THE INFLUENCE OF LUBRICATION OILS AND FILTERS ON THE OILS PRESSURE, TEMPERATURES AND FLOW DURING ENGINE WARM-UP AT SUMMER CONDITION

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Abstract: *The key issue to an automotive engine's reliability and its durability is the quality of the lubrication system. The primary task of the lubrication system is to provide a continuous supply of filtered oil between two sliding surfaces. By using adequate lubrication oils will reducing friction between moving mechanical parts. Rheological characteristics of lubricating oil directly caused the friction losses due to internal engines mechanisms (piston group, valve train, fuel pump, crankshaft, bearings and seals, etc.). The main components of lubrication system has a poor lubrication during cold start up process of an IC diesel engine and thus is necessary a proper lubricating oil to full fit the complex demands of all engine components and subassemblies. The aim of this paper is experimental investigating of the influence for different classes lubricating oils characteristics and oil filters which are present in market of Republic of Kosovo, especially those with lower prices on engine oil pressure, temperature and flow during start up until the oil warms up some. The obtained results are taken from measuring device which is installed into Fiat passenger car with Spark Ignition Engine for different working regimes.*

Keywords: LUBRICATION OILS, OIL FILTER, PRESSURE, FLOW RATE, TEMPERATURE, SPARK ENGINE, PUMPS

1. Introduction

The adequate lubrication of engine parts is critical for the engine durability, and insufficient oil supply to the various friction areas might result in catastrophic engine failure. The oil provides a separation of the surfaces in motion and carries away heat generated by contact resistance.

Most automotive engines have a pressurized oil lubrication system which draws oil from a sump and delivers it to the various engine components. The capability of the oil pump to transport oil within the engine depends on the surrounding temperature, rheological properties of oil, as well as the geometry of the passages. When the environment temperatures are low, the presence of oil between friction surfaces may be significantly delayed, especially during the engine start-up.

From the literature review, authors have shown grown interest in investigation of the influences of the engine lubrication system on the overall performance of an engine. The focus has been in study of the influence of oil condition on; engine durability, reduction of wear, friction losses, and most recently, engine emissions.

Author Hayashi [2] has investigated the effects of various engine operating conditions on the engine oil temperature. Oil temperatures were monitored for various engine speeds, loads, and oil feed pressures. The results of these tests showed that the rise in oil temperature was more greatly influenced by higher engine speeds than by an increase in load. Hayashi found that the oil pressure had little effect on the lubricating oil temperature rise. However, it was noted that it was essential to maintain a minimum oil supply pressure to the bearings, as a rapid increase in the bearing metal temperature occurred with inadequate lubrication at low supply pressures.

Similar results were found by authors Andrews, G. E. et al.[1], whose work concentrated on Spark Ignition engine warm-up and the influences of water and oils temperatures on engine emissions.

Authors Seth and Field [5], made an attempt to increase the understanding of the behaviour of the lubrication system of a Ford, four cylinder, petrol engine. The lubrication system was instrumented throughout with pressure sensors. The objective of this study was not to enhance the design process of an engine but to provide a method of detecting lubrication related abnormalities in an existing engine.

Author Kyto [3], conducted a comprehensive series of motored engine tests on two petrol engines under cold start-up conditions. Oil pressures, oil temperatures, and engine torque were recorded for 12 different oils. The purpose of the tests was to establish the most suitable oil for cold start conditions, rather than the analysis of the oil properties within the lubrication system. There were however some interesting observations:

- An oil pressure transducer was installed in each engine on the most remote lubrication point on the camshaft bearing. The results showed that it could take a large amount of time for the oil pressure to rise at this point, using some types of oils in cold ambient temperatures. For a typical 10W40 class mineral oil, for example, the maximum pressure was reached at +20°C in 23 seconds, while it took 192 seconds at -30°C. This was primarily due to the oils much higher viscosity at low temperatures, resulting in large pumping losses through the lubrication system.
- The torque required to motor the engine at 150 rpm increased from 60 Nm at +20°C, to 125 Nm at -30°C.

