WEAR PROPERTIES OF CAMSHAFT CAMS AND IMPROVEMENT OF THEIR WEAR RESISTANCE

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Abstract

In the article, the problems of increasing the durability and wear resistance of the cam of gas camshaft by using the ion implantation method were considered. In operation, since the cams of camshaft work the working profile under high pressure, the wear is fast. As a result, the regular operation of the engine is disturbed and the engine does not provide the necessary power and force at the output. It is known that the gas camshaft mechanism requires complex and quite economic costs in the repair of engines. In this regard, increasing the wear resistance of camshaft using the ion implantation method is appropriate. To conduct the research, samples of steel 40X, 50X and X6B3MTiC used in the production of camshaft were prepared and researches were conducted.

Keywords: internal combustion engines, camshaft, ion implantation, coating, wear resistance.

I. Introduction

Camshafts with cams used in internal combustion engines (ICE) of cars, ships and other transport vehicles have a complex construction, and during their operation, uneven wear occurs on the working surface of the cams as a result of moving friction of the valve pusher in their working profile. The uneven wear observed on the working surface of the pistons has a negative effect on the efficiency of the ICE work process, the cycle of supplying the fuel mixture to the cylinder and removing burnt gases from the cylinder. At the same time, the analysis of the construction of gas camshaft shafts with additional cams shows that gas distribution shafts with different constructions, including whole and differently assembled cams, are used in order to reduce cams wearing in ICE of different sizes and powers [1-4].

The wear of cam shafts during operation depends on a number of factors:

1. The gas distribution shaft should be constructed in such a way that the kinematic relationships placed in front of them, i.e., the nature of the contact between the cam and the pusher, work with a regular trajectory of movement corresponding to a sinusoidal smooth curve and minimize the impact of striking forces, etc..:
2. The kinematic connections must be designed so that the intake of the fuel flow of the valves and the expulsion of the burnt mixture from the cylinder can be performed with high precision.:
3. The material of the cam relative to the pusher should be selected in such a way that its wear is compatible with the physical and mechanical properties of the material that affects the wear character of the contact pair.

By examining the mentioned issues on the basis of scientific analysis, it is possible to reduce the wear of the working surfaces of camshafts and, as a result, to increase the operating efficiency of internal combustion engines. For example, the problem of increasing the durability of cams against wearing should be solved by using modern coating technologies, the issue of using cams equipped with wear-resistant coatings, so that it is possible to extend their service life.

The theoretical and practical solutions to the above-mentioned technological issues were investigated and the development of new technologies was considered.

Purpose of work. Improving the operational quality of the available integral and assembled gas distribution shafts is aimed at reducing the intensity of wear of working profiles of cams and the linear size of wear of this surface. A new construction of the gas distribution mechanism was developed in order to make the repair of the gas distribution mechanism during the operation period without disassembling the engine and to achieve a high result. At the same time, coating is applied to the surface of more cams at the same time in the chamber of the coating device.

II. Research methods

The accuracy of the geometric dimensions of the prepared cams was studied with the help of a transfer polishing machine using special designs and watch-type indicators with an accuracy of 1 μm. The hardness of the surface after quenching was studied using the Portable Hardness Tester Tm 210 hardness measuring device. The thickness of the coating applied by diffusion was studied with the help of the Tm-8812C ultrasonic thickness measuring device. After polishing, the roughness of the surface of the cams was measured using a TR220 profilometer-profilograph. The resistance to wear of prepared cams was experimentally studied depending on the friction path of 10,000 km at the contact pressure of 250 kN at the base of the İİ5018 friction machine. The camshaft installed on a Kamaz truck for the purpose of testing under real operating conditions continues to be in working condition by completing 160,000 km mileage. The powder profile of the cams subjected to friction test was studied by dividing them into 5°- angles. The essence of the measurement methodology is that the profile of the cam is 3 mm apart, and the graph of the wear is made by measuring at 360 points, one every 5°-on the profile, in five cross-sections.

III. Discussion of research conducted.

The wear of the cam shafts of the internal combustion engines of KAMAZ 740 trucks, which is one of the widely used vehicles in the transport system, depending on the service life, was studied. In this machine, the role of the rocker in the kinematic relations was considered in order to reduce the cams wear. Also, ways of reducing the intensity of wear cams made of different materials are being investigated.

