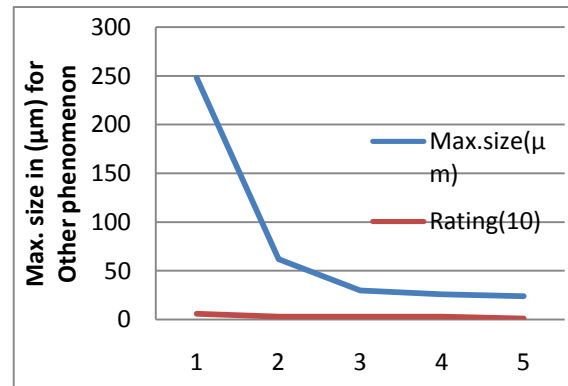

Figure 8: Graph between maximum size of particle in other phenomenon and vehicle runs

Case hardness steel wear particle in sample1 are in marginal quantity, sample2, 3, 4 are in small quantity and in sample5 these particles are negligible, Hence rated as normal.
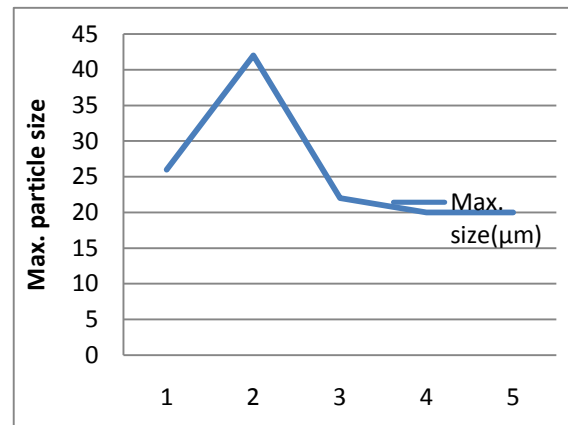

Figure 9: Graph between maximum size of medium steel wear particle and vehicle runs

These particles are found in chains on the slide and appear greay- white. Medium alloy steel wear particle in sample1, 2, 3 are found in small quantity and sample 4, 5 medium alloy steel particles are negligible.The maximum size 42 micron seen in sample 2. After sample sample2 as vehicle runs size and concentration of these particles reduced.

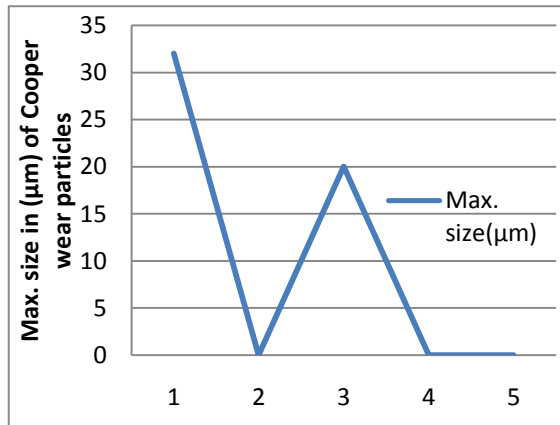**Graps for non ferrous wear particles**

Figure 10: Graph between max. sizeof copper wear particle and vehicle runs

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 are resting at entry point of the slide. Cooper wear particle in sample1 are in small quantity of max size is 32 micron. In sample2, 4, 5 very fine copper particles are seen.
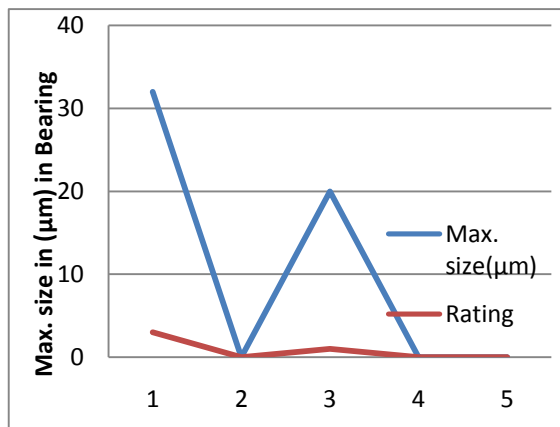

Figure 11: Graph between max. size of non ferrous wear particle and vehicle runs

Bearings are worn out in sample1 and sample3 max. size is found 32 micron and in other sample there is no non ferrous wear particles in Bearing.
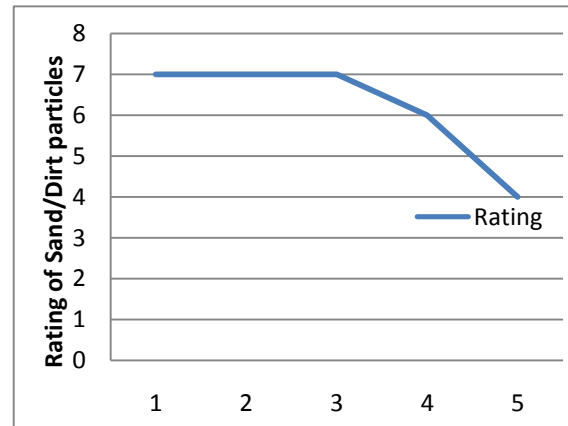

Figure 12: Graph between Rating of sand/dirt particles and vehicle runs

Sand/dirt particles do not change in appearance after heat treatment , they can appear as white crystals and easily identified by the transmitted light source, that is , they are somewhat transparent. Contaminants appear randomly on the slide and are commonly dyked the chains of ferrous particles. These particles are observed in large quantities but as vehicle runs rating is change near critical to normal condition.
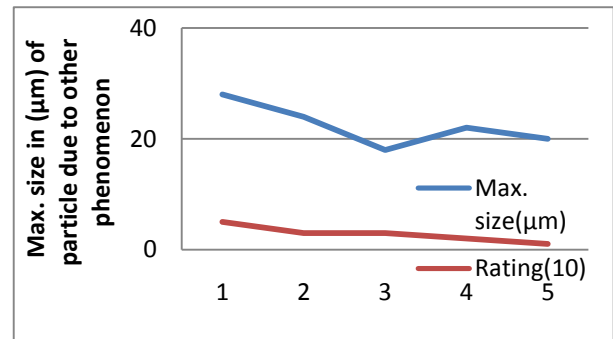

Figure 13: Graph between max. size of particle in other phenomenon and vehicle runs

White metal wear particles in sample1 are in marginal quantity, sample2, 3, 4 these particle are in small quantity and in sample5 white metal particles negligible. These particles not appears in chain these are randomly deposited. As vehicle runs these are in normal range.

Conclusion

After taking the samples of lubricating oil in clean bottle. We analyzed each sample by ferrography technique and concluded that the wear particle concentration which is actually the number of wear particles increases up to third sample because the particle sizes are bigger in initial sample there after size of particles is reduced hence number of small size particles are increased. But at all weight of wear particles is reduced with vehicle runs.And after third sample weight of wear particles as well as wear particle concentration is reduced. It is observed that the maximum size of wear particle is 248 micron which shows critical situation of wearing. This particle is belongs to case hardened steel hense case hardened steel wear in marginal quantity. Camshaft is made by case hardened steel hence most weared part of the engine is camshaft in first sample. There is no need for changing oil after fourth sample upto vehicle runs more over 12000 kilometers.

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Author Biblography

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