Asian Journal of Chemistry Vol. 20, No. 1 (2008), 361-365

Comparative Study Between Oil Analysis and Sludge Analysis of Marine Diesel Engines

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This paper presents a comparative study between detecting metallic particales in the lubricating oil and the sludge by spectrometric analysis. The diesel engine is the key power equipment in ships so it is important to monitor wear state of the engine. The presence of increased levels of metallic particles in the engine reduces the lubricant effectiveness. Oil analysis is a useful method for forecasting wear trend and has been used in diesel engines successfully while the sludge analysis can provide several informations concerning the lubricant and the engine wear.

Key Words: Diesel engine marine, Oil, Sludge, Metallic particles, Spectrometry.

INTRODUCTION

The diesel engines marked an importance in the maritime sector. Indeed they present the only means on ship which can ensure the propulsion and the production of electrical energy without which no installation can function.

Marine diesel engines are distinguished by the working environment on the waterway (*i.e.*, moisture, salinity, *etc.*) their long length of working and great powers (great volume, great load, high fuel consumption, great quantity of lubricant, *etc.*). Therefore, the costs of repair and maintenance become too high.

In order to preserve a good reliability it is then necessary to establish an efficient maintenance system based on prognostication and precise data. To this effect it would be necessary to extract correct information concerning the wear state of the diesel engine and his evolution.

Oil analysis is the main condition monitoring method for the marine diesel engines because it is difficult to monitor its wear condition by measuring vibration. Indeed measuring vibration meet a several constraints such as the complex sources of vibration, multiphasic interference and lower frequency[1].

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However, the diesel engine is a complicated tribological system. Therefore, several phenomena are produced at the time of working of the engine, as the sludge formation[2], oil contamination, *etc.* what acts of ominous manner on the oil quality and thereafter on the surfaces of the mobile parts of the engine.

The formed sludge in the centrifugal purifier is rich of wear particles generated in the contact surfaces of the engine. Then sludge analysis can provide several informations concerning the lubricant and the engine wear.

In present study, the spectrometric analysis of the lubrication oil of a marine diesel engine and the formed sludge the long of 1000 h of working after complete oil drain of the crankcase have been investigated.

EXPERIMENTAL

Present study consists to follow the evolution of a four-stroke marine diesel engine having a power of 2200 horse-power and the degradation of the oil of lubrication by spectrometric analysis. The oil in question has a class SAE 40 based on highly-refined mineral oil naturally paraffin specially designed for main propulsion and auxiliary marine trunk piston engines burning distillate fuel. It was characterized by its strong resistance to the severity of the marine environment and destined to the centrifugal purification system[3].

We have two finds of samples: The engine oil and the sludge formed in the centrifugal purifier.

Along 1000 h and at each 100 h of work in normal navigation after complete oil drain of the crankcase of present engine adding up 3805 h of work. The oil samples are taken by drainage before its return to the crankcase of the engine in working.

The fashion of normal navigation is combined whith a fixed regime of engine working characterazed by a fairly stable load, speed and temperature. This condition is so important in the friction and the wear process[4].

The sludge samples are taken at the time of the centrifugal purifier cleaning. This operation is recommanded by the manufacturer at each 100 h of working since the last oil drain. Then it contains several elements separated from the oil by the centrifugal purifier.

The spectrometic analysis of the different samples has been made by means of a spectrometer DCP (Direct Courant Plasma) SPECTRASPAN 7 at the PMEL laboratory (Precision Measurement Equipement Laboratory).This analysis enabled us to determine the content in the engine oil and the sludge of wear particles.

RESULTS AND DISCUSSION

The results obtained by spectrometry are showing that the generated principal elements by engine wear in the contact surfaces are iron, copper and chromium (more than 85 % of the present elements).

In the Figs. 1-3, we regrouped the evolution rate of the elements *i.e.*, iron, copper and chromium relating to the lubrication oil and the sludge according to the working hours of present diesel engine.

