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NEW LUBRICATING OILS FOR DIESEL ENGINE WITH SILVER BEARINGS

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Abstract
The improvements of internal combustions engines, namely rise of combustion ratio, supercharging, power density increasing from cylinder unit and size reduction led to the increased performances for lubricating oils and also to the decrease of oil volume in lubricating system [1]. New engines request severe service conditions to the lubricants, by their mechanical and thermal conditions [2]. Lately, a great number of medium speed Diesel engines uses silver-plated bearings, especially in marine and railway applications. Silver bearings utilization the provides increase of engine performances, service life and reliability but impose new requirements for lubricants.
Modern Diesel engines require crankcase lubricants providing oxidation stability, bearings anticorrosive protection and detergency properties, for suspend the combustion products. High alkalinity is also required for neutralize acids formed during fuel combustion and to reduce the frequency of oil changes [3]. In addition, these lubricants have to contain special protecting agents in order that silver parts of the engine are attacked neither by the additives in the oils or by the dispersed neutralized decomposition products- produced during the engine working..
This work presents the analytical results of special formulated lubricating oils for Diesel engines with silver bearings as performances on laboratory test stands and in normal condition of exploitation. The new lubricants exhibit excellent performances and fulfil all the requirements imposed by the engine manufacturers.
Key words: *engine lubricants, two-stroke Diesel engine, silver-plated bearing, zinc free oil*

1. INTRODUCTION

The improvement of internal combustion engines generates more and more severe work conditions for lubricating oils. The oil, considered for a long time just an accessory, became at present a very important component, indispensable for engines [4].

Mineral oils had to be improved continuously to assure the work of new engines in better and economical conditions. Their improvement started with base oil selection and higher processing, as well as the use of substances generic named additives, that replenishment the natural properties or created new others. Nowadays, for engines lubrication there are used high performance oils, with superior characteristics that ensure working in any conditions, at low maintenance costs. Once the internal ignition engines developed, lubricating oils have been imposed more and more severs conditions concerning their rational and long time exploitation, as well as the reduction of pollution.

Some of the new requirements are referring to the apparent viscosity at negative temperatures, dynamic viscosity at low temperatures,viscosity at high temperature and high shear rate, shear stability (in the case of multigrade oils), total base number, evaporation loses, compatibility with elastomers, the ash and phosphorus content. One of the most recent conditions imposed for silver bearings two stroke Diesel engines lubricants consist in limitation of zinc content at maximum 10 ppm, problem that represents the subject of the present work [5].

2. OIL FORMULATION

It is well known that commercial oils ,which are tcurrently manufactured and used for engine lubrication contains antioxidant additives - zinc Dialkyl Dithiophosphat or zinc Aryl Dithiophosphat types.

These additives imposed themselves in engine oil fabrication because of their great effect in resistance improvement against oxidation. Moreover, they confer to oils superior properties of antiwear and anticorrosion.

In the case of silver bearings engines, it was proved that zinc presence in lubrication oil determines a faster corrosion of bearings with undesired consequences. For this reason, there must be formulated oils with better properties of antioxidation, antiwear and anticorrosion and with a max. content of 10 ppm zinc. The oils containing more than 10 ppm zinc are considered to be contaminated in excess with zinc ditiophosphat or antioxidant additives that cannot ensure an adequate lubrication and long working life for silver bearings engines.

Besides the usual condition of limitation zinc content oil in the limitation of zinc content imposed to engine oil, for the new type of oil designated to silver bearings engine lubrication, the level of sulphur from fuel must be less than 0,5%. Therefore the oils alkaline reserve must be correlated in this case with the sulphur contained in fuel, knowing that a low base number can not diminish the corrosive wear, while a bigger value of this presumes a higher content of sulphated ash with undesired results in deposits. Taking into consideration laboratory results, it was formulated a lubricating oil that corresponds to the mentioned conditions. The new oil, zinc free, named Lubricerp D- 40 Super 5, has been made of a base paraffin component which containes antioxidant, antiwear, anticorrosion, detergent - dispersant, depressant, neutralising and antifoaming additives.

The chemical and physical characteristics presented in table 1, place the formulated engine oil in viscoclass S.A.E. 40.

The presented characteristics of the oil show the behaviour in some used conditions. For example, the pour point show the behaviour of the oil at low temperature; Total Base Number show maximum content of the sulphur in fuel.

All the specific characteristics of the oil are important, but not sufficient for rate its performance level .

