Motor oil control in propulsion of modern transport vehicles: Review

S V Remizov¹ and M K Korolev²

¹Research and Academic Centre Kuzbass, Kemerovo, Russia
²Federal Research Center for Coal and Coal Chemistry, Siberian Branch, Russian Academy of Sciences, Kemerovo, Russia

E-mail: remizov.stanislav@yandex.ru

Abstract. The presence, quality and proper quantity of motor oil ensures smooth operation of propulsion system for the whole service life of transport vehicle. Oil film is formed during pressure feed of motor oil to structural elements of combustion engine via oil channels. Not every modern vehicle is equipped with automated oil level control.

1. Introduction

For a long time, propulsions of motor vehicles use different-design combustion engines. Hybrid propulsion systems and electric cars which are engineered recently are unattainable for mainstream consumers due to high cost. The backbone of the car fleet in Russia is motor vehicles with combustion engines.

A combustion engine needs motor oil for lubrication of friction mating surfaces. An oil film is formed by forced feed of motor oil to structural elements of the engine via oil channels. Apart from the primary function, motor oil participates in cooling of engine members. There are two types of lubricating systems—an open lubrication system, with gravity flow of oil to an oil sump or an oil box, and a lubricating system with dry crankcase. The open system is simpler and dominates in combustion engines of civil and commercial transport. The dry-sump system is a special kind of circulating oil system. It is used in high-power engines of sport cars, tractors and purpose-built vehicles.

Motor oil operates in extremely difficult conditions. Other motor lubricants—gear oil and grease—function in lower-duty conditions. They preserve their properties in the relatively uniform operating environment, under nearly constant temperature, pressure and load. Operating mode of motor oils is nonuniform—the same portion of oil every single moment undergoes drops of thermal and mechanical loads for a long period of time since lubrication conditions of different engine components differ. Moreover, engine oil is exposed to chemical factors—atmospheric oxygen, other gases, incomplete combustion products, fuel which bleeds into oil though in a very small amount [1].

2. Oil consumption

The presence of oil, as well as the proper oil quality and quantity ensures smooth operation of propulsion for the whole service life of a vehicle. Automakers express key quality indicators of motor oils in use, and oil replacement volumes and periods. Ignorance of the recommendations can result in failure of combustion engines, or in more grievous irreversible after-effects. Deficient volume of motor oil can initiate ‘oil hunger’. The consequences of oil hunger for an engine can be severe wear of gas-distribution shaft, connecting rod bearings and main bearer of crankshaft, axial offset D-ring.
When a vehicle is still run with such troubles, either wear of all participative elements or seizure of engine can happen. These parts are designed to sustain high friction and loads, and go fast out given deficient oil in the engine therefore [2].

Excessive feed of motor oil is also harmful. Oil surplus gets in the ventilation system of crankcase housing, which is adverse to catalyst. Earlier on, when mineral oil was used as lubrication, excessive grease deformed and displaced packing seals of crank shaft since pressure in the system jumped upon actuation of propulsion due to high viscosity of mineral oil. Modern semi-synthetic and synthetic oils thicken weaker in cooling. Nonetheless much extra oil penetrates cylinders, which results in sticking of piston rings and in caking of oil. Thus, excess oil feed is also impermissible. The consequences of deficient motor oil level control are illustrated in figure 1.

![Figure 1. (a) Oil hunger after-effects; (b) sticking of piston rings.](image)

The major area of Russia occurs in the midlatitude continental climate zone. Outdoor winter temperatures can hold at minus 30°C for a long time. Operation of combustion engines in such harsh climate conditions aggressively affects engine service life. Oil becomes highly viscous under low temperatures, and cold starting needs time for oil to get to friction parts. Actually, early engine rpm takes place without oil, and only a thin oil film prevents friction. Availability of oil in desired quantity is also critical for survival of propulsion system during winter operation.

3. Lubrication systems
In the past 20 years, the automotive industry enjoyed intense advance, many innovations were introduced. A modern vehicle is equipped with plenty of electronic digital systems. Various control systems are proposed for pressure and level of motor oil (figure 2).

