DIESEL ENGINE DIAGNOSIS BY VIBRATION OIL ANALYSIS

Prof. DR. DO DUC TUAN
MEng. LE LANG VAN
University of Transport and Communications

Abstract: *This paper presents a research of oil and vibration analysis in machine condition monitoring and evaluating the use of oil and particle analysis in practice. The paper also mentions to capable of this method in diesel engine diagnostic based on the result of oil and vibration analysis at Hanoi Locomotive Entreprise, Vietnam.*

I. INTRODUCTION

Vibration and oil analysis can reveal a great deal of information about machine's health. Therefore, vibration and oil analysis are two key components for machine condition monitoring. Oil analysis has been used for at least fifty years in determining the wear condition of machinery. Rails road companies in the late 1940s and early 1950s found that the metals in a sample of used oil revealed the condition of the wearing parts in their locomotive engines. Vibration and oil analysis today are used to monitor the condition of everything from aircraft jet engines and helicopter gearboxes to construction equipment industry, commercial transportation, and industrial plants. Oil analysis is taking place alongside vibration monitoring as an indispensable and valuable predictive maintenance tool in industry. This paper presents a study of integrating vibration and oil analysis for diesel engine condition monitoring based on the result of oil and vibration analysis at Hanoi Locomotive Entreprise, Vietnam.

II. CONTAINS

2.1. Oil analysis application

The wearing parts of a machine such as the gears, hydraulic pistons, bearings, and wear rings generate fine metal particles during normal operation. At the onset of a severe wear mode the particle size increases and the appearance of the particles change. Knowledge of the particles and how they relate to the mode of wear permits a trained analyst to determine the wear status in a machine by measuring the fine and coarse metal particles and then examining the particles under a microscope. The testing for wear metals for condition monitoring and predictive maintenance is tested predominantly in spectrometric analysis or in wear debris analysis.

The advantages of oil debris monitoring compared with other monitoring methods include:

- The evidence in the oil is to be found nowhere else.
- The cost benefit ratio is better than other technique.
- The oil carries evidence of faults from various parts.

2.2. Chemical identification of debris

Quantitative measurement is often required for many machine condition monitoring applications. Quantifying debris gives a feel for the likely wear that is occurring in machines. The measured mass of debris is determined to know any change in the trapped quantity, such as weight per ml, intensity per ml, or shape of the size distributions. Chemical identification instruments used in this research is Alloy Pro 9388 Metal Analyser (*Figure1)*.

Figure1. *ALLOY PRO 9388 Metal Analyser*

Figure 2. *Chemical identification of piston of D12E engine*

2.3. Wear particle image analysis

Oil samples and vibration data which were collected regularly at the Hanoi Locomotive Entreprise over a period of 14 months were carefully examined and compared. A particle analyzer was used to determine oil sample to assess the general trend of diesel engine conditions. Normal wear process from oil samples of locomotive No 660, 657 and 658: number of particles and particle dimensions were small (from 0.2 to 5 micromet).