Author Tran et al [6], conducted a similar investigation to that of Kyto, but placed the emphasis of their work on the analysis of friction throughout the engine. The friction torque of each engine component was found by dismantling the engine down to the crankshaft and conducting motored tests at various stages of engine rebuild.

The effects on the overall torque were measured. Again, the results showed that, generally, the lower the oil viscosity, the lower the frictional torque. However, it was found to be the inverse in the case of the valve system. It was suggested that the friction losses would be minimized if the valve system were supplied with greater oil feed rate (3-4 l/min) than the crankshaft bearings (1-2 l/min).

Authors Kaplan and Heywood developed a model which predicted the mean temperature of the major components' of an engine during the warm-up process. In this case the 'major components' were; piston, head, block, oil reservoir, and the coolant reservoirs in the head, block and radiator. The model was simplified to one-dimensional heat flow, and a lumped thermal capacitance was used for each component.

The limitation of this approach, with respect to the present study, was the method of accounting for the heat transfer to the oil. The heat transfer paths to the oil were; convection on the under-side of the piston; convection on the head and thermal energy generated by the pump and crankshaft. Although the approach taken was suitable for the calculation of the temperature trends of the major components, the model was not capable of detailed temperature analysis.

2. Methodology for determining lubrication parameters

Parameters of lubrication system are determined by experimental way in a passenger vehicle by spark ignition engine, manufactured by *Fiat*, model *Tipo* with engine displacement of 1.4 l (power is 57 kW at the engine speed of the 6000 rpm, torque 108 Nm at the engine speed 2900 rpm, produced in 1992 year, Fig. 1.

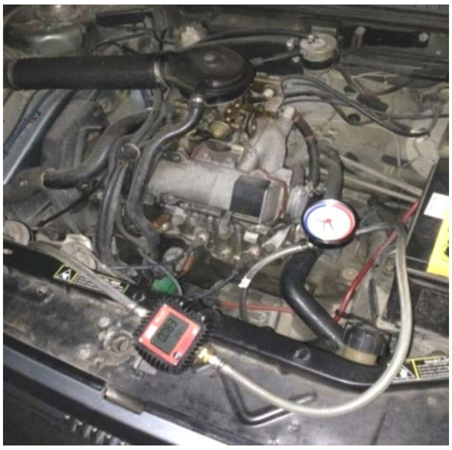

***Fig. 1.** Performing experiment in Fiat Tipo by installing measuring device*

In order to perform measurement is produced an adapter piece from PVC. That adapter is fixing in particular locations of lubrication circuit between oil pump outlet and inlet oil filter, Figure 2.