All modern transportation vehicles are fit with different tools to control the presence and level of oil in engines. Efficiency of lubrication system is estimated using an engine oil pressure lamp included in the indication system. Depending on design, the indication system can include: oil pressure oil sensor (OPS), power train control module (PCM), engine oil pressure lamp, instrument cluster (IC), and digital pressure sensors sometimes. Oil level is tested in most vehicles using a dipstick. Premium class cars may have no customary dipstick in their toolkit. In this case, oil level is tested by oil level sensors in-built in the oil sump. The actual level of oil is transferred by PCM to IC and/or to display of the on-board computer. Sometimes sensors determine temperature and quality of motor oil.

Oil pressure lamp is a dominant tool of lubrication efficiency control in most present-day vehicles. This system is so popular due to simplicity and inexpensiveness. The system is highly reliable though claims driver’s attention every time a combustion engine is actuated. The key disadvantage of the system is its normal performance even at minimum level of motor oil. A driver has to visually observe the presence of oil and test its level with a dipstick.
Figure 2. Routine systems of lubrication control: (a) analog system with pressure capsule; (b) system with pressure capsule and digital PCM–IC linkage; (c) analog system with oil pressure sensor and oil level sensor; (d) digital control with digital engine oil level and temperature sensor.

The present-day motor cars are readily equipped with different oil level sensors such as float-type sensor, infrared sensor, ultrasonic sensor or capacitive sensor (figure 3).

Figure 3. (a) Float-type sensor; (b) infrared sensor; (c) ultrasonic sensor.

The float-type sensor has the simplest design. This is a float vertically displaceable along a guide tube. The float has inner magnet, and the magnetically operated contact is arranged inside the tube. The contact acts on approach of the magnet, which identifies the minimum level of oil in the engine. The contact closes the control circuit which forms a warning signal on the dashboard. The sensor acts at the fixed point, which limits its range of use in vehicles [3].

The infrared sensors of oil level have found the widest application. The feeler in this sensor is wire which heats up in the short run to the temperature higher than the oil temperature. When de-
energized, the wire cools down to the oil temperature. The level of oil is calculated in terms of the time of the feeler cooling. The oil level is determined simultaneously with measurement of oil temperature by a proper sensor. It is in-built in the housing of the oil level sensor. Signals from both sensors are fed to the engine control block and then to the dashboard.

The ultrasonic sensor is more efficient in oil level measurement. The sensor processes ultrasonic pulses reflected from the surface of oil. The oil level is determined in terms of the time lapse between the fed and reflected ultrasonic signals: the signal transmission time is higher with lower level of oil. The signals are processes by the electronic measurement unit and, together with signals from the oil temperature sensor, are transmitted to the engine control unit and then to the indicator on the dashboard. The use of the ultrasonic sensor enables graphical indication of oil level.

Premium class cars use sensors of oil level and quality. The capacitive oil level and quality sensor is composed of two vertical capacitors. Each capacitor uses electrodes in the form of nested metal tubes. Motor oil functions as dielectric between the electrodes. The upper capacitor measures oil level and the lower capacity determines oil quality.

4. Conclusions
Lubrication system of engines is critical in maintenance of serviceable condition of all assemblies. Proper control of the lubrication system efficiency is of specific concern when vehicles operate in severe climatic conditions. Motor oil level can be controlled using various tools, but the most popular approach yet remains a dipstick. Digital communication systems are not in mass circulation as yet, although they exist and are used [4]. Thus, the time dictates engineering of a universal tool for automated oil level control for different-design transport vehicles.

References
[1] Tolmachev D I and Golubenko N V Mekhaniki XXI veka 15 404–408
[2] Tretyakov K V and Badikov K A 2015 Proc. of Int. Conf. and Workshop on Mechanical Transport Performance (Tyumen: Tyumen. Industr. Univer.) pp 197–202
[3] www.systemsauto.ru/lubrication/oil-level-sensor.html
[4] Nikitenko S M 2006 Innovatsii 4(91) 3–5