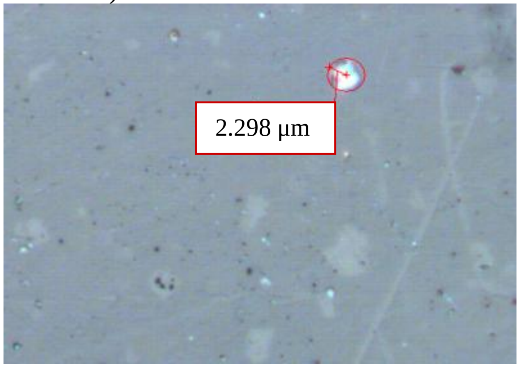


Figure 3. *Particles in oil sample (Locomotive No 660)*

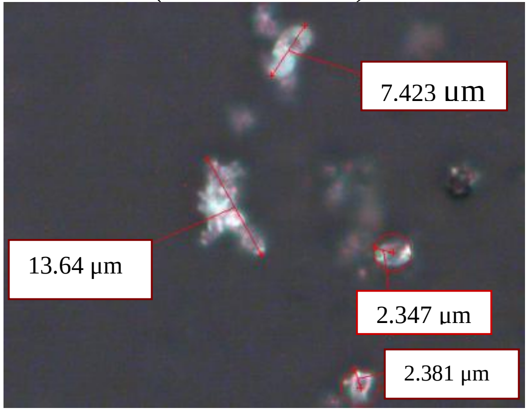


Figure 4. *Particles in oil sample is increasing in numbers*

(Oil sample on Locomotive No 658)

Various types of wear process give various types of particle shapes: spheres, fibers, slabs, curls, spirals and slivers, rolls, strands and fibers.

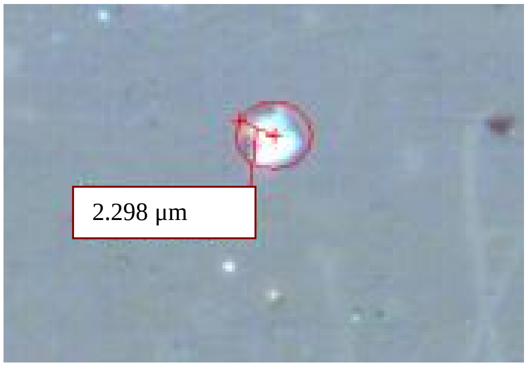


Figure 5. *Sphere shape particle*

(In oil samples of locomotive No 660)

Sphere shape: the presence of spheres in oils is quite frequent. Sometime spheres are found in the new lubricating oil from a container.

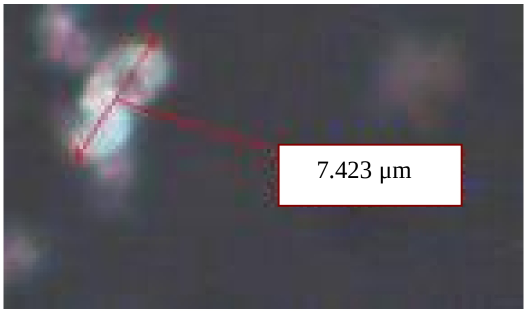


Figure 6. *Pebble shape particle*

(In oil sample of locomotive No 658)

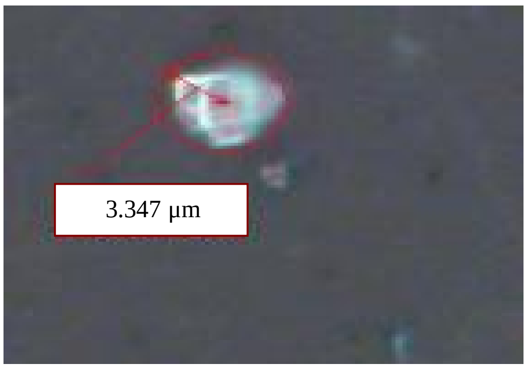


Figure 7. *Chunks and slabs shape particle*

(In oil sample of locomotive No 658)

The smooth sphere is often found in the running-in period. The rough seems to involve more severe wear. The other shapes include: distorted smooth ovoid/pebble shape, chunks and slabs, curls, spirals and slivers, rolls, strands and fibers. The research process draws the following conclusion:

Rubbing wear and normal wear: are regular wear particles which are formed from between lubricated sliding surfaces. They would take the shape of ‘platelets’ up to 10 µm.

Cutting wear: These particles are formed by the metal parts digging into each other [2].

Rolling fatigue: Spherical particles appear quite often. It would have to be assumed that the spheres come from fatigue cracks in bearings. Chunks of metal can appear from fatigue with the size up to 100 µm. Another form of particle is the platelet, perhaps up to 50 µm.

