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# DETERMINATION OF OPERATING VALUE INDICATORS OF HYDRAULIC DENSITY OF RESTORED PLUNGER PAIRS OF HIGH-PRESSURE FUEL PUMPS OF SPECIAL VEHICLES

**Abdullayev Alimardon Ikromjonovich**

Andijan State Technical Institute, assistant

alimardon.abdullayev@inbox.ru

tel: +998901406517

**Annotation:** This article examines the operating characteristics of plunger pairs used in high-pressure fuel pumps of diesel engines, their wear causes, and restoration methods. The reasons for the sharp decrease in the service life of plunger pairs in the conditions of Central Asia with a hot climate and high dust content are cited. The limits of the operational value of the hydraulic density of the reconstructed plunger pairs have been determined.

**Keywords:** plunger pair, high-pressure fuel pump, hydraulic density, operation, restoration, value limits, repair.

In the world, the development, research, and improvement of the performance of new technologies that increase the service life of machines and mechanisms are of great importance in modern mechanical engineering. At the same time, ensuring timely repair and high-quality maintenance is one of the main tasks for the effective operation of car parts. Therefore, special attention is paid to conducting scientific research aimed at studying the characteristics of units and parts of the fuel supply system of special vehicles and increasing their service life.

The plunger pairs of high-pressure fuel pumps of special vehicles with diesel engines are one of the main parts that ensure uniform fuel supply to the engine in all operating modes.

The plunger pairs wear out during operation. The operating conditions of plunger pairs determine their wear characteristics. In the conditions of Central Asia, with hot weather and high dust levels, the service life of plunger pairs is significantly reduced. The presence of abrasive particles in the fuel leads to the formation of cracks on the working surface, which leads to a sharp change in dimensions and tightness of the parts. The main type of wear of plunger pairs is hydraulic abrasive wear. Hydroabrasive wear is the effect of abrasive particles in the liquid 2].

Modern filters with fine fuel cleaning cannot capture particles smaller than 0.002 μm, which leads to wear of the plunger pairs.

There are several methods for restoring worn plunger pairs, which are as follows.

- recovery method;
- methods of chemical-thermal treatment of the plunger and its bushing;
- Electrophysical methods of plunger processing;
- Method for obtaining nanocomposite hydraulic coatings.

Restore method. The restoration method is widely used in plunger pair manufacturing plants. The essence of this method is that the worn plunger pairs are sorted by size, and then the plungers and bushings are individually rubbed on special sizeing machines to eliminate wear. Abrasive plungers and bushings are restored, and their dimensions are selected so that the plunger fits fully into the bushing. The selected plunger and bushings are subsequently rubbed against each other. This method allows for the restoration of 15-20% of plunger pairs requiring repair.

Methods of chemical-thermal treatment of the plunger and its bushing. Chemical-thermal treatment methods consist of saturating the surface of plunger pairs and the inner surface of the bushing with some element. Under the influence of diffusion processes, changes in the size of the plunger diameter and the diameter of the bushing hole occur. In the production of 25X5M, 38XMIOA plunger pairs from nitratable steels, these parts can be re-nitrated. The process is carried out at a high temperature of 450-500°C for 20 hours. Such a restoration process is considered inefficient, the process is prolonged, and the dimensions along the length of the bushing and plunger are variable.

Electrophysical methods of processing plunger pairs. The most common method of electrophysical restoration and strengthening is electrical spark treatment. This method has become widespread in the restoration and strengthening of parts of vehicles with diesel engines. The essence of the method is that in a gaseous medium, a pulsed discharge occurs between the cathode and the anode. As a result of discharge, the anode material passes to the cathode, and the part is restored. By changing the process time, a complete and uniform coating with minimal roughness is achieved. In this method, a diffusion layer with high hardness, consisting of carbides, nitrides, carbon nitrides, and the like, is formed on the restored surface of the part. Tungsten, vanadium, tantalum, titanium, chromium, and similar refractory metals are used as anodes. The electric spark treatment method is comparable in results to chemical-thermal treatment methods, and its advantages and disadvantages are similar. The main disadvantage is the low productivity of the process compared to chemical-thermal treatment.

