Machine elements evaluation diagnostic devices development using compressed air on crankshaft bearings example

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Abstract. Devices for diagnosing the degree of wear of crankshaft bearings, suitable for embedding in the on-board system for diagnosing a vehicle during its operation have been developed.

Failures of KAMAZ vehicles often occur due to cranking the connecting rod inserts [4,8,9,10]. The performance of bearings is mainly determined by the lubrication conditions and wear of the crankshaft bearings during operation, which lead to a decrease in pressure in various parts of the lubrication system [5, 6, 7].

The use of diagnostics of the technical condition of the crankshaft bearings involves [3, 7, 11, 12, 13, 14, 15] that during the operation it is possible to find deviations and inconsistencies, wear, changes in the shape and interaction, including changes in the gaps in the connecting rod bearings of the engine crankshaft.

Diagnostics can be carried out using the onboard system installed in the car at the exit from the manufacturer of automotive equipment, and subsequently in road transport enterprises and service centers. Due to this, the resource of the crankshaft and the engine can be used completely by grinding the necks for repair dimensions and installation of inserts of the next repair size, provided maintenance and repair documentation of the manufacturer, preventing the achievement of limit gaps and even more failures in the form of turning liners. To solve this task, a method has been developed for determining the clearance in the connecting rod bearing of an engine crankshaft based on a pneumatic device of differential type used in active control devices [1, 2] (Fig.1). The development is related to the field of engineering for the production of automotive and specialized vehicles, the operation of vehicles and can be used to monitor and diagnose the technical condition of their internal combustion engines.
In the differential circuit (Fig. 1, a) the prepared compressed air is used and two pressures $p_1$ and $p_2$ are compared. Bellows, membrane differential pressure gauges reacting to the pressure difference $\Delta p = p_1 - p_2$ in the two branches of the system are used as a pressure meter. Figure 1, b shows the scheme of the differential bellows device. Compressed air from the pneumatic network, passing through the filter and stabilizer unit, under constant pressure flows through the inlet nozzles 3 and 8 in the bellows cavity (metal corrugated springs). From the left bellows air through the annular gap $S$, formed by the end of the measuring nozzle 6 and the surface of the controlled part, flows into the atmosphere. In this bellows a measuring pressure $p_1$ is created, the value of which depends on the size of the part being monitored. From the right bellows air flows to the atmosphere through the backpressure node 5, and a constant pressure $p_2$ is created in the cavity of the bellows. The free ends of the bellows are rigidly connected by a screed 2, suspended on flat springs 4 and 7. The position of the moving system of the device is determined by the difference between the measuring pressure $p_1$ and some constant back pressure $p_2$. Figure 2 shows a diagram of the measuring device for determining the clearance in the connecting rod bearing, the section of the first main journal and the first crank pin of crankshaft 1. In the oil channels of the crankshaft, a common air supply channel 2 is made, from which air is supplied to the gap between the crankshaft neck and the inserts 3 through the measuring system of the nozzle-flap at the end of the channel on the surface of the connecting rod neck. The design of the nozzle is made in the form of a screw with an outer diameter of 4 mm, calibrated holes in it with an inner diameter of 1 mm on the spout, recessed by 2 mm, with exhaust air vents inside the crankcase and into the atmosphere. The function of the flap is performed by the working surface of the upper connecting rod liner. Compressed air with a pressure of 0.2 MPa (Fig. 2) from the air preparation unit 5, 6 is supplied through the air line to the transition sleeve 4, the pressure is controlled by a pressure gauge 6, then the air passes through the transition sleeve 4 into the rotating crankshaft and the two nozzles - valve 2, diametrically opposed to the surface of the crank pin, the function of the valve is performed by liners. The volume of air passing through the connecting rod bearing nozzles determines the pressure drop across the diaphragm in the pressure transducer. The pressure drop across the membrane is converted into an electrical signal and the meter indicator readings with a scale calibrated from 0% to 100%.
Fig. 2. Diagram of diagnosing the clearance of the connecting rod bearing by measuring air flow:
1 - crankshaft; 2 - air supply pipes to the jets; 3 - connecting rod insert; 4 – transfer coupling; 5 - electronic measuring device; 6 - air preparation unit

Air under pressure of 0.2 MPa is supplied to the connecting rod bearing gap for measurement through throttling devices, the “Sapphire-22D” pressure transducer, a Marposs measuring device (Fig. 3, a) a transition sleeve to the connecting rod bearing gap. These devices are used in the active control when honing cylinder liners.

Fig. 3. Device for measuring the gap in the crankshaft bearings during diagnosis:
a) measuring unit, air preparation unit, differential pressure gauge; b) receiving choke of the internal combustion engine and transitional coupling for the supply of air

From the measuring unit, the air enters the transitional air supply coupling of the receiving choke (Fig. 3, b), which allows the air to pass from the non-rotating part to the rotating part. Inside the crank pin there are two diametrically opposite holes in the plane of 30° from the axis of the crank into which the tubes are inserted. The outlet of the tubes ends with a precise jet with a diameter of 1 mm (Fig. 2).

The amount of air entering the connecting rod bearing gap is adjusted by setting an air pressure of 0.2 MPa and adjusting the position of the throttles at the start of the test.

The measuring device measures the pressure drop on the membrane, which increases depending on the increasing flow rate with increases gap.

Calibration of the measuring instrument scale at “100%” of the gap size is carried out by supplying air to the zone of the nominal clearance at the beginning of the engine operation, when the gap between the crank neck and the liner is known. Deformation of the connecting rod bushings with the
formation of a deflection leads to a decrease, and wear to an increase in the gap with the connecting rod neck, which should be fixed by the device. The control algorithm onboard system must be provided with the same conditions, for which the measurement should be made after the engine stops at a certain position of the crankshaft at the angle of rotation. For the on-board system, the electrical signal must be converted and stored in the onboard computer. Measurements should be made after each engine stop, then superimposed on the mileage data and displayed on the display as a gap value, increase or decrease, intensity, residual life to the limit state. The device with the use of compressed air was used in the diagnosis of the forming of crankshaft connecting rod bearings at the KAMAZ engine factory.

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