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1 Title : A STUDY OF TRUCKS ENGINE FAILURE RELATED TO

2 ENVIRONMENTAL CONDITIONS

3 Col.M.Sc (Eng) M.F. Hussein Youssef*

4 ABSTRACT On operating new trucks in one of the areas of the Egyptian western desert, unexpected fast engine failure occured. Although the technical maintenance to these trucks, was regularly done, the engine failure took place after covering 26000 Km only. In the meantime, no similar failures of trucks operating in other zones have been reported. Therefore, the main reason that led to the engine failure was attributed to the environmental conditions characterised by high dust concentration and relatively high temperature.

After reviewing the air and oil filteration systems of the damaged engine and making the necessary inspection and measurements it could be said that the failure occured mainly due to inefficient oil filteration.

A new oil filter, designed by the manufacturer, and the old one have been tested by a special testing rig that has been designed and constructed by the author.

Tests on the old and new filters showed that the new one has considerably better performance. In addition, a new engine having the redesigned oil filter has been tested on an engine dynamometer for 400 hours. During engine testing, a contaminat dust was added to the oil sump to simulate the actual working conditions, the test results showed no drop in oil pressure and no excessive engine noise which proved the suitability of redesigned oil filter.

* Leader of automobile department, Lecturer of Automobile theory, Technical Institute of Armed Forces, Cairo, Egypt.

SUMMARY-Upon uitilization of new trucks, in dusty zones, of Egypt, unexpected failure of some engines occured after covering a relatively short distance. In the mean time, no failures in simillar engines operating in other zones have been recorded The main reason of the failure was attributed to the environmental field conditions characterized by high dust concentration and relatively high temperature. The engine failure was manifested by a high drop in the oil pressure and a noizy engine run.

After reviewing the air and oil filteration systems of a one damaged engine, and making the necessary inspection, it could be said that the failure reason is the inefficient oil filteration.

A new oil filter had to be designed by the engine manufacturer. The old and the new filters have been tested on a special testing rig designed and conducted by the author. The test rig enabled to evaluate the oil filter performance under simulated local environmental conditions.

To determine the actual performance of the new filter, a similar engine provided with the new filter has been tested. The test results showed no drop in the oil pressure, and no excessive engine noize. This results proved the efficiency of the new filter under dusty conditions of Egypt.

INTRODUCTION

Lubricating oil is essential to the internal combustion engine. It cools, cleans, seals, and lubricates the engine, Clean oil performs these jobs much better than contaiminated. Therefore the engine should be continuosly cleaned from impurities.

Two types of the oil filteration systems are used in engine lubrication. The first type is the full-flow filteration, in which all the outlet oil fully passes through the filter. The second type is the partial flow filteration system having two elements, coarse and fine filters, the total amount of the oil passes through the course filter and a small quantity of oil (10% approximately) goes though the fine filter. A by-pass valve allows full oil flow in cases of cold oil and filter clogging. Thus the engine mainline would have unfiltered oil and by this ensures the protection of engine bearing.

DESCRIPTION OF THE PROBLEM OF ENGINE FAILURE

A new type of trucks had to work in a dusty area in Egypt. A sudden failure occured in the engines after covering a distance ranged from 2000-26000 Km, which is really too short distance. The main features of the environmental conditions in this area are, relativly high temperature (35 - 45 °C), high dust concentration over the year (0,004 - 0,008 gm/m^3). The dust is fine and contains a higher percentage of clay. It due time advised by manufacturer. The engine complete failure was proceeded by a drop in engine oil pressure and noisy engine run. The values of oil pressure in the damaged engines and the recommended value for overhaul engine repair are given in tables (1),(2).

Engine No	Covered distance (TH.KM)	Oil pressure in main line 600 r.p.m	2800 r.p.m.	approx, engine life in hr (50 km=1 hr)
1	26 638	0.0	2.0	520.0
2	25 297	0.2	3.0	500.0
3	23 131	0.0	3.0	462.6
4	19 514	0.5	2.5	390.00
5	4 756	0.5	2.5	96.00
6	3 729	0.4	2.0	74.60
7	2 421	0.2	3.5	48.00

Table (1) Main data of the damaged engines "in-service" data.

Engine Speed	600 r.p.m.	2800 r.p.m.
Oil pressure in the main line	0,5 (kp/cm^2)	2,5 (kg/cm^2)

Table (2) Factory recommendation for overhaul engine repair according to oil pressure in the main line.

DIAGNOSTIC INSPECTION AND MEASUREMENT OF THE DAMAGED ENGINE

To determine the character and nature of the failure in the engine, the following inspection and measurements were carried out :

1- Analysis of a sample of the used oil of the damaged engine according to ASTM standards, so as to find out the insolubles in normal pentane.
2- Visual inspection of the air cleaner filtering element to determine its technical condition.
3- Determination of the grain size distribution of the dust sample.
4- Visual inspection of the oil filter and measuring the mesh size of the coarse element. Also determination of the main technical specifications.
5- Disassembly of the engine so as to determine the technical conditions of the crank mechanism components by visual inspection of the crank journals and pins.
6- Determination of the wear in the damaged parts by measuring the oil clearance.

RESULTS OF INSPECTION AND MEASURMENTS OF DAMAGED ENG.

Analysis of the used oil sample showed the existance of a considerable percentage of insoluables in normal pentane. Most of the insoluables are dust of fine grain size as table (3) shows. The air cleaner has retained sand particles in the metal case around the filtering element. Fine particles were also found in the cylinder head internal surface.

The grain size distribution curve of the dust samples shown in Fig (1), which indicates a higher percentage of silt, fine silt and clay. Visual inspection of the crank shaft journals, pins, and the bearings showed deep scratches and severe wear as Fig (2) shows.