Self-regulating chromium coating electrolytes were selected for obtaining chromium-based nanocomposite electrolytic coatings. This electrolyte is widely used in the repair industry, as it allows obtaining high-quality chromium coatings with high microhardness (8...10 GPa). In addition, it allows changing the physical and mechanical properties of coatings in a wide range when changing the modes of chrome coating, which is very important for the research and creation of new wear-resistant coatings[3].

The preparation of chromium coating and iron coating electrolytes for obtaining nanocomposite electrolytic coatings is as follows. First, the main electrolyte is prepared. Subsequently, the electrolyte and nano-sized powder are mixed in a separate glass container and ground into a mixture for 10 minutes. The resulting concentrated suspension is poured into the electrolyte with constant stirring. Electrolytes are filtered and pre-treated. After this, the electrolyte suspension was treated with ultrasound at a frequency of 22 kHz for 10-12 minutes using an ultrasonic generator of the UZG-2M type [4].

During the repair process, the stability of the cyclic fuel supply of the YUBYON is ensured by selecting plunger pairs with the same group of hydraulic densities on the KI-759 device, followed by their assembly and adjustment.

During the tests, limit values were determined to ensure the required quality of plunger pair selection for the set based on hydraulic density. The obtained results made it possible to assess the quality of selecting the plunger pair in the set when performing technological operations during the repair of fuel pumps [4].

The study was conducted on the KI-759 device. The device is used in the selection of plunger pairs for the set. Based on the research objective, object, and subject, indicators characterizing the state of the issue are considered.

The value of the hydraulic density depends not only on the technical condition of the plunger pairs being tested, but also on the testing system, the pressure and viscosity of the liquid, and the active movement of the plunger.

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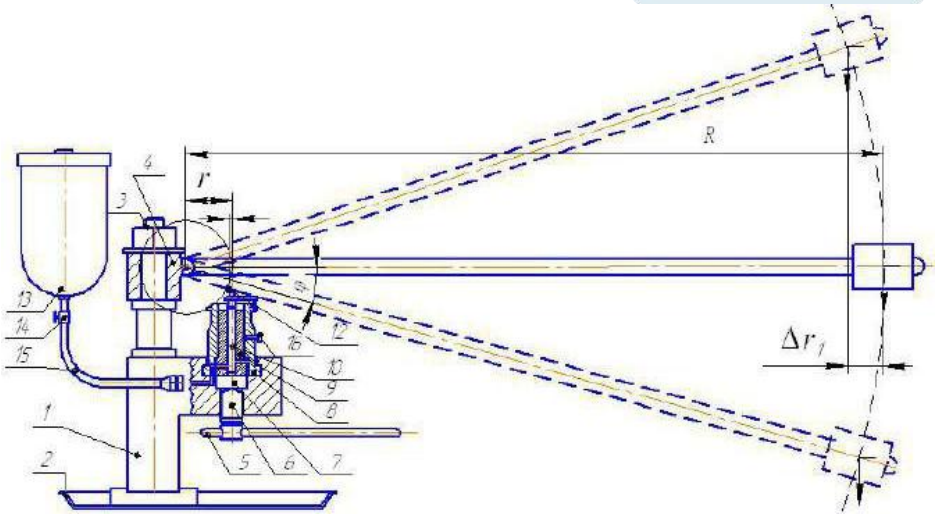


**Figure 1.** ***Device for determining hydraulic density KI-759-scheme***

The need for bench tests stems from the fact that with small investments in time and material resources, it is possible to achieve a result that allows assessing the feasibility of the developed restoration method.

During the bench tests, the goal was not to limit the tested units that had specific parts. The duration of the tests is limited by the time that allows obtaining a dependence of the resource-determining parameters of the tested units on the duration of the tests and the method of restoring precision parts.

