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INTERPRETATION OF DRAIN OIL ANALYSIS

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The primary function of lubricating oil is to provide adequate lubrication and component protection during the life of an engine. In conjunction with air or water cooling systems, the oil also acts as a heat transfer medium and aids the removal of heat from the combustion region of the engine. Another important function of the oil is to act as a scavenger and collecting medium for debris and impurities derived from engine operation.

Naturally exsist many normal forms of contamination which enter the oil from reasonably well maintained gasoline and diesel engines. This report is a general survey of complex subject, anomalies and exceptions which can occur in practice during estamination of drain oil. Unfortunately, there appear to be more exceptions than can be reasonably expected so that drain oil analysis and its interpretation is still as much an art as a science.

1. INTRODUCTION

The primary function of engine lubricating oil is to provide adequate lubrication and component protection during the life of an engine. In conjunction with air or water cooling systems, the oil also acts as a heat transfer medium and aids the removal of heat from the combustion region of the engine. Another important function of the oil is to act as a scavenger and collecting medium for debris and impurities derived from engine operation.

Naturally exsist many normal forms of contamination which enter the oil from reasonably well maintained gasoline and diesel engines. This report is a general survey of complex subject, anomalies and exceptions which can occur in practice during estamination of drain oil. Unfortunately, there appear to be more exceptions than can be reasonably expected so that drain oil analysis and its interpretation is still as much an art as a science.

2. TESTING DRAIN OIL AND INTERPRETATION OF RESULTS

Although the larger customer may possess oil laboratory facilities which will allow him to check drain oil condition, most customers will assess the suitability of their engine oil in terms of engine condition, usually by random checks dictated by the frequency of minor overhauls, and also by major overhauls after a
specified period of duty. The results of periodic drain oil analyses during oil life can be used to check and supplement the final results of oil tests derived from engine inspections.

They are of value in:

- Indicating that the oil is likely to cause deleterious effects if the oil change period is extended
- Indicating the onset of dangerous or potentially dangerous conditions which could lead to loss of engine protection and ultimately to engine failure.
- Providing comparative data regarding oil performance in relation to engine condition.
- Obtaining some insight into general rules of an empirical or theoretical nature applicable to different oil formulations under different conditions of duty

The testing of drain oils is usually divided into the several following sections dependinig on laboratory equipment in which is sample of drain oil procedured.

1. Preliminary Inspections
2. Sampling Procedures in the Laboratory
3. Estimation of Water Content
4. Estimation of Viscosities
5. Acid and Base Numbers
6. Gas chromatography (Estimation of Fuel Dilution)
7. Estimation of Insolubles Contents
8. Ferrography (Separation of debrisis)
9. Microscopic Examination of Engine Components
10. Spectrographic Analyses (Volume of Ba, Ca, Zn, P, B, Al, Cu, Fe, Pb)
11. IR (infra-red spectroscopy)

Considering to the quantity of subject about analyses and interpretation of drain oil, for better explanation and demonstration the above sections for testing drain oil we have not got enough space. This report deals with some specific analyses, which author tried to adapt for conditions in daily practise.

3. PRINCIPLES OF INFRA-RED ANALISIS AND ITS USE IN USED OIL ANALISIS

Infra-red analysis is possible use with very high efeciency for testing of drain oil, generally for reason of quickly comparation to unused oil and finally we could obtain inportant informations about degree of oil degradation against to original quality.

Chemical bonds absorb light at a frequency characteristic to the bond. The bonds of interest in oils and other organic compounds have characteristic absorptions in the infra-red spectrum. As infra-red radiation passes through a given thickness of sample, some frequencies are absorbed to a greater or lesser degree, whilst others pass through with undiminished energy, producing a pattern rather like a "finger-print" of the sample.

An infra-red spectrometer can be used to scan the pattern and the sample is identified by reference to known samples, ie. The presence of paraffinic bonds is evident in oils and strong absorption is detected at 2900, 1460 and 1380 cm^{-1}. These are characteristic of all oils.

Some samples show strong absorption at 1750 cm^{-1} approx. caused by the presence of esters and/or organic acids, in the case of used oils it could be due to the breakdown of the oil, in other oils esters are a normal constituent. In the former, the appearance and increase in absorption at this frequency could indicate oxidation of the oil.

It must be emphasised, however, that care and experience are required in the interpretation of patterns of absorption.

The whole pattern must be studied as, for example, acids, esters, amides, aldehydes and ketones, all absorb at or about 1750 cm^{-1}.

Used crankcase engine oils are usually difficult to analyse by IR due to their highly contaminated condition, which lowers transmittance of the infra-red radiation through the sample.