The measured oil clearance between bearings, and journals, and the maximum allowable are shown in Fig (3) .

The measured oil clearance between shaft pins and breaings is presented in Fig (4). The clearance value has a maximum of 145 microns and that permissible is 95 microns.

It is worthy to mention that the damaged engine had run 96 hours only and the minimum engine service life under the most severe conditions is more than 2000 hr. The oil clearance in crank shaft journals, pins, and bearings were measured by plastic ganges adirsed by the engine manufacturer.

Kinamatic viscosity at 38 °C (100 F)	105,84 CST
Kinamatic viscosity at 00 °C (210 F)	11,197 CST
Viscosity index	100, %
Neutralization Number of the oil	0,48 KoH/1 gm
Carbon residue contadson	1,06 %
Sulphated Ash	0,75 %
Insoluable in n-pentane	0,51
Wear/Cupper sheet at 100 °C for 3 hr	1-B
Acides, Alkalines, soluable in water	---

Table (3) Results of analysis of the used oil of the damaged engine.

The insoluables in normal pentane has been investigated, and found that the nature of the contaminant is a true dust.

DESCRIPTION OF OLD and NEW OIL FILTERATION SYSTEMS.

The partial flow lubricating system of the damaged engine is shown in Fig (5),and Fig (6). shows a section in the old filter. It consists of two filtering elements, the outer element is the coarse, it is built of metalic screen filter of mesh size of 84 microns. The inner is the fine, it made of a dense media of a retention size of 20 microns. The by-pass valve of the filter opens at a pressure difference between inlet and outlet of 1,96 bar.

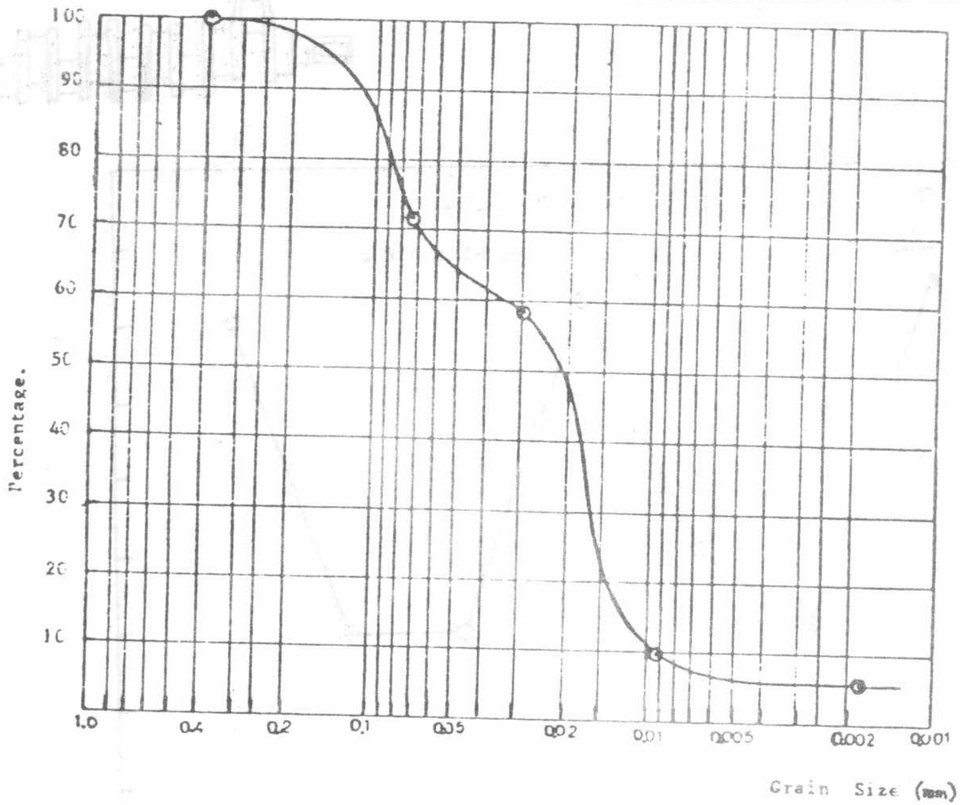
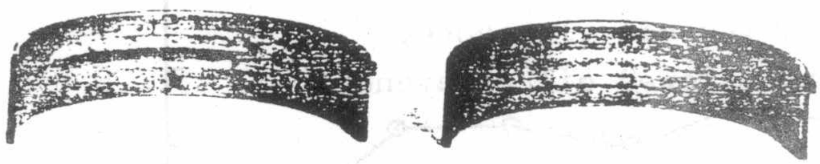


Fig.(I),Gradation curve of the dust sample collected from the dusty area.



Figure(2a).

Figure(2b).

Fig.(2a),Crank pin&bearing of the damaged engine in field.