During testing, data on reliability were obtained, processed, and analyzed in accordance with GOST 27.301-95, which determine the methods for planning tests when assessing reliability indicators. The NUT test plan was used in conducting the tests (N - number of objects placed under observation, U - objects that failed during testing are not restored or replaced, T - tests are stopped after each test time or after operating time) [5].

For experimental tests, it is necessary that the plunger pairs have the same hydraulic density, respectively. The hydraulic density of the plunger pairs is determined by the KI-759 device (Fig. 1). A ten-stage planned experiment was conducted to determine the optimal limit values of the hydraulic density of the plunger pair.

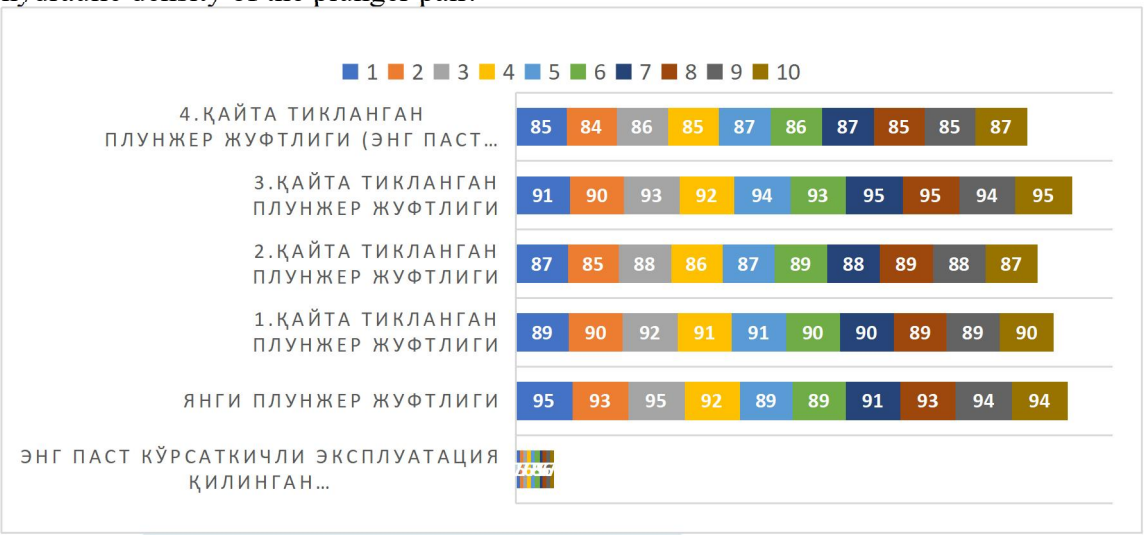


**Figure 2. Self-loading excavator XCMG WZ 30-25**
**Graphs of optimal limit values of the hydraulic density of plunger pairs.**

***Summary of the test results obtained on the KI-759 device.***

During the tests, it was established that the first high-pressure fuel pump after restoration of the plunger pairs is close to the indicators of the new plunger pairs. When conducting bench tests and experimental tests, in order to compare the performance indicators of the restored plunger pairs relative to the new plunger pairs and obtain real results, new plunger pairs with restored plunger pairs were installed on the high-pressure fuel pump [6].

During the tests, it was established that the plunger pairs of the third high-pressure fuel pump after restoration are close to the indicators of the new plunger pair. To ensure the reliability of the results of the bench and experimental tests, a new plunger pair was also installed in this group.

During the test, after the restoration of the plunger pairs of the second high-pressure fuel pump, during the preliminary test (determination of the hydraulic density of the plunger pairs of the high-pressure fuel pump requiring repair), the lowest indicator was recorded, and the worst indicator was recorded after the restoration of the plunger pair. For this reason, two new plunger pairs were installed on this high-pressure fuel pump.

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