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Application of electric erosion machining for the restoration of splined surfaces

A T Kulakov[1], E P Barylnikova[1], F L Nazarov[2], S Yu Kovalenko[3] and K V Gribkov[3]

[1] Kazan Federal University, Naberezhnye Chelny Institute, 423812, Russia, Naberezhnye Chelny, Prospekt Syuyumbike 10A
[2] Engine Plant of PC KAMAZ, Russia, 423800, Russian Federation, Naberezhnye Chelny, Avtozavodsky Ave., 2
[3] Orenburg State University, Russia, 460000, Russian Federation,. Orenburg, Pobedy Avenue, 13, Senior lecturer of the Department of Motor Transport,

alttrak09@mail.ru

Abstact. The paper presents an analysis of the possibility of using electric erosive machining when restoring splined surfaces on specialized equipment.

It is well known that spline joints are used to fit such parts as gear wheels, pulleys, bushings etc. on the crank and in comparison with keyed joints they have a number of advantages, in particular less bearing stress at the spline boundaries and higher shaft strength with dynamic and variable loads. At the same time the experience in the operation of road transport shows that wear of slotted joints occurs frequently.

The restoration of splined surfaces is a complex and time-consuming process and includes as a rule such operations as surfacing, normalization, turning (broaching - in case of hole reconstruction), milling, heat treatment and grinding, which makes the recovery process economically unprofitable, for which reason the details are scrapped, and instead of them new ones [1,2,3] are installed during the repair. One of such details are carriages of synchronizers of IV-V transmissions of KAMAZ gear change box. These carriages are characterized by the wear of internal splined surfaces in conjunction with the secondary shaft of the box, accompanied by extrusion and cutting of a part of the metal from the side surface of the spline (Figure 1).

When such spline wear is restored existing technological processes [4,5] imply, as it was described above, surfacing with further machining and heat-strengthening, which is extremely unprofitable against the backdrop of the cost of the part, and given that separate synchronizer carriages are not supplied, this makes the whole unit is not repairable. With the cost of a new