Fig.(2b),Crank journal&bearing of the damaged engi

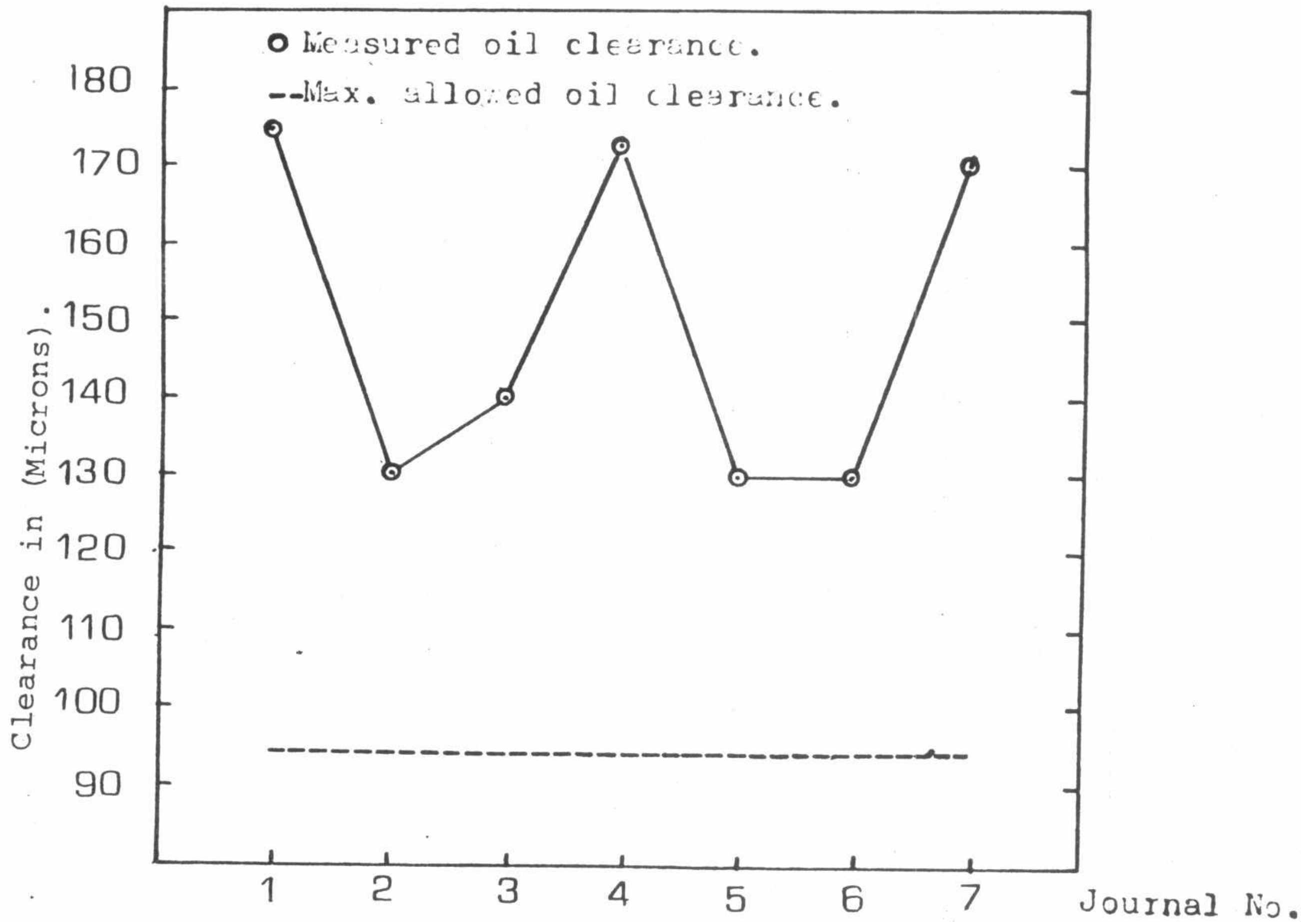


Fig. (3) ,Oil clearance between journals & bearings.

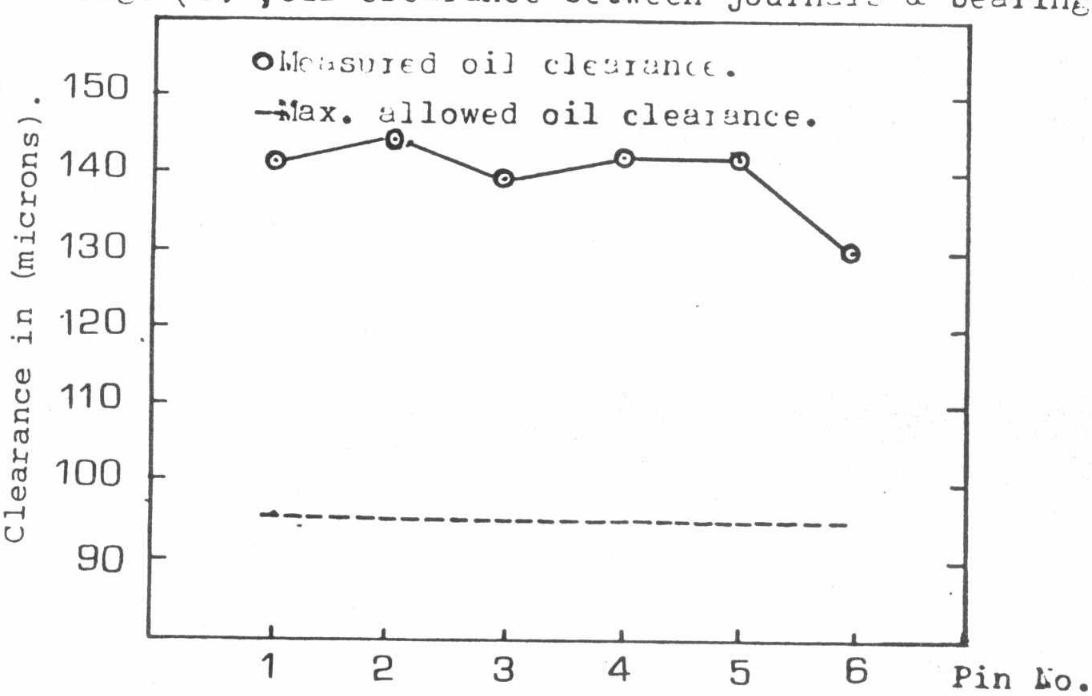


Fig. (4) ,Oil clearance between pins & bearings.