We have developed a laboratory procedure to remove these solids by dialysis which is based on the principle of differential diffusion of colloidal components from true solution components of a hydrocarbon solution, through a thin gum rubber membrane using a low-boiling paraffinic hydrocarbon as solvent (Petrolnaphta 60-80). The dialysate fraction containing the compounds that pass through the membrane is distilled in a rotary evaporator and the clarified oil extracted. This fraction contains the oxidation products which appear in a broad complex band at approximately 1750 cm^{-1} and blow-by products (nitrogen oxides) 1630^{-1} cm. The advantage of this procedure is the fact that all polymers and dispersants which also appear at 1750 cm^{-1} removed.

The fact that infra-red transmission diminishes in the region of 1750 cm^{-1} as the oil becomes more oxidized had led to the thought that the measure of absorbance in this band may be a measure of the degree of oxidation of the oil. By using the same 0.20 mm cell and the same operating conditions the spectra of the new and used dialysed oils are recorded and compared at 1750 cm^{-1}.
By correlating this IR data with engine inspection and conventional used oil tests, condemning limits which vary with type of service may be established.

Pictures:
1. Typical infra-red spectra of the fresh and used lubricant
2. Typical nitro oxidation absorbance peaks
3. Differnce spectrum of fresh and used lubricant

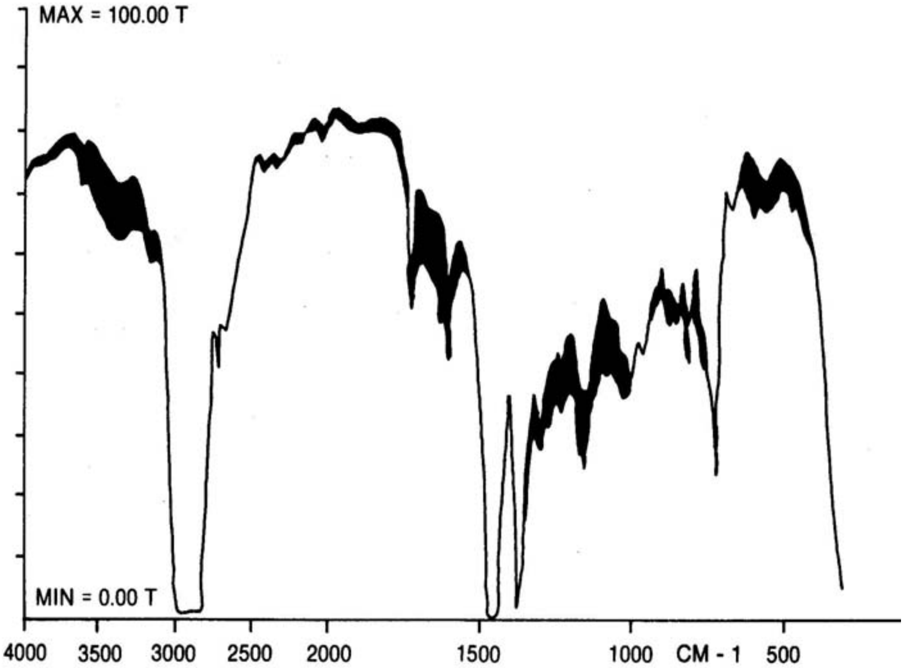

Fig. 1. Typical infra-red spectra of the fresh and used lubricant

