FH – HES Fachhochschule – Hautes Ecoles Spécialisées

Chimia 59 (2005) 990–991
© Schweizerische Chemische Gesellschaft
ISSN 0009–4293

Diagnosis of Engines by Oil Analysis

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Abstract: Oil analysis is an easy and cheap diagnosis procedure to check the optimal functionality of engines. Often it prevents major breakdown situations. The metal content in engine oil measured in function of time delivers significant information on wear and/or mechanical irregularities of the engine.

Keywords: Diagnosis · Engine · Metal particles · Oil · Wear

Introduction

The department of analytical chemistry of the Geneva Institute of Technology, certified ISO 9001-2000 since February 2005, is a highly equipped laboratory with many analytical instruments (X-fluorescence, ICP-MS., GC-MS, FT-IR, AA, *etc.*). Although the main field of study is environmental analysis, the laboratory allows industries to benefit from its services by developing specific analyses. One of them is oil analysis.

The analysis of engine oil is a very easy way to obtain information about the optimum functionality of an engine. It is mainly used by the main oil manufacturer industries but its application field spreads to the automotive and aircraft industries [1], railway servicing [2] and machine industry. Unfortunately it is not very well known in our country and mechanical industries such as car garages and maintenance garages underestimate its advantages.

Oil analysis enables two principal diagnoses. One is the oil quality by determination of the physicochemical properties. The other is an estimation of the engine's health by measurement of metal contamination in function of time. In order to obtain a correct diagnosis, it is necessary to know the average profile of the engine to be tested (Fig. 1). This profile requires an important amount of testing with correct statistical correlation. Three phases appears on the profile: running in, normal use, deterioration.

The oil analysis can be compared to blood analysis in medical diagnosis. It is extremely useful for the maintenance of the engine. It enables to see whether the engine is functioning normally or whether there is a possibility of a future breakdown, which the test may prevent from happening without having to dismantle the engine beforehand.

The Tests

The main test is the analysis of different metallic elements that the oil contains. Indeed, the measurement of the amounts of Fe, Cr, Al, Cu, and other metals indicate the level of wear of the engine and show which are the most damaged parts. Also, by

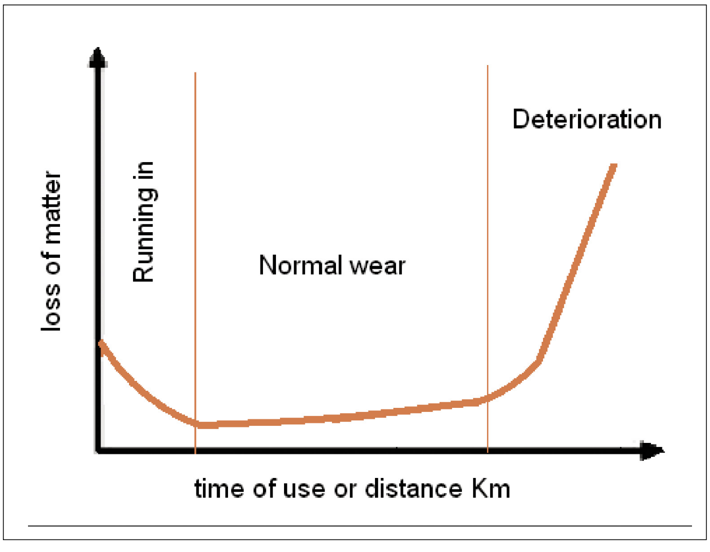

Fig. 1. Theoretical wear profile for an engine with the three phases: running in, normal use, and deterioration

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knowing the amount of K, Na, and Si, it is possible to establish whether there is any contamination by the cooling fluid.

A second test is the determination of other physicochemical parameters, such as viscosity. This test reveals a lot of other information [3] such as oil oxidation, oil dilution by fuel or water, dirty engine and so on. Also, the analysis by infrared (FT-IR) may indicate the presence of soot and/or glycol and the oxidation level.

X-ray Fluorescence

Usually the analyses of the elements are performed by ICP-AES. A new method by X-ray fluorescence [4] is being developed and appears to be much faster. The disadvantage is that it requires the creation of a large database of standards for each type of oil that is used, due to the X-ray calibration.

The preparation of such standards at low concentrations (from 1 to 300 ppm) is not an easy process. Metals do not directly dissolve in oil in contrast to aqueous medium. Indeed, the nature of particles in the fluid is not well known. It depends of the mechanism of contamination such as erosion, which may produce submicron metal particles, and corrosion, which produces probably ionic species. These species are maintained in the medium in suspension by the dispersible and detergent components of oil.

In order to elaborate our first standards, we used some contaminated oil samples that we had previously analyzed by ICP after a long process of mineralization. In the future, we hope to develop a wearing machine functioning with different types of oil and materials. As a result, we would be able to produce samples with various concentrations.

Industrial Application

In collaboration with the 'Transports Publics Genevois (TPG)', we have undertaken a series of oil analyses from the engine oil of 15 Volvo 7000A buses. These tests revealed the average level of wear of the engine (Fig. 2). Thus, we have been able to establish a three-zone chart (normal, danger, and critical) with the different breakpoint values. One of the buses had an abnormal level of iron positioning in the critical zone. Later, the engine appeared to be defective. Obviously, it is important to continue the testing on the vehicles in order to refine the average metal profile of engines and therefore obtain a more relevant diagnosis.

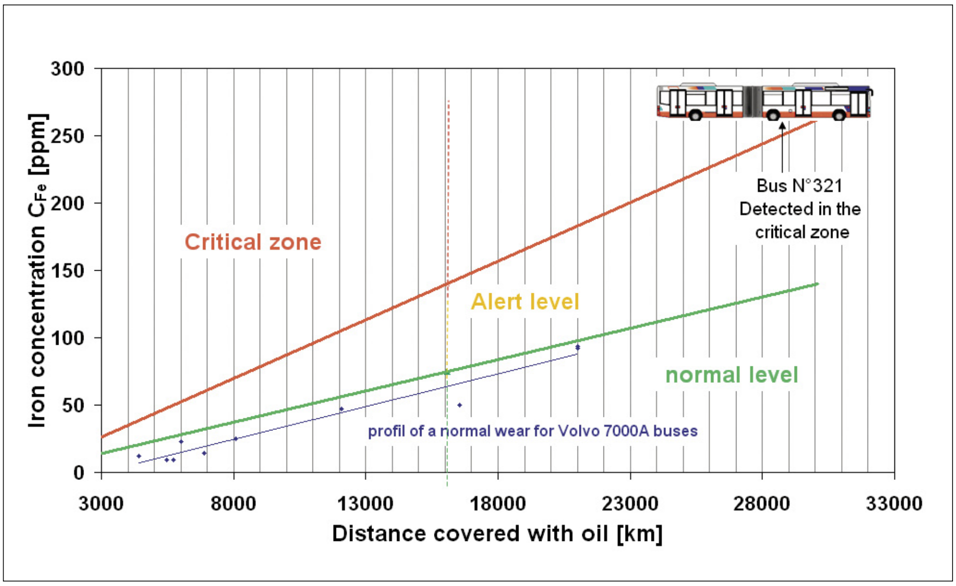

Fig. 2. Normal wear profile for a Volvo 7000A bus with values for normal, alert, and critical level

Conclusion

Oil analysis is a quick test that can detect a potential failure of an engine and reduce its maintenance costs. Therefore, many industries can benefit from it, both directly and indirectly. In order to obtain an accurate diagnosis, it is important to establish the engine profile with a large number of tests. This kind of analysis is not only restricted to oil but can also be applied to other fluids.

Received: October 31, 2005

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