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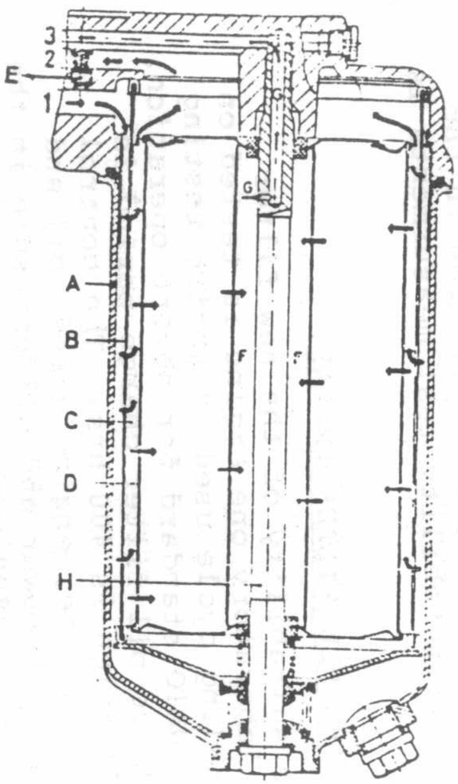

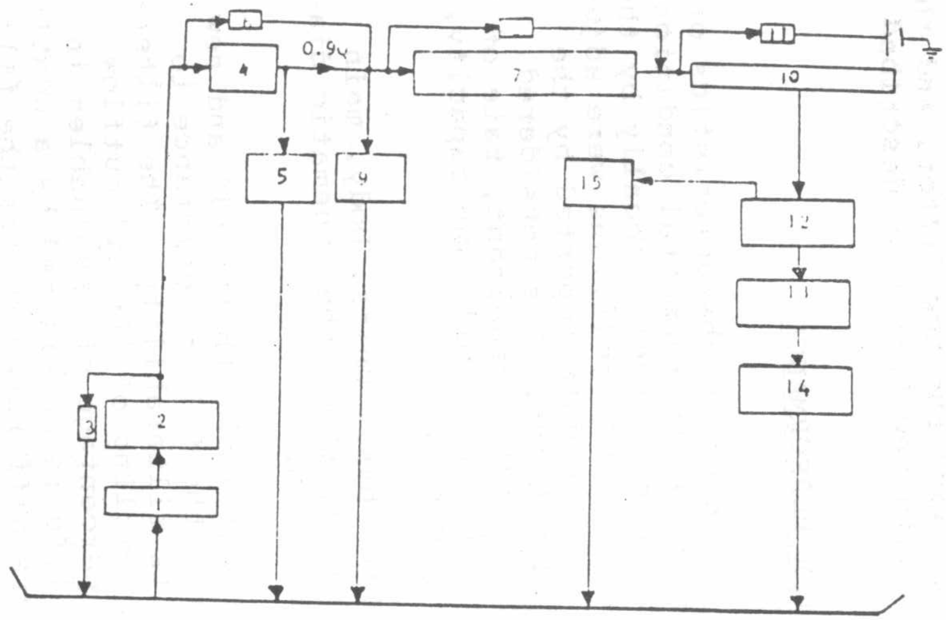

Fig. (5) Lubrication system of the damaged engine.

1 = Oil screen
2 = Oil pump
3 = Oil pump relieve valve
4 = Oil filter -coarse
5 = Oil filter - fine
6 = Oil filter by pass valve.
7 = Oil cooler
8 = Oil cooler by pass valve.
9 = injection pump.
10= main line.
11= oil pressure gauge
12= Crank shaft bearings
13= Cam shaft bearings.
14= Rocker arms.
15= Air compressor.

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(6) Cross section in original filter

1=oil outlet from oil pump to filter
2=oil outlet from coarse filter element
3=oil out let from fine filter element
A=oil filter housing
B=Coarse filter element.
C=filtered oil.
D=fine filter elemnt.

the old. It is a full flow folded shape filter with particle retention of 20 microns. It has a by-pass valve similar to that of the old filter. Fig (7), shows the new filter, and the lubricating system of the engine with new filter as described in Fig (8).

TEST RIG FOR OIL FILTER PERFORMANCE EVALUATION

In order to get the basic performance characteristics of the old and new oil filter under local environmental conditions, a new test rig has been designed and constructed locally by the author. Testing procedure, materials and conditions were adjusted according to the real in - service data reported by the users based on the actual field conditions. The considered test conditions include structure of the contaminant, rate of contaminant addition, oil test temperature, oil sump capacity, rate of oil flow, test period, and cycle.

The test rig consists of three basic units, body, main system, and measuring system. Fig (9), shows the schematic diagram of the rig and its main aggregates.

Two main tests were carried out for both the old and new filters. The first test determines the filter resistance to flow, and the second determines its filterability. The filterability test depends on periodic sampling of the oil outflow from the filter to determine the percentage of insoluables in normal pentane. The oil filter life is determined by a continiuous recording of the oil pressure difference across the filter with testing time. The filter life is the time period from starting of the filterability test till the moment of reaching the maximum pressure difference across the tested filter as Fig (10) shows.

The resistance to flow results of the old and new filters are shown in Fig (11). The contaminant concentration in the test rig oil sump during the filterability test measurments is shown in Fig (12).

RESULTS OF TESTING THE NEW FILTER IN LAB.

In order to check the suitability of the new filter under severe conditions in laboratory one engine is tested on engine dynamometer. The loading cycle used in engine testing is the same as specified by NATO standard for severe operation. The test oil is SAE 40, and the oil filter change period is 20 hours. The test cycle duration is 400 hrs. The control parameters during engine looding are, engine speed, oil and water temperature, engine out put power and oil pressure in the mainline at engine speeds of 600, 2800 rpms.

The test results obtained showed no up normal increase in oil or coolant temperatu...