Table 1: Analytical results of the formulated oil, Lubricerp D-40 Super 5 (CF-2)

Characteristics and tests	Results	Test Methods
Density at 20 °C, g/cm³	0,883	STAS 35
Kinematic viscosity at 100°C, mm²/s	14,88	ASTM D-445
Viscosity Index	95	ASTM D-2270
Pour Point, °C	-24	ASTM D-97
Flash Point, °C	250	ASTM D-92
Sulphated Ash, wt., %	1,47	ASTM D-874
Total Base Number, mgKOH/g	14,49	ASTM D-2896
Total Acid Number, mgKOH/g	0,37	ASTM D-664
Volatility Noack, %	3,4	DIN 51.581
Calcium Content, %	0,45	DIN 51.391
Molybdenum Content, ppm	8	STAS 1269
Nitrogen Content, ppm	70	ASTM D-5291
Foaming (tendency-stability), ml - Sequence I - Sequence II - Sequence III	 0 - 0 0 - 0 0 - 0	ASTM D -892
Copper Corrosion (3 hrs at 100 °C)	1a	ASTM D-130

Therefore, the behaviour of oil in the real engine will be rated only after the investigation on special stands in accordance with its performance level.

3. LABORATORY TESTS

The formulated oil was firstly tested on special laboratory stands, type Labeco L-38, Mercedes OM 616 and Caterpillar 1 M-PC, to evaluate the antioxidant, antiwear and detergent properties. These tests are required for all lubrication oils used by two-strokes Diesel engine, corresponding to“CF2" performance level in accordance with A.P.I. specification.

On Labeco L-38 stand (FTMS 791-3405) evaluates the oxidation stability, copper-lead bearing corrosion and vanish deposit-forming tendency of a crankcase lubricating oil. For the new formulated oil, we obtained the following results:

- Bearing weight loss, mg 7,80
- Viscosity increase at 40°C, % 6,25
- Piston skirt varnish, merit 9,80

The antiwear properties were tested on Mercedes OM 616 stand, in accordance with CEC L-17-A-78 method and were registered the following results:

- Cam wear, average, µm 18
- Cylinder wear, average, µm 10

The tests on Caterpillar 1M-PC stand, in accordance with STP 509 A method, determine the piston rings sticking effect of the oil, the wear and accumulation of deposits under high speed and supercharged conditions. For the tested oil we obtained the following results:

- Rings of piston condition free
- Groove no. 1 (top) carbon fill, vol. % 35
- Weighted total demerit 170
- Rings side clearance loss, µm 11,5

The laboratory results obtained situates the oil at performance level ”CF- 2” in accordance with A.P.I

4. FIELD TESTS

The formulated oil for two strokes Diesel engine with silver-plated bearings had to be tested in real working conditions. For this reason, we chose two strokes Diesel engine type 8 - 710 G3 made by General Motors from USA, mounted on a locomotive.

The Lubricerp D - 40 Super 5 oil was produced in an industrial installation and then tested along 250.000 km route in normal working conditions.

The evaluation of oil’s behaviour in those engines has been done by periodical analyses and final examination of the cleanliness of the pistons, piston rings, and cylinders of the engine assembly.

By periodical analysing of the samples from engine’s carters we evaluated the degree of oil’s degrading

In laboratory we analysed the samples elevated after each 50.000 km to show the modifications concerning viscosity at 40 °C and 100 °C, the inflammation point, total acid number, total base number, water content, undisolved in organic solvents - in heptanes and in heptanes with coagulant.

Analytic results obtained for oil are presented in table 2.

Table 2: Analytic results of Lubricerp D-40 Super 5 recorded at different period of work in real conditions of service.

Characteristics and tests	Fresh oil	Used oil, km					Admissible limits	Methods of analysis
		50.000	100.000	150.000	200.000	250.000		
Kinematic viscosity at 40°C, mm²/s, %	161,5	161,5	143,5	170,1	187,5	195,4	+/-25	ASTM D-445
Kinematic viscosity at 100 °C, mm²/s, %	14,88	15,21	13,34	15,99	16,04	16,21	+/-20	ASTM D-445
Flash Point (COC), °C	250	250	238	250	244	242	min. 195	ASTM D-92
Total Base Number, mgKOH/g	14,49	14,43	15,83	11,40	13,98	13,64	min. 7,25	ASTM D-289
Total Acid Number, mgKOH/g	0,37	1,78	2,20	2,54	2,74	2,54	max. 3,5	ASTM D-664
Insoluble in heptanes, %	-	0,0 2	0,03	0,38	0,32	0,34	max. 2	STAS 10.632 I, II
Insoluble in heptanes with coagulant, %	-	0,43	0,36	0,85	0,72	0,84	max. 3,0	
Water content in oil, %	-	trace	trace	trace	trace	0,05	max. 0,5	STAS 28-88