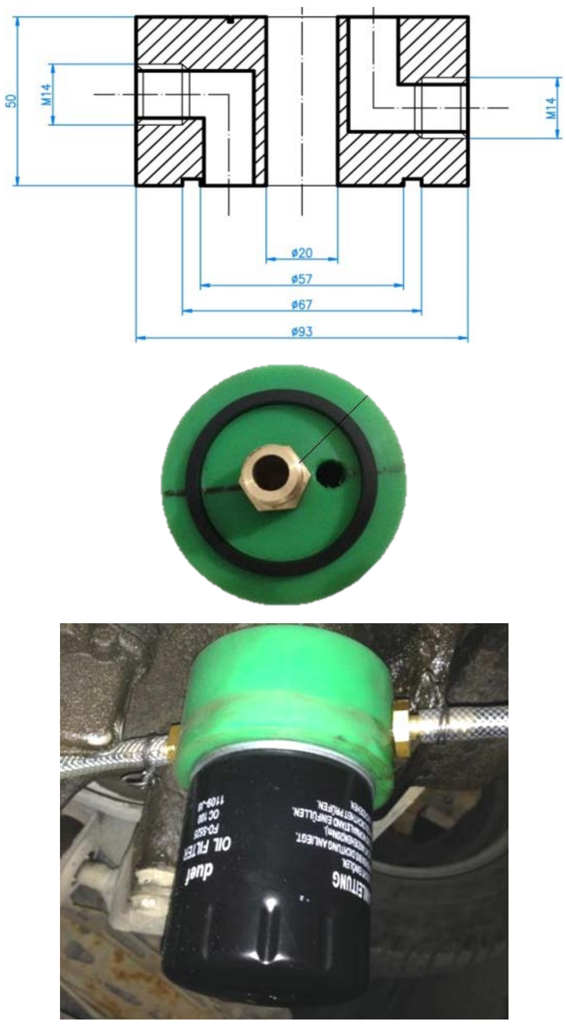

***Fig. 2.** Adapter piece with cross-section view for fixing oil filter*

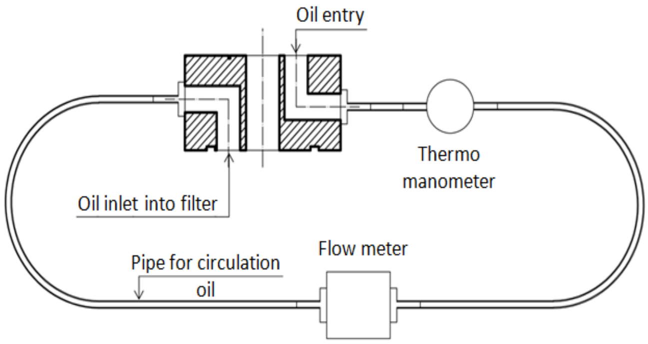

***Fig. 3.** Connection scheme for measuring performance lubrication system*

Oil pump takes oil from sump through strainer, the suction oil delivered through respective pipe which passes in the hole of adapter (inlet of oil). In the hole of the adapter is open metric screw M14 which serves to place the bolt that connects the oil pipe. Oil pipe allows the oil to flow through outer pipe of pump into inlet of the oil filter. In the oil pipe are integrated thermo manometer for measurement of temperature and pressure and oil flow meter to measure the amount of circulating oil (flow).

For measuring number of rotation of engine, is used device installed in board of vehicle, Figure 4.

***Fig. 4.** On board of vehicle of Fiat Tipo*

3. *Measuring Results*

Measuring parameters of the lubrication system such as: temperature, pressure and flow rate circulation of oil in vehicle engine are done for several working regime as well as for different type of oils and filters for spark ignition engine.

Woking regimes are: 850 rpm and 2000 rpm of engine. Type of used oil during performing experiment are presented in Tab. 1.

***Table 1:** Technical data of used oil for experiment*

	Measuring unit	Properties data according producers			According standard
		FAM/ *Fenix Bm Extra*	FAM/*Sint*	*Dianra Oil*	
Density at 15 °C	g/ml	0.88	0.865	0.88	EN ISO 3675
Kinematic viscosity at 40 °C	mm^2/s	98	82	/	ISO 3104
Kinematic viscosity at 100 °C	mm^2/s	14	13	14 – 14.5	ISO 3104
Viscosity index	-	146	159	145	ISO 2909
Flash point	°C	220	230	220	EN ISO 2592
Pour point	°C	- 33	<-45	-35	ISO 3016
TBN	MgKoH/g	10.0	16.0	8	ISO 3771

Used filters during experimental measurement are shown in Table 2.

Table 2: *Technical data of used oil filter for experiment*

Producer of filter	
DUEF	DAG
Outside diameter: 76 mm Inside diameter 1: 62 mm Inside diameter 2: 71mm Length: 89 mm Connection screw: M 20x1.5 	Outside diameter: 77 mm Inside diameter 1: 59 mm Inside diameter 2: 68 mm Length: 50 mm Connection screw: M 20x1.5 

4. *Discussion of Results*

In order to implement an appropriate analysis of parameters for lubricating system that are studied, further are presented in graphical form the influence of oils and oil filters of different producers for work regimes: 850 rpm and 2000 rpm.