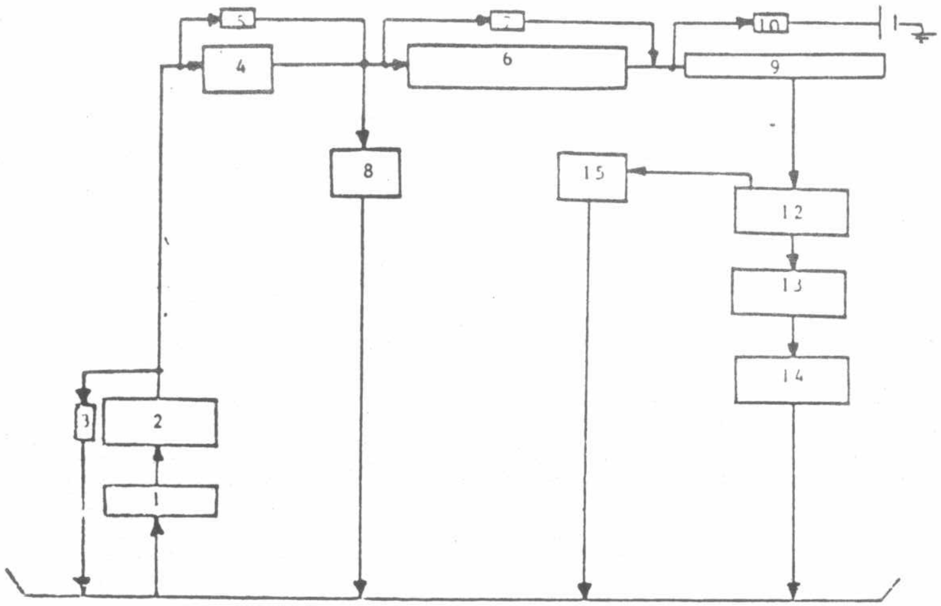
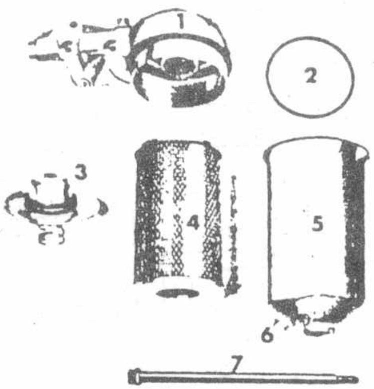


Fig. (8) Lubrication system of the new engine with modified oil filter.

1=Oil screen.
2=Oil pump.
3=oil pump relieve valve.
4=Oil filter full-flow type.
5=Oil filter by pass valve.
6=Oil cooler .
7=Oil cooler by pass valve.
8=Injection pump.
9=main line .
10=Oil pressure gauge.
11=Battary.
12=Crank shaft bearings;
13=Cam shaft bearings.
14=Rocker arms.
15=Air compressor.



Fig(7), The new oil filter.

1 = Oil filter holder.
2 = Seal ring.
3 = Spring plate.
4 = Full-flow filter.
5 = Filter Casing.
6 = Drain plug.
7 = Centre bolt.