Severe sliding wear: These are also large particles depending on the magnitude of the sliding action load and speed. Usually in the form of platelets with surface stress acted on the wearing surfaces. The higher the stress level, the larger the ratio of large particles to small particles [4].

2.4. Particle Dimension

Dimension of the particle changes from several micromets to 100 or 300 micromets. Particle shape varies depends on wear procces. A large dimension of particle informs severe wear process. The research indicates:

Normal wear procces produces particles with sphere shape and their dimensions are between 5 and 10 micromet.

Cutting wear is caused when an abrasive particle has imbedded itself in soft surface of copper alloy wear.

Fatigue wear occurs when cracks develop in the component surface that leads to generation of particles. Particle dimension is up to 100 micromet.

Sliding wear evolves during equipment stress. The dimension of particle is more than 10 micromet.

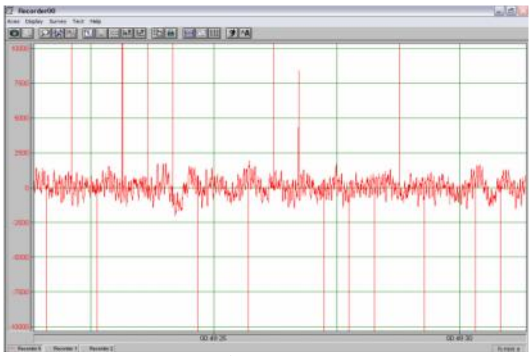
The particle dimensions from oil samples of fault engines on locomotives were between 100 micromets and 120 micromets.

2.5. Number of wear particles

Determining the number of wear particles is one of demands for diagnosis procces. The number of wear particles per millilitre gives an explicit, easy-to-understand format for characterising wear conditions of lubricated tribosystem monitored. The numbers of wear particles per millilitre counted from oil sample collected from fault engines on locomotives were over 100 particles per millilitre.

Vibration Analysis

The equipment used for measurement and analysis includes: vibration meters, analyzer and DasyLab software. The experiments were carried on Hanoi Locomotive Entreprise over period of 14 months.



on engine of locomotive No 643

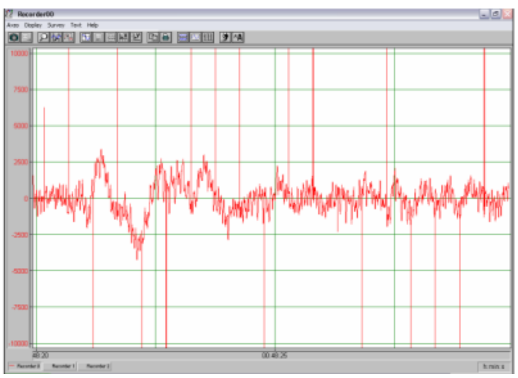


Figure9. *Vibration spectum measured on engine of locomotive No 642*

The vibrations are taken in the three Cartesian directions. In vibration nomenclature, these are the vertical, horizontal and axial directions. This is necessary due to the construction of machines – their defects can show up in any of three directions and hence each should be measured. The data collector can collect and store the data for comparision and trending. The database program stores vibration data and makes comparisons between current measurements, past measurements and predefined alarm limits. Alarm limits for locomotives D12E are 20mm/s and 7mm/s^2.

III. CONCLUSION

The diagnosis technique of combustion engines by oil and vibration analysis has been researched in several countries and has some success. This research integrates vibration and oil analysis for diesel engines of K6S230DR used on D12E locomotives. When wear particle dimensions exceeds 120 micromet, when concentration of metals (Cu, Fe, Cr) has been increasing, shapes of oil debris are unnormal, vibration velocity and acceleration exceeds 20mm/s and 7 mm/s^2, engine faults may occur on piston, valves or piston rings. Oil analysis confirms the results of vibration analysis. Both wear debris and vibration analysis techniques were used to assess the diesel diagnose problems during this research. Oil debris analysis confirm the conclusions about the faults of diesel engine elements when had vibration alarms.

Reference

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