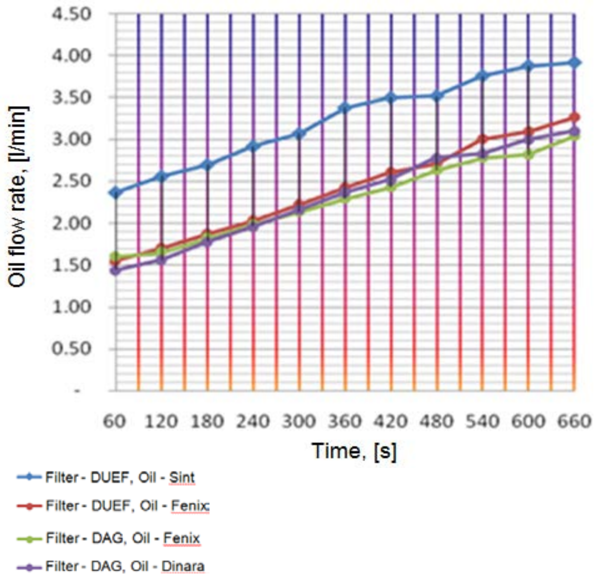

Fig. 5. *Oil flow rate vs time for 850 rpm*

Based on fig.5, the curve in blue color is the result of 11 measurements with used oil in a vehicle that has more than 3500 km driven. This is from the produces *Sint* SAE 10W-40, and new oil filter *Duef*. It can be noticed that in the first minutes of engine work, flow of oil in engine is 2.37 l/min, and in the 11th minute of oil flow, it is 3.92 l/min. As a conclusion, there is an increase of 65.5%.

From the same diagram, Fig.5, can be noticed that other curves (red color, green color, purple color) that has to do with oils and filters of *DAG* producer, the flow has little difference. In the first minute of engine work, the flow is about 1.5 *l/min*, and in 11th minute, oil flow is 3.0 *l/min*. There is an increase of 100 %.

After comparison of blue curve with other curves, can be concluded that oil flow has increased with approximate values of 40%. Increase of oil flow is a result of low viscosity of *Sint* oil.

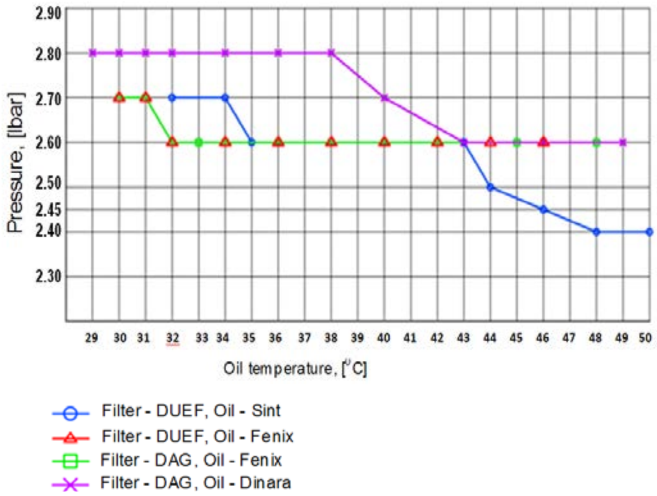

Fig. 6. *Oil pressure vs oil temperature for 850 rpm*

Based on Fig.6, can be noticed that curve with purple color, that is oil from producer *Dinara* SAE 10W – 40 and *DAG* filter, pressure has higher value of 2.8 bar. Oil pressure increases due to hydraulic resistance that has the filter from producer *DAG*.