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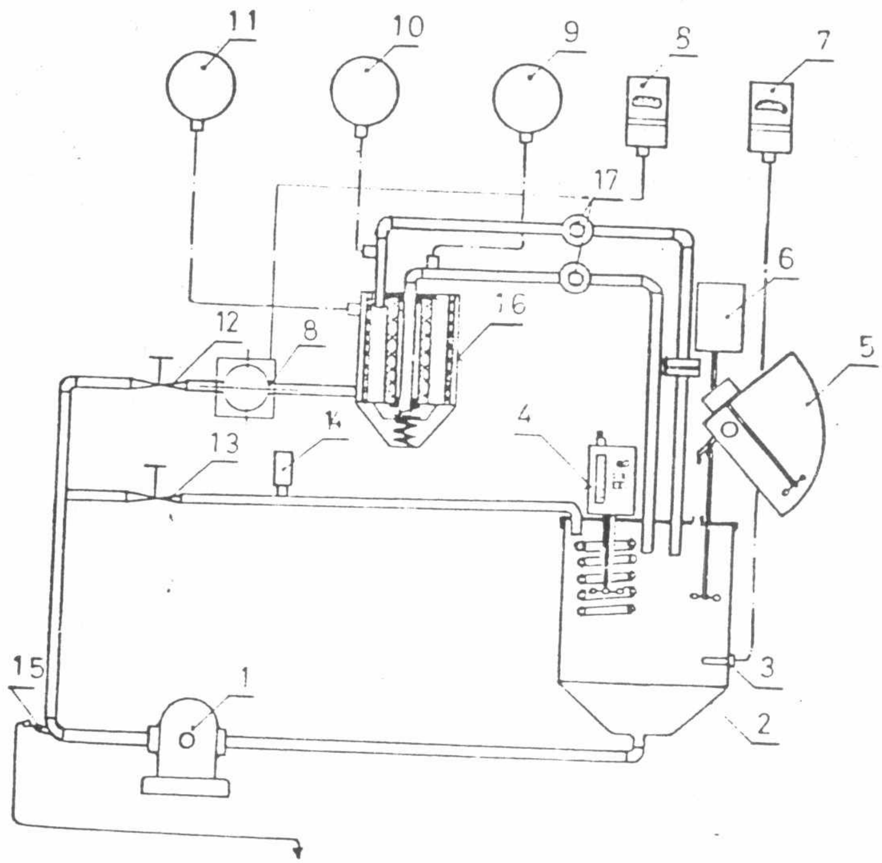
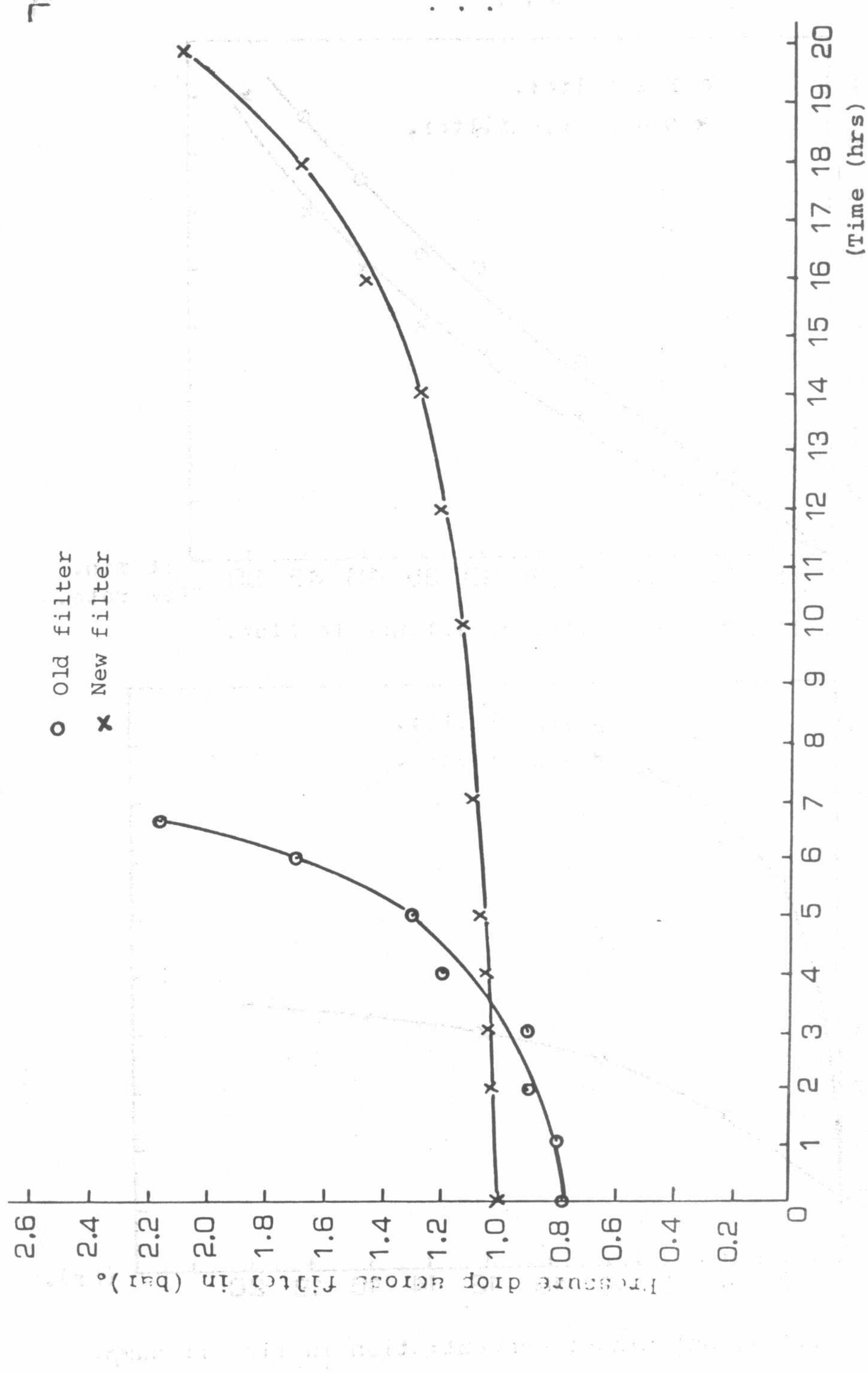


Fig.(9). The test rig scheme.

1.Main pump.
2.Oil sump.
3.Temperature bulb.
4.Thermostirrer.
5.Contaminant addition unit.
6.Stirrer.
7.Temperature controller.
8.Flow controller.
9,10,11, Pressure meter.
12,13 Cock.
14,High pressure relief valve.
15.Drain cock.
16.Test filter.
17.Sampling port.



Rig (10): The pressure differential across the tested filters during filterability test.