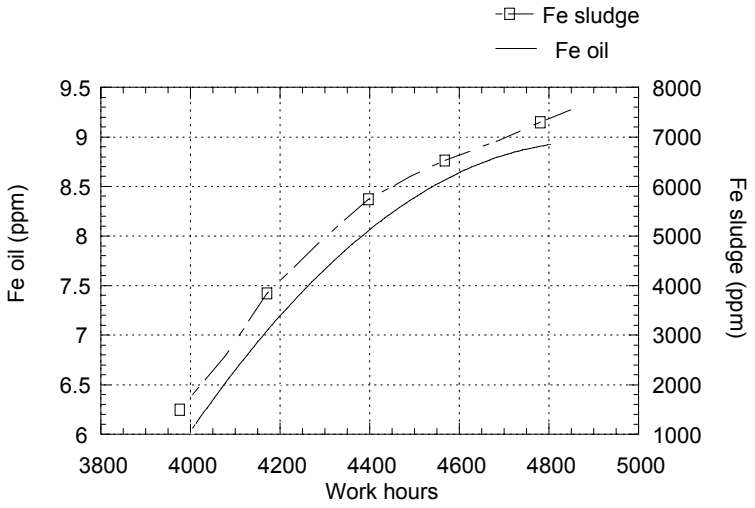

Fig. 1. Iron rate variation in oil and sludge

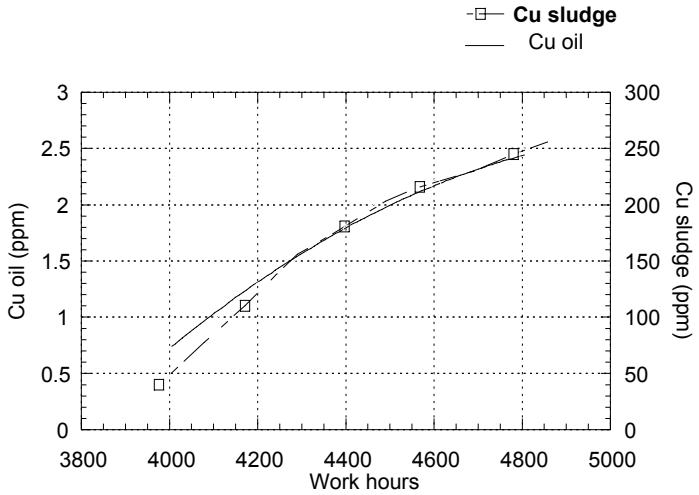

Fig. 2. Copper rate variation in oil and sludge

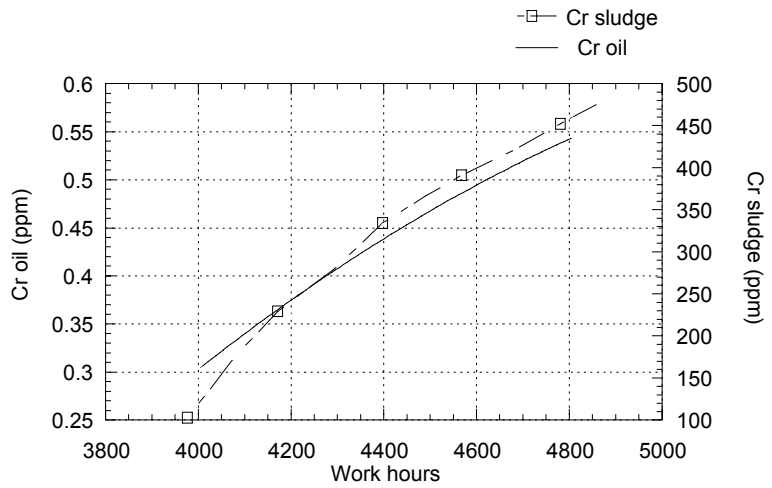

Fig. 3. Chromium rate variation in oil and sludge

The severe conditions of working of the marine diesel engine favours the production of several chemical phenomenon to which the lubrication oil can't resist without additives. Then the additives role is to maintain the oils quality lubricating and to its degradation.

The results obtained show a qualitative resemblance between the shapes of the curves relating to rate evolution of the each majority element contained in oil and sludge. That proves the system effectiveness of centrifugal purification for this kind of engines. Hence the spectrometric analysis of the sludge can indicate the content in the lubrication oil of wear particles.

The shapes of the curves present a logarithmic progression with a light tendency toward the saturation. However the regeneration of metallic particles by wear of contact surfaces of the engine is fairly steady for a fixed work regime (load, speed and temperature)[4].

The tendency of oil toward the saturation is due to the loss of its anti-wear and detergent properties caused by the additives depletion. Indeed, the anti-wear additives are adsorbed onto metal surfaces and sacrificially create a chemical-chemical contact instead metal-metal contact[5]. Besides the principal function of the detergent additives is to maintain in suspension the metallic and carbonic particles in order to avoid their deposit on some pieces of the engine and to neutralize the acid products of the combustion[6].

Otherwise it was noted experimentally[7] that the soot produced by the chemical reactions of the combustion reduces the effectiveness of the anti-wear additive by preferentially adsorbing the active anti-wear additive

components before they can form the anti-wear surfaces coating. Consequently the wear of contact surfaces of the engine increases imperatively[8] and produces a appreciable quantity of abrasives.

The soot produced by the combustion has a capital role in the depletion of detergent additives and anti-wear additives that present a major factor in the diesel engine wear.

The tendency of oil toward the saturation leads the diesel engine toward a deceasing quality of lubrication. Indeed the deposits located between cylinder and piston requires oil in good state to be cleaned[9].

Conclusion

If the maintenance of centrifugal purifier the manufacturer program and follow concentrations of metallic particles, respectively in oil and sludge have the same progression. The sludge analysis by emission spectrometry is an effective means for monitoring the engine lubricant and discovering the boundary of oil performances. Hence, we can judge the periodicity of oil drain.

Additives depletion presents a harmful effect for the lubricant and the engine. Indeed oil can't load any more metallic particles and the engine begins to receive a deposits combination of metallic particles and combustion products. Otherwise, sludge analysis can be a useful method for establishing some maintenance operations and predicting wear trend of diesel engine.

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(*Received*: 23 October 2006; *Accepted*: 14 September 2007) AJC-5833