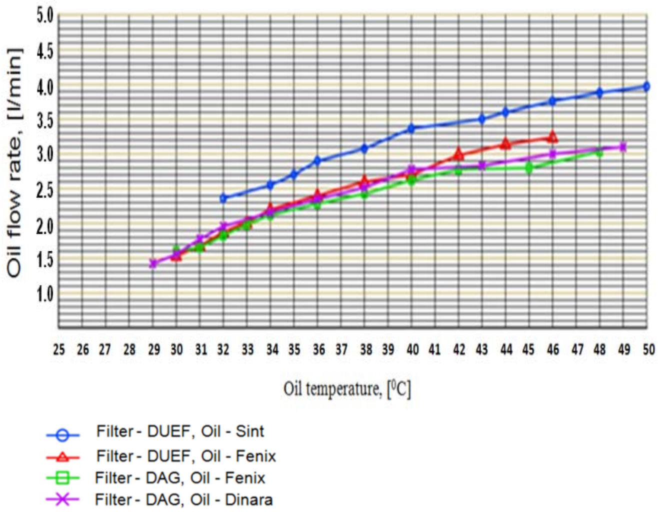

Fig. 7. *Oil flow rate vs oil temperature for 850 rpm*

Based on Fig.7, can be concluded, that after comparison of blue curve with other curves, oil flow has increased approximately for about 40 %.

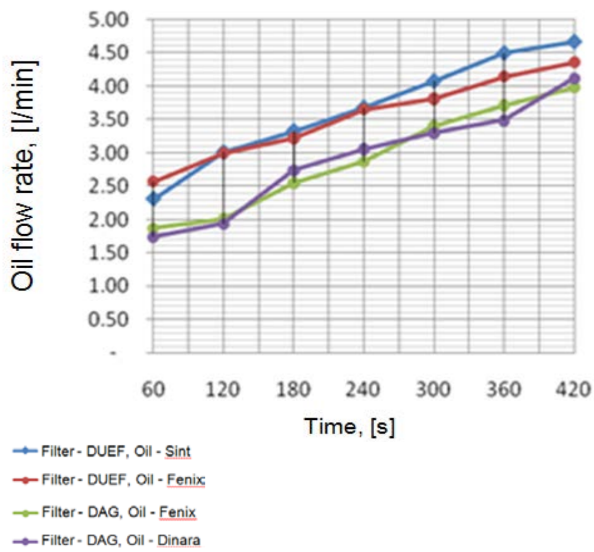

Fig. 8. *Oil flow rate vs time for 2000 rpm*

Based on Fig.8, can be noticed that oil type *Fenix* has different flow depending on filter. Flow in 7th minute is 4.35 *l/min* for the case when *Duef* filter is used, and 3.95 *l/min* when *Dag* filter is used.

After comparison of blue curve with other curves, oil flow has increased approximately 25 %, due to lower resistance of *Duef* filter.

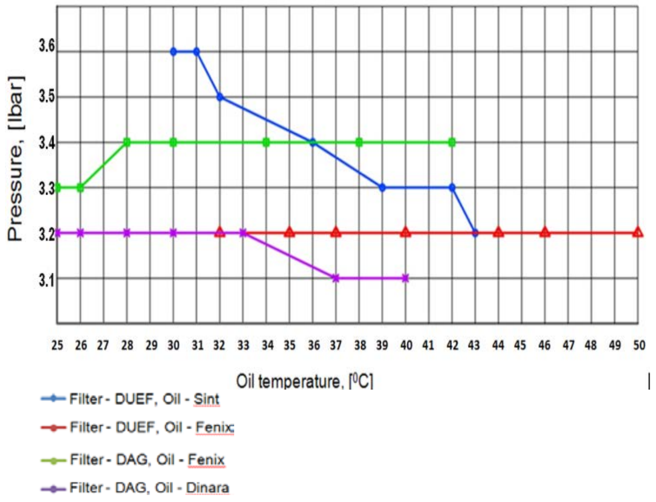

Fig. 9. *Oil pressure vs oil temperature for 2000 rpm*

In Fig.9, can be noticed that curve with blue color, for *Sint* Oil and *DAG* filter, drop of pressure is more emphasized from 3.6 bar to 3.2 bar. Pressure drop is as a result of low viscosity of oil. Curve with green color has to do with Dag filter and *Fenix* oil. Pressure has almost same value 3.4 bar from temperature 28 °C up to 42 °C.