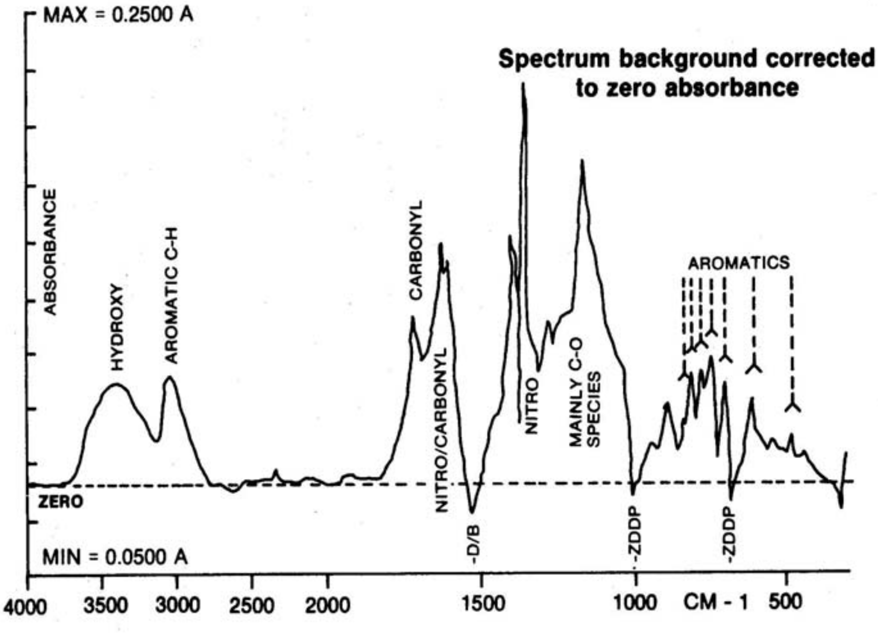

Fig. 2. Differnce spectrum of fresh and used lubricant

Summary

Oxidation: characterized by the emergence of carbonyl type compounds which are moderately acidic and appear 1750 cm^{-1} approx.

Nitration: oxidation can be accelerated by nitrogen oxides termed oxides (termed nitro oxidation) present in blow-by gases. The fixation of nitrogen in the lubricant may be estimated at 1630 cm^{-1}.

Zn.Di.T.P. Depletion: use IR information 960 – 1060 cm^{-1} together with spectrographic determination of zinc and phosphorus. (Very approximate as zinc dithiophosphate degradation products still play a useful part in anti oxidation, anti wear etc.).

Of course, the same principles we could use for others lubricants and oils, not only for drain oil.

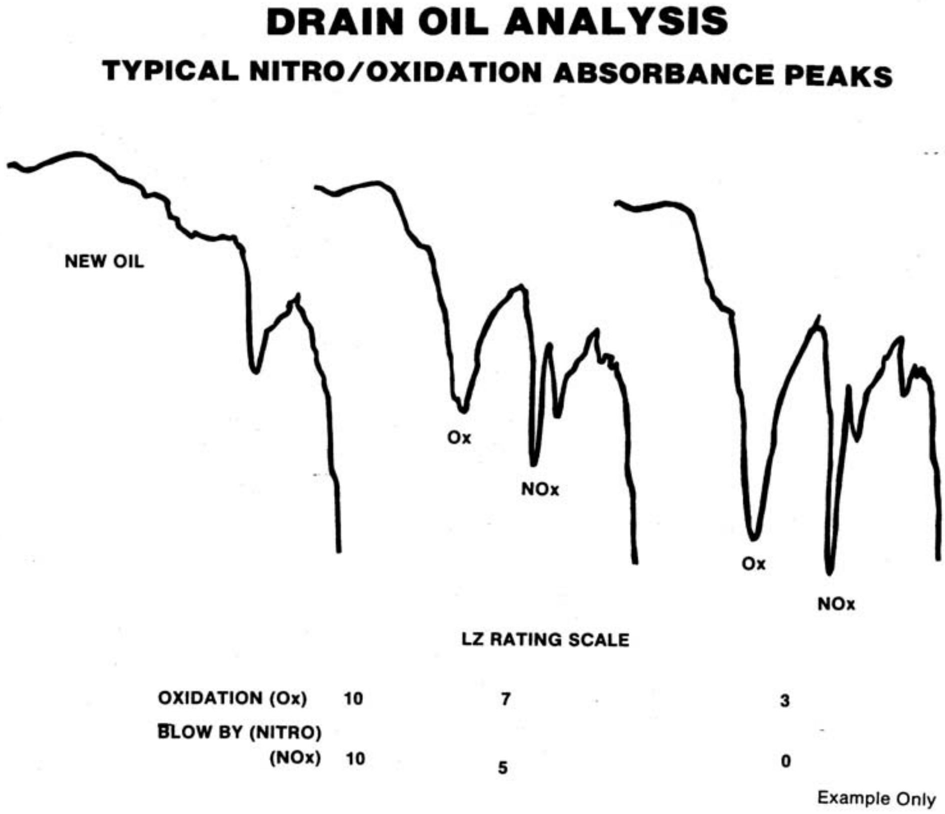

Fig. 3. Typical nitro oxidation absorbance peaks

4. CONCLUSIONS

Important problems associated with engine operations and performance can be usefully studied in terms of Used Oil Analysis, in the main infra-red spectroscopy currently play very important role. An understanding of the sequence of chemical events leading up to the problem phenomena provides an important adjunct to the time-honoured engineering approaches to their definition and solution. Viewing the engine as a chemical reactor permits the integration of chemical and engineering disciplines in an area where the nature of the problems changes with equipment design, severity of the operating conditions and the quality of the lubricant.