Adaptive system of supplying lubricant to the internal combustion engine

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Abstract. This paper assesses the impact of reducing the pressure in the lubrication system on the failures of the crankshaft bearings. The method of adapting lubricating system of the diesel engine as the wear in operation and depending on the operation modes.

In the operation of the internal combustion engine (ICE), the connecting rod bearings are experiencing oil starvation because of the gap in the supply flow channels. This increases the likelihood of such costly failure as rotation of the inserts [1] due to the lubrication system pressure reduction [2,3] (Table 1, Fig. 1).

Table 1
The pressure in the engine lubrication system, KAMAZ-740 on different runs

| Frequency, min<sup>1</sup> | Operating vehicle mileage, th. km |
|---------------------------|----------------------------------|
|                           | 20 | 40 | 60 | 80 | 100 | 120 | 140 |
| 2600                      | 0.39 | 0.34 | 0.35 | 0.29 | 0.24 | 0.23 | 0.23 |
| 600                       | 0.21 | 0.7 | 0.16 | 0.12 | 0.07 | 0.09 | 0.07 |

The reason for reducing the pressure in the engine lubrication system to nominal mode to P = 0.2 ÷ 0.3 MPa after 100 ÷ 140 thousand km may be insufficient performance of the oil pump [3, 4].

Starting with the engine KAMAZ-740.11 is used the pump of increased productivity [2], which made it possible to slow down the pressure reducing operation (Fig. 1).

The efficiency of bearings is determined mainly by lubrication conditions and in its turn wear of the bearing lead to reduce the pressure in different parts of the lubrication system [2]. Therefore the degree of wear of bearings of the internal combustion engine (ICE) determines the pressure at different points of the lubrication system.
Fig. 1. Dependence of pressure in the engine lubrication system by KamAZ use: unprimed - KAMAZ-Euro; primed - KAMAZ-740
(1 - for n = 2200 min\(^{-1}\) and 2 - when n = 600 min\(^{-1}\))

To ensure constancy of the flow of oil to the connecting rod bearings its continuity and availability in its centrifugal trapped it is necessary to preserve constant oil pressure for the excess crankshaft axis is not less than 0.2 MPa as in the initial period of engine operation [3].

With increasing of the engine crankshaft rotation speed increase pressure loss of inertial forces. The gap in the crank bearing increases because of wear as well as under influence of the load due to the increase of the relative eccentricity. This increases oil flow through the clearance in the main bearing. This oil flow through the channel of the crankshaft to the axis is constantly decreasing. All this leads to the fact that oil pressure on the axis of the crankshaft will decrease. At the same time increase flow gaps in the connecting rod bearings because of the growth gap dimensions. The magnitude of the pressure on the crankshaft is reduced continuously and can be zero that is the limit value. It is found that new engines value of engine pressure is 0.2-0.3 MPa. Allowable pressure can be taken as 0.05 MPa, 0 MPa is limit.

In the method developed by the ICE on vehicleservice limitthe degree of wear of bearings [5] is proposed to measure the pressure in the oil line on the oil supply channel portion to the crank bearing on the crank shaft after the main bearings during the engine operation. The value obtained at any time must be greater than zero.

Using the proposed method of evaluation of the technical condition of the internal combustion engine can reliably determine the condition of the bearings of the crank mechanism as well as to predict the time of trouble-free operation of the engine and the remaining service life.

In order the lubrication system is self-adjusted according the ICE wearis developed adaptive lubrication system which differs from the traditional following.

There are valves in the oil pump body: pressure reduction and lubrication systems (differential). Pressure reducing valve is designed to limit the maximum oil pressure at the outlet of the pump and adjusted to the opening pressure 0.85-0.89 MPa and valve lubrication system has to maintain operating pressure in the main oil line 0.40-0.45 MPa. In this case the control pressure is supplied from the master cylinder oil passage. Its main purpose is to control draining oil from the high pressure area, preventing from decreasing and increasing of the set pressure [1].

The disadvantage of this device is that the valve setting does not take into account changing of oil flow through the users particularly through the connecting rod bearings to the extent of wear during operation.
The adaptive tuning lubrication system allows for differential pressure valve taking into account changing flow of oil through the connecting rod bearings as they wear in service due to the fact that the channel for supplying the pilot pressure to the differential valve from the crankshaft axis through the sleeve (Fig. 2).

At the beginning of operation of the engine the adaptive system will support oil pressure at the outlet of the oil pump 3, equal to the sum of the overpressure 0.2 MPa and losses from centrifugal forces and losses to customers. This amount is 0.5 MPa. With increasing pressure losses because of increased flow of oil through the main and connecting rod bearings due to wear of parts, to maintain the desired excess pressure of 0.2 MPa the differential valve lubrication system 2 will be covered. The pressure at the outlet of the oil pump will increase thus the pressure will rise in the lubrication system. Similarly the device will operate with increasing rotation frequency of the crankshaft 16 leading to an increase in pressure loss by centrifugal forces.

![Schematic diagram of the adaptive system of supply of lubricant to the internal combustion engine](image)

Thus the valve setting will take into account the change in the oil flow through the bearings as they wear during operation, that will help to change the pressure in the internal combustion engine lubrication system and maintain optimal lubrication conditions.

**Literature**

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