By comparing the oil characteristics on route with fresh oil,we bserved the following changes :

- Viscosity and inflammation point of oil varied as a result of it accidental contamination with fuel ;

- Total acid number increased gradually as a result of oxidation and accumulation of some acid products in oil ;

- Total base number decreased as a result of neutralization of acid products accumulated in oil ;

-Partial insoluble, determined inheptanes, registered very low values in comparison with admissible maximum limit ;

- Total insoluble, determined in heptanes with coagulant, have higher values, but smaller than admissible limit.

Oil's characteristics have been slightly modified along the 250.000 km route in comparison with maximum admissible limits established by engines manufacturer.

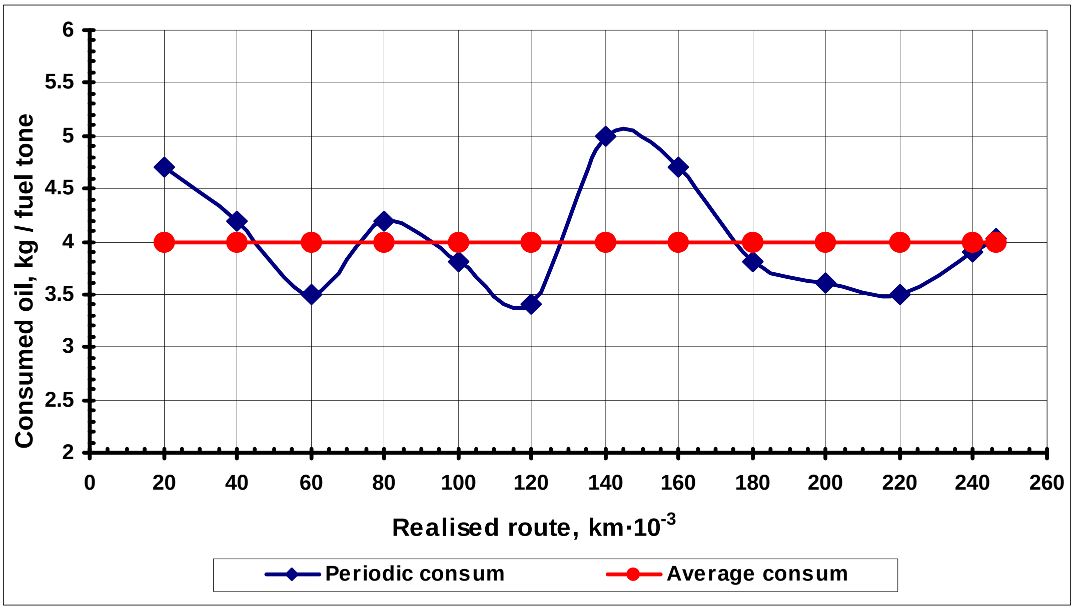
Similar results have been obtained concerning engines cleanliness especially for piston, piston rings assembly, evaluated at the end of testing period.

During testing, the oil was not discharged from engine's carter, but only completed in order to maintain the right level. The amount of oil consumed during the test for the necessary completion is graphic represented in figure 1, (function of the realised route and consumed fuel).

The completion of oil during the test has been made at each 20.000 km route, using amounts between 3,4 - 5,1 kg for every consumed fuel tone. So, media consumption of burned oil represented 4,03 kg per tone of consumed fuel in comparison with maximum 5 kg - recommended by engine's manufacturer

On the basis of these results, it was decided the service oil drain interval at 200 000 - 250 000 km.

Fig. 1: *Oil consumed during the test*



5. CONCLUSSIONS

∢ The chemical and physical characteristics place the new zinc free engine oil, named Lubricerp D - 40 Super 5 in viscoclass S.A.E. 40;

∢ The laboratory results on engine test stands situate the oil at performance level "CF-2" in accordance with A.P.I.

∢ The Lubricerp D - 40 Super 5 oil was produced in industrial installation and then tested in normal working conditions.

∢ Oil's characteristics have been slightly modified along the 250.000 km route in comparison with admissible limits established by engines manufacturer.

∢ Media consumption of burned oil represented 4,03 kg per tone of consumed fuel in comparison with maximum 5 kg - recommended by engine's manufacturer.

∢ On the basis of the obtain results, it was decided the service oil drain interval at 200 000 - 250 000 km.

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