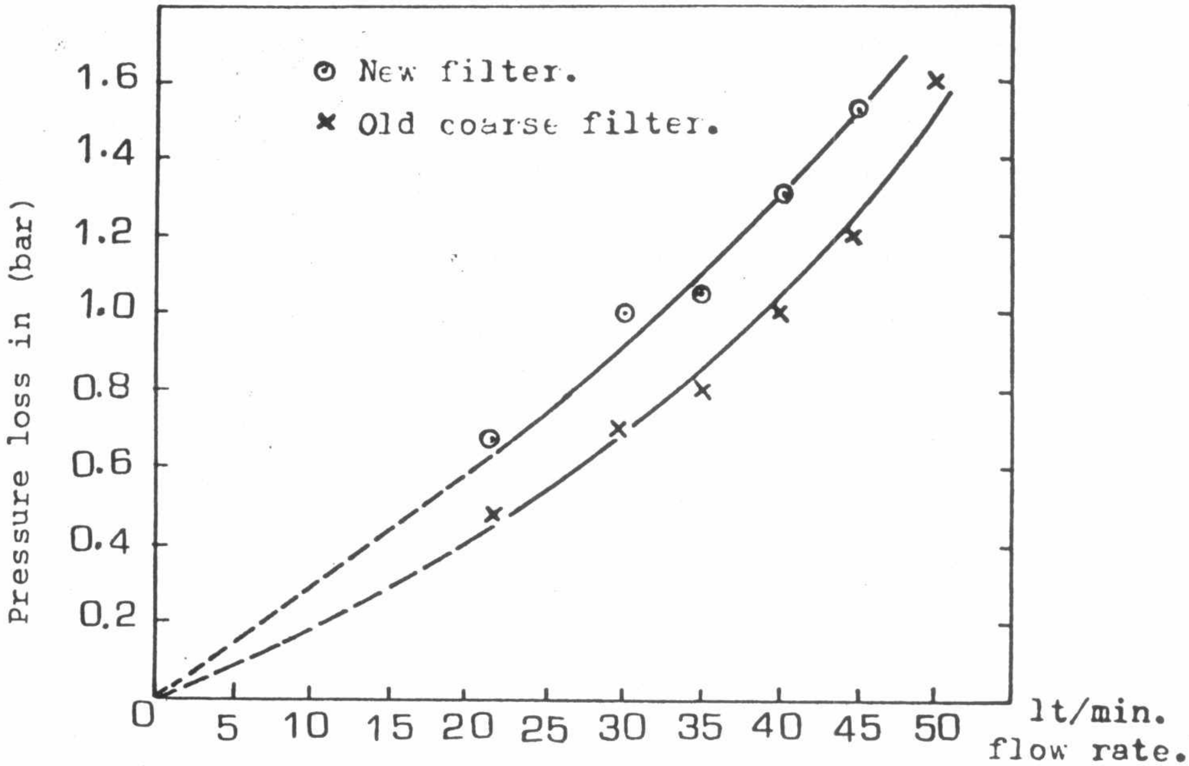


Fig.(II),The oil filter resistance to flow.

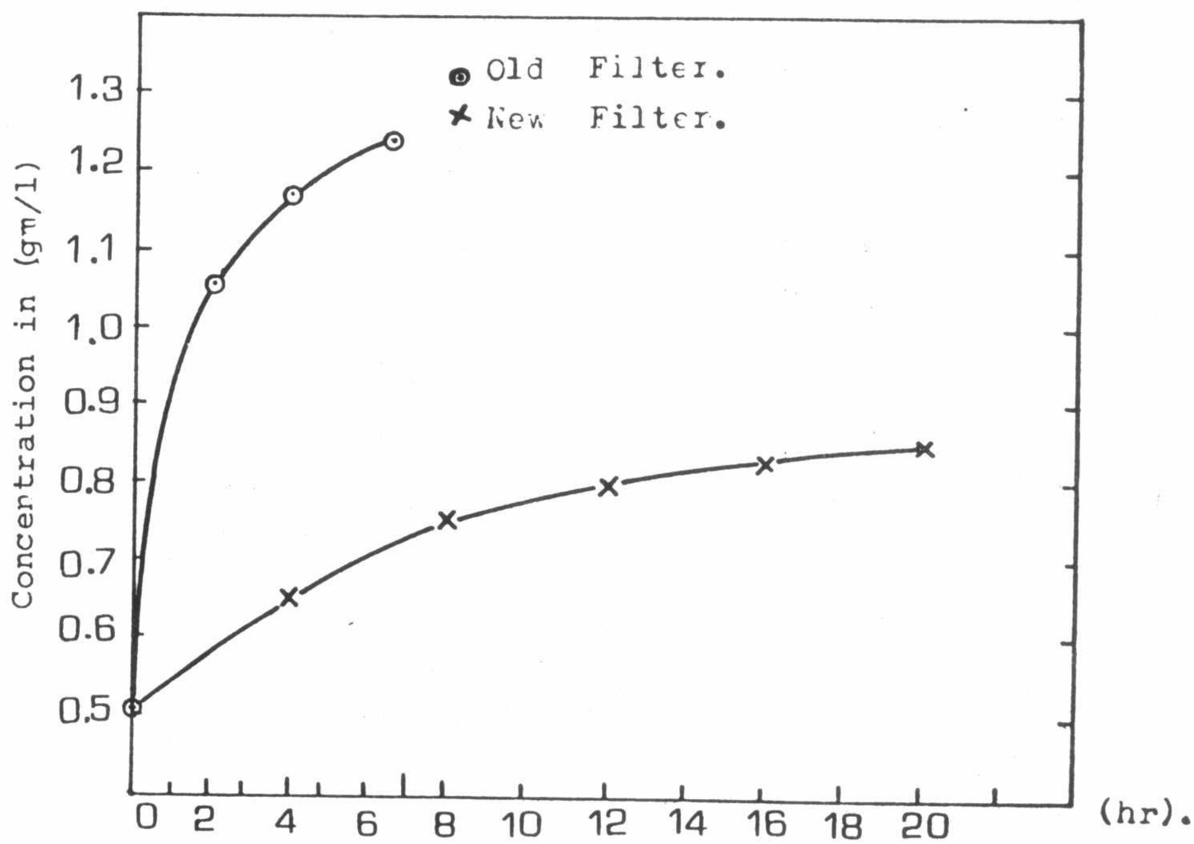


Fig.(I2),Contaminant concentration in rig oil sump.

values at the end of the cycle are 2,4 bar at 600 rpm, and 3.2 bar at 2800 rpm. These values lie in the range given by the manufacturer. The total added amount of dust in the whole period of testing was 2000 gm. The engine had passed the lading cycle without any failure or excessive engine noise. At the end of the test, the engine was disassembled, and the oil film thickness between crankshaft journals, pins, and bearings has been obtained in order to check the wear in these parts. Results of measurments are shown in Fig (13), and Fig (14). The measured values of oil clearance are in the recommended range by the manufacturer.

CONCLUSION

Regarding the aforementioned experimental results and investigations, the following conclusions can be drawn;

a- Inefficient engine oil filteration is one of the main factors that influences the wear of crankshaft parts and cause rapid engine failure.

b- The oil filter duration can be considered as a function of the environmental conditions, and is determined by the maximum pressure difference across the tested oil filter.

c- Oil filter having coarse and fine filtering elements has shown lower filterability if compared with the full flow filter of folded shape and having surface to volume ratio aproximately equals 10.0.