It has been determined from the researches that the nature of the contact between the cams and the pusher is caused by one of them, i.e. the rotation of the cams, and the other as a result of the back and forth movement of the pusher. Wear of the cam's profile depends greatly on its speed of rotational movement, as well as the force acting on the profile, the speed of back-and-forth movement, and shocks due to the increase in clearances caused by contact. Therefore, the appropriate material was selected, which has a positive effect on the reduction of cams wear in the first place. In the studies, cams were made from the following materials: steel 40X, 50X, X6B3MTiC.

The technology of making cams is based on their physical and mechanical properties. Thus, in the selection of the material, taking for example 45X, 50X from low-temperature annealed medium carbon alloy steels is related to the efficiency of their machining process and wear resistance. Their high hardness and resistance to wear make it possible to use instead of cemented steels. Thus, instead of the expensive and long-term cementing process, it is possible to obtain the required hardness on the surface of the cams made of steel 40X, 50X materials by using a low-labor and productive high-frequency induction heating method.

Taking these into account, a new assembly structure of the camshaft was created. [2]

The purpose of the new construction is aimed at increasing the service life of camshafts, reducing the wear of cams and improving its production process, simplifying the repair process.

The new construction was solved in several ways as follows. The camshaft installed in the assembly construction consists of a stepped shaft with a diameter difference between the cam journal and cams heels, the cams fitted very tight above shaft key fastened with different method. That is, the purpose of the construction is to cancel the fastening scheme on the top of the cams and the central bolt, and the fastening of the cams on the cam heel is carried out according to the different schemes given below.

The cams is fitted on the cam heel in a form based on its side surfaces and is fixed by means of hole is opened on the side surface, and it is fixed by riveting to the hole. (Figure 1)

In the mounting scheme of the camshaft with the proposed assembly structure, the impact force acting on the cams has a relatively small effect on the pressed fastening axis. Since the external-side surfaces of the fixing axis are made in accordance with the profile of the cams, the contact with other parts that may occur during the rotation of the camshaft is smooth.

According to the second fastening scheme, the cams is fixed by means of a bolt with a threaded hole with a bottom in the cam heel, which facilitates the replacement of wearing cams in the repair areas. In both proposed fastening schemes, the normal and tangential forces on the cams, as well as other forces, are cross-distributed between the frame and the bolt, thus preventing the formation of gaps in the fitting surfaces of the cam.

In all proposed fastening options, the working profile of the cams, the top has a smooth geometric profile, and its change will be subject to wear during operation, depending on the material, construction and other factors.

The design of the cams made in the new versions allows the camshaft to be reused for a long time by changing them periodically after wearing. The production of cams with the proposed fastening scheme can be applied to the assembly of camshafts using sufficiently available technological processes: drilling, milling, cutting, heat treatment and polishing operations [1,5,6-8].