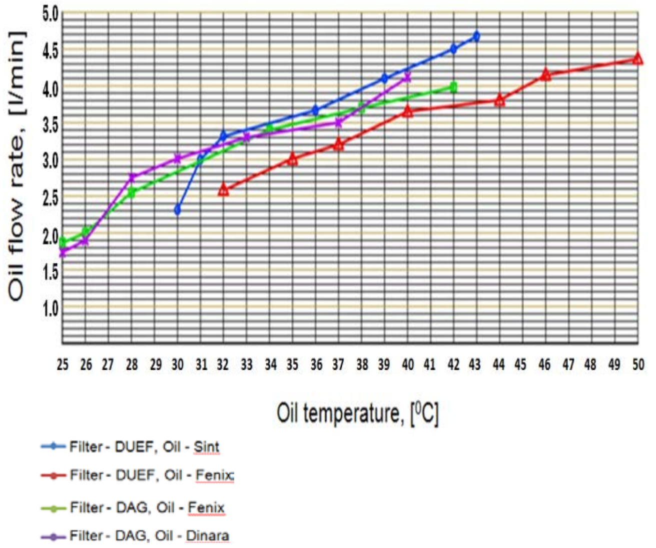

Fig. 10. *Oil flow rate vs oil temperature for 2000 rpm*

In Fig.9, can be noticed that after comparison of blue curve with red curve, can be concluded that oil flow has increased for about 13%. Increase of oil flow is as a result of low viscosity of *Sint* oil in the same temperature.

5. *Conclusions*

Based on gained results, for parameters of lubrication system, as oil flow, oil pressure, and oil temperature, can be concluded as follows:

When the engine works with engine speed at idle 850 rpm, can be concluded:

- For used oil of producer *Sint* and filter *Duef*, oil temperature has increased from 32°C to 50°C for the work time 11 min. Oil Flow value is 2.37 *l/min* in the first minute, and in the 11th minute oil flow value is 3.92 *l/min.*, which means that there is an increase of 65.5 %, and oil pressure has dropped down from 2.7 bar to 2.4 bar.
- For the oils type *Fenix* and *Dinara*, and filter *Dag*, oil temperature has increased from 30°C to 46°C, for the work time 11 minutes. Oil flow in engine in the 1st minute is around 1.5 *l/min*, and in 11th minute is 3.0 l/min. There is an increase of 100%, and oil pressure has a dropped down from 2.7 bar to 2.6 bar.

When the engine works with engine speed 2000 rpm, can be concluded:

- For used oil of producer *Sint* and filter *Duef*, oil temperature has increased from 30°C to 43°C for the work time 7 min. Oil Flow value in the 1st minute is 2.31 *l/min*, and in the 7th minute oil flow value is 4.67 *l/min.*, which means that there is an increase of 102 %, and oil pressure has dropped down from 3.4 bar to 3.2 bar.
- For the oils type *Fenix* and *Dinara*, and filter *Dag*, oil temperature has increased from 25°C to 42°C, for the work time 7 minutes. Oil flow in engine in the 1st minute is around 2.06 *l/min*, and in 7th minute is 4.15 l/min. There is an increase of 101%, and oil pressure has a dropped down from 3.2 bar to 3.1 bar, for oil types *Dinara*, has value 3.4 bar for oil types *Fenix*.

Based on gained results can be concluded that higher oil flow amount that circulates in engine is for the case when is used oil type *Sint* and filter *Duef*.

Filter Dag, because of smaller dimensions offers higher resistance during oil circulation, and is recommended not to be used.

6. *References*

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