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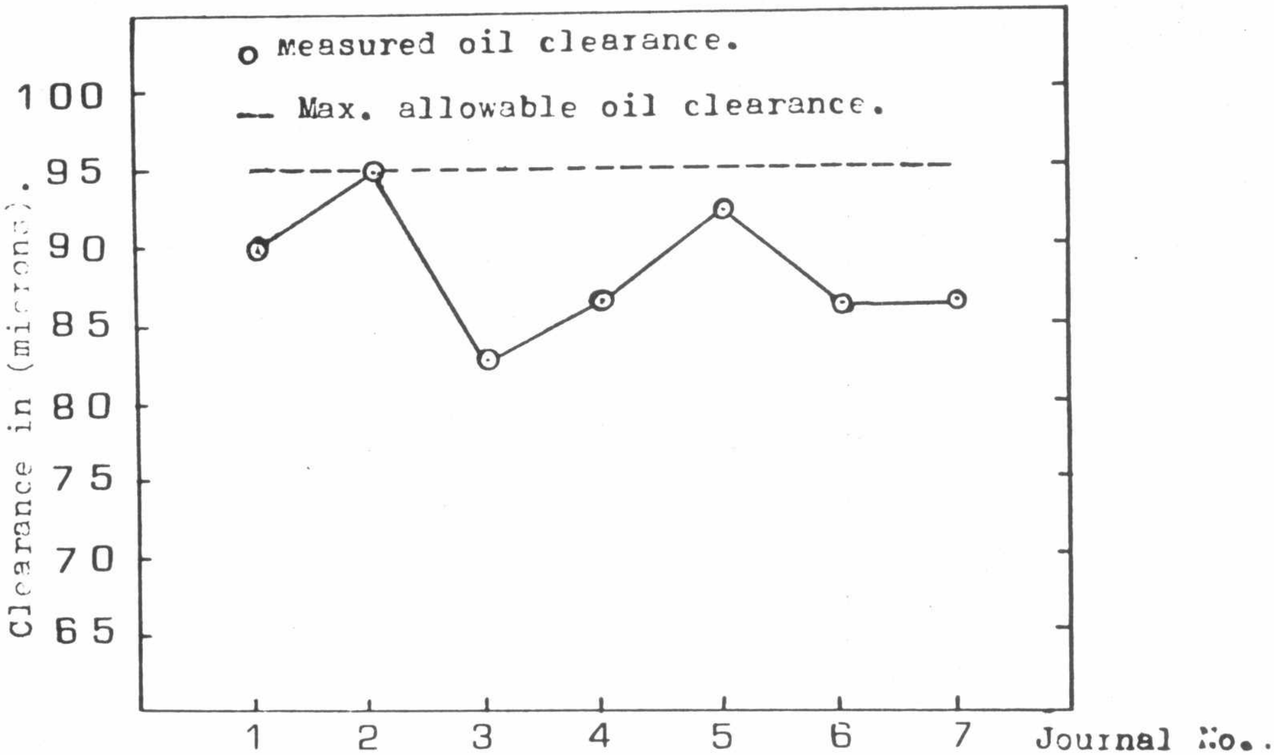

Fig.(13), Oil clearance between journal&bearings

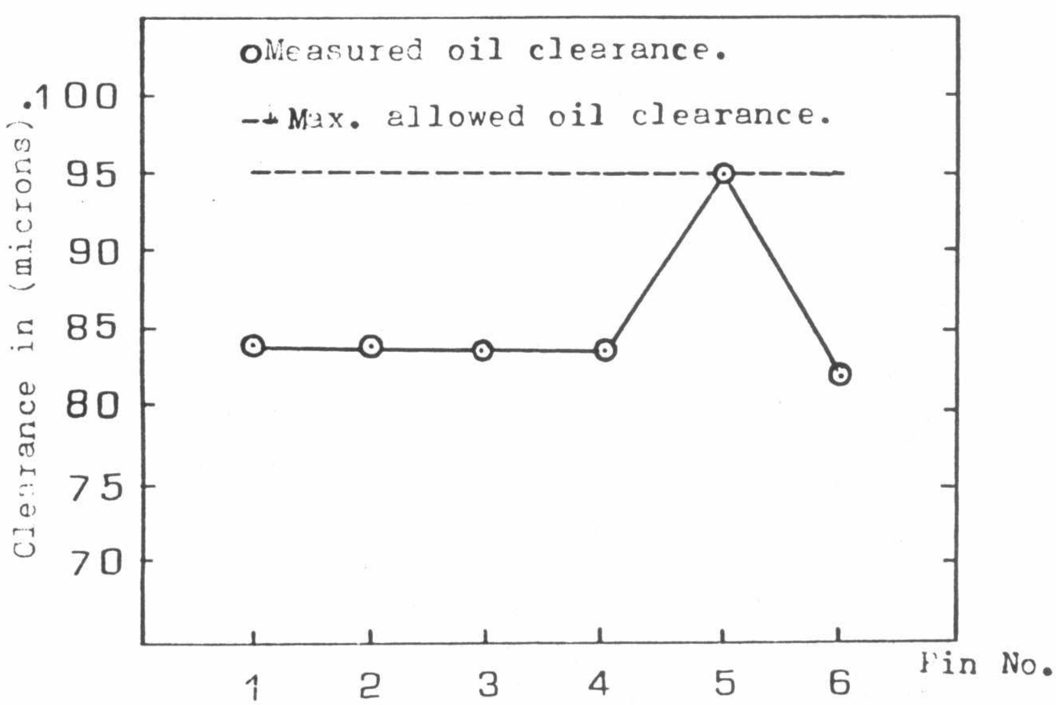

Fig.(14), Oil clearance between pins & bearings

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