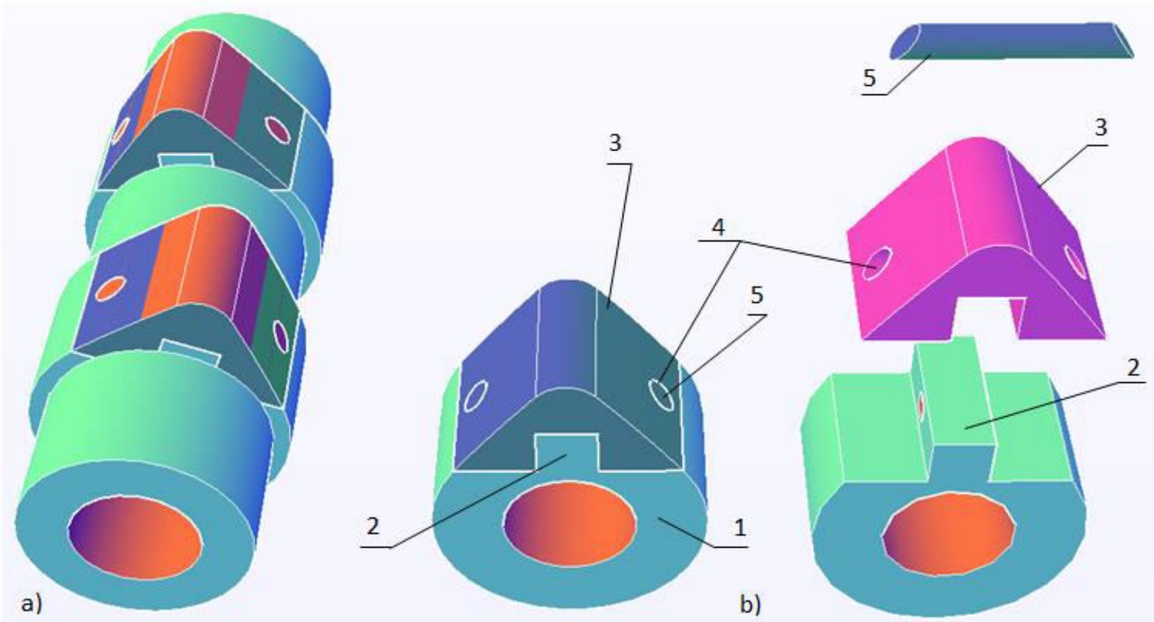

Figure 1: *a shows a schematic view of part of the camshaft. b shows the construction of camshaft 1 cam heel and its elements. Here, 1- cam heel, 2-shaped surface of shaft key, 3-cam, 4-hole opened in the direction perpendicular to the shape of the cam, 5-axis connecting cam with cam heel are extra*

According to the first fastening scheme (Fig. 1.), the cams (3) is fitted on the figure in the cam heel (1), then it is connected to the cam heel by press fit through the holes (4) opened in the cam and the shift key. The pressed axis (5) limits the displacement of the cam in the direction perpendicular to the axis and axis of the camshaft during the working process, which leads to reduction of shocks and noises that may occur during operation of the engine.

It is known that the cams is loaded more than other structural elements of the camshaft. It is also suggested to make the cams from harder, wear-resistant, abrasive materials that withstand cyclic loads, for example, X6B3MTiC [1,5,6-8]

Making technology of the cams of row material made of X6B3MTiC powder material is as follows

1. Cold pressing to 45-50% density;
2. Pre-sintering in argon or nitrogen atmosphere at a temperature of 600-7000C;
3. Final sintering in a vacuum for 30-60 minutes at a temperature of 1320-13800C and a residual pressure of 1...0.1 MPa

The composition of the material produced by X6B3MTiC sintering technology is given in table 1:

Table 1

Content		HRC hardness				Strength limit, MPa		Density obtained as a result of sintering
Carbide steel		After sintering	After anealling	After quenching	After anealling	$TM_{Н}$	$TM_{сж}$	%
X6B3M 90%	TiC 10%	47	15	57	56	1320	2500	98-99

With the continuous cooking technology, it is possible to obtain the necessary sizes and shapes of the cams lobe from the material of the press-forms, keeping a small amount of processing for polishing with a small labor capacity and high productivity. By applying the above mechanical properties, it allows to increase the service life of the cams.

Production of cams from steel 40X and 50X material was carried out by two methods. After the steels taken in the first method, the whole structure of the gas distribution shaft is prepared by forging the cams, after passing through the appropriate mechanical processing process, the surface is subjected to a surface treatment within the limits of HRC 55..58 with a high frequency current, and the profile is polished on the transfer polishing machine. The resistance of these cams to being wear is being studied. [7-9]

In the second case, after the ends of the cams made of steel 40X and 50X have undergone mechanical processing and the surface is subjected to high-frequency current treatment with a depth of 1.5...2 mm, the support surface is subjected to HRC 52..55 limit and diffusion chrome plating process in the CHB 1.3.1/6 vacuum oven. it is intended to increase the resistance to wear of the working hardness of the cam. The thickness of one layer of the applied coating varies between 20÷30 μm. If required, by increasing the number of coating layers, it is possible to increase the thickness of the coating layer and increase the life of the cam.

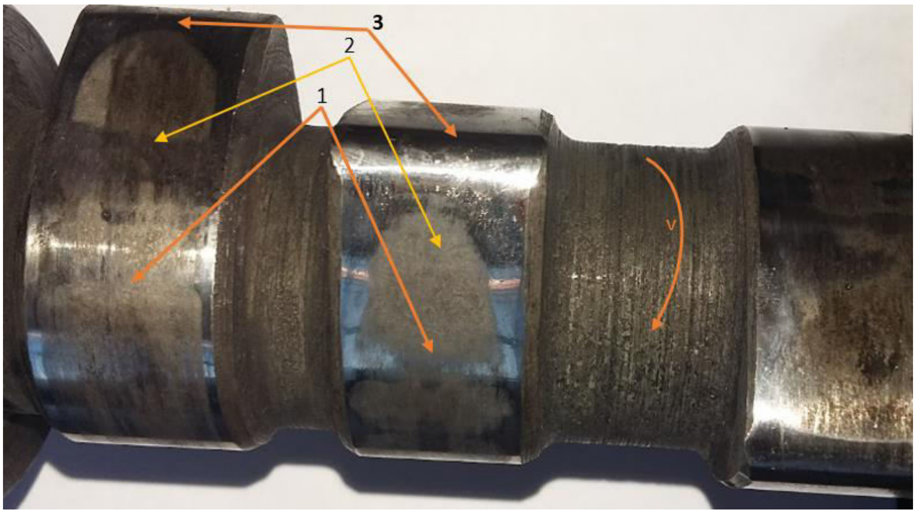

Figure 2: *Wear characteristics of the working surface of a camshaft with a single-piece design*

Wear was studied by taking the cams of the gas distribution shafts manufactured by the existing industrial method and used in the Kamaz 740 vehicle from different materials, for example, steel 40X, steel 45. After taking the steel 45 material in the martensite structure and undergoing thermal treatment, the punches with a hardness of 56÷58 HRC were examined for exploitation and experimental wearing in laboratory conditions. Figure 2 shows the behavior of these cams after they were used in real conditions on the Kamaz 740 vehicle.

From the study of the used distributor camshat, it can be seen that the smoothness of the transition from its surface 1 to the working surface of the cams to ensure the opening of the valve in the working process with the rotation speed v is disturbed due to wear. The study of the linear dimensions of the wear on the surface of 1 (from the point of creation of the tension medium between the valve pusher and the cam) in different areas shows that the depth of the wearing surface varies in the range of 0.15-0.25 mm. Due to the increase in the pressure caused by the effects of the return spring of the valve and the pusher compared to the 1st surface, the amount of wear of this area has increased by 35-40% compared to the 1st surface. Since the 1st and 2nd areas of the cam serve to open the valve, the wear occurring in this area initially reduces the opening distance of the valve and causes the formation of a stepped surface at the top of the cam in the 3rd 1.7° area, i.e. in the transition to the valve dwell time, which at the moment of full opening of the valve, under the influence of additional force and increased frictional moment, it causes sudden critical loading of the camshaft and the generation of noise in the engine. Regardless of the hardness obtained from the thermal treatment of the surface of the cams of the current construction, despite the fact that the pressure generated at the top of the cam during the operation of the cam is at its maximum value, the wear occurring in areas 1 and 2 of the profile of the cam is not less than the wear at the top of the cam. There are various factors that influence this: uneven distribution of hardness of the surface of the cam, irregularity of residual stresses generated on the working surface of the cam, roughness of the surface of the cam, etc. [1,4].

Depending on the thickness of the coating layer to be applied to the surface, the coating method is selected. During the application of each method, a set limit is determined for the quality and reliability of the coating to be applied.

Taking this into account, in order to increase the wear resistance of cam and ensure the surface hardness of its working profile, the following studies were conducted on the ННВ-6.6.И1УХЛ4 model Ion implantation device.

a)

b)

Figure 3: *Ion implantation device model ННВ-6.6.И1УХЛ4*
a) general view, b) working chamber of the device

1. Deposition of the XrN coating on the samples of the working surface of the cam in different modes;
2. Deposition of the ZrN coating on the working surface of the cam on the samples in different modes;
3. Deposition of the TiN coating on the working surface of the cam on the samples in different modes;

On the basis of the ion implantation device model ННВ-6.6.И1УХЛ4, the purpose of carrying out the coating material on special samples in different modes is to conduct a comparative analysis of the surface hardness of the practically obtained coatings and the thicknesses of the obtained coating.

IV. Conculicion

1. Based on the research, it can be concluded that the cam shafts are subjected to uneven wear on the surface due to the maximum load at the initial start-up of the engine and high frequency friction at operating temperature.
2. As a result of the literature research, the maximum amount of wear on the surface of the cam can reach 300 μm. At the same time, there are deposits of 90÷150 μm in size on the surface of the cam, which ensures the time of staying away, which is caused by the compression of the pusher and the cam with the maximum contact force.
3. Taking into account the conditions of the impact of the gas camshaft cam, the new construction was studied in operation and made it possible to achieve a significant result in the direction of improving the efficiency of the repair.
4. New technological mode parameters and an improved oven design were developed for conducting ion implantation of the wear surfaces of the gas camshaft cam of ICE. The efficiency of the coating method carried out in new technological conditions and in an improved oven has been confirmed

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