Improving the performance of cylinder liners by creating thin-layer coatings in the interface

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Abstract. The paper presents the technological process of brass plating of the cylinder bore. Application of the coating allows to increase the operational reliability of parts of the cylinder-piston group and the technical life of the entire engine.

Failures of the internal combustion engine in operation are shown in the form Natarov and scuffing of the cylinder group. The working conditions of the cylinder-piston group are significantly affected by the ovality of the sleeve, due to the design features of the head attachment to the cylinder block and the gas joint [1]. The ovality and non-cylindrical shape of the sleeve is formed during Assembly and is preserved during operation of internal combustion engines.

The cylinder liner is brought to the standard parameters for cylinder shape, ovality, and taper when manufactured at the KAMAZ engine plant, but its shape is distorted after installation in the cylinder block and tightening the cylinder head bolts, deviations reach ±0.02...0.05 mm from the nominal size. The ovality of the sleeve is aggravated during installation (Fig. 1) due to a breach of the bolt torque, and asymmetrical arrangement of the mounting bolts to the cylinder head. When four bolts with the same torque are tightened due to uneven positioning, the larger axis of the oval is located in sectors A and B, and the smaller axis is located in sectors C and D [2, 3].

![Diagram of cylinder liner]

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Fig. 1. Asymmetry of the location of the cylinder head mounting bolts and the shape deviation sectors (maximum (A and B) and minimum (C and D))

Physical and chemical, anti-wear and anti-pressure properties of lubricants, properties of the surfaces of sleeves and rings often can not prevent intensive wear and destruction of rubbing surfaces, expressed in the form of rubbing, teasing, cauterization on sleeves and rings (Fig. 2).

Fig. 2. Rubs (a) and teasers (b) on the working surface of the sleeve

To improve burn-in, the inner surface of the sleeve is lubricated with spray and oil mist, sometimes it can be covered with phosphating or porous chromium.

The effect of selective transfer during friction has a positive effect, when a metal-coating film is spontaneously formed on rubbing surfaces in the contact zone [4].

Thanks to the creation of a metal-coating film that separates the rubbing surfaces even at high loads, the wear of parts under selective transfer conditions can be reduced to zero (the wear-free effect), and the coefficient of friction can be reduced to values under liquid friction.

Selective transfer conditions for reducing the wear of rubbing surfaces are usually created using simple methods:
- introduction of copper-containing additives into the oil;
- applying a layer of non-ferrous metal (brass, bronze, copper) to the work surfaces of parts;
- installation of inserts from non-ferrous metals in machine parts.

In KAMAZ engines with an unloaded gas joint on the cylinder liner, it is advisable to apply a self-working coating that adheres well to the cylinder surface (Fig. 3), and when working due to the removal of the rings creates a form that ensures complete fit of the entire surface of the rings to the sleeve, and thus provides good burn-in characteristics and work in conjunction with the compression rings and the piston without rubbing and teasing [5].
Joint research by PJSC «KAMAZ», VNPO «Remdetal», NIIAT and KFU obtained results on the impact of finishing antifriction-free treatment with brass in the form of tribolatuning (FABO) and surface-plastic deformation (FABO PPD) on the wear and tear resistance of the cylinder liner - piston ring pair of the KAMAZ-740 engine [6].

The coating was obtained using LMC 58-2-2 brass (Cu 57-60%, Mn 1.5-2.5%, Pb 1.5-2.5%, the rest is zinc) [7]. Rollers are made of brass rods for installation in a modified honing head (Fig. 4).

As an activating solution, a process liquid is used, which is a mixture of glycerol with metal chlorides and in one liter contains the following components (g/l): zinc chloride (ZnCl₂) 24 g; copper chloride (CuCl₂) 10 g; tin dihloride (SnCl₂) 16 g; iron chloride (Fe₂Cl₃) 14 g; urea (Co(NH₂)₂) 4 g; technical glycerine (C₃H₅(OH)₃) 200 g; drinking water. The materials used are standardized, produced by industry in mass quantities, and are relatively cheap.

The layer of applied metal at FABO (8-10 microns) was very effective in the initial period of operation and allowed to exclude cases of unsatisfactory burn-in of the cylinder-piston group during acceptance tests.

A special advantage of the internal combustion engine with this treatment of the cylinder liner is that the layer does not require final processing and can be carried out during installation in any conditions when assembling a new engine and repairing it.
During bench tests of engines for failure-free operation for 1000 hours, it was found that the average wear of latuned sleeves in the upper dead center zone is 30% less than that of uncoated sleeves.

The wear intensity of the raw sleeve processed by the PPD-FABO and FABO methods is two orders of magnitude higher ($2\cdot10^{-10}$) when tested on a friction machine compared to the sleeve processed by the PPD-FABO and FABO methods ($1\cdot10^{-12}$ and $4\cdot10^{-12}$) (table 1).

### Table 1 - The wear rate of the liners and chrome-plated rings

| A method of brass plating raw shells | Wear rate |
|--------------------------------------|-----------|
|                                       | sleeve    | ring      |
| Crude                                | $2\cdot10^{-10}$ | $8\cdot10^{-11}$ |
| PPD-FABO                             | $1\cdot10^{-12}$ | $4\cdot10^{-11}$ |
| of FABO                              | $4\cdot10^{-12}$ | $5\cdot10^{-11}$ |

Using the liner coating on «Remdiesel», it was possible to eliminate grates and teasers during the burn-in process and get an improvement in operational parameters [8].

The obtained results of samples with brass coatings applied in two different ways (using the FABO and FABO PPD method) during laboratory and bench tests allow us to recommend processing in the production of KAMAZ engine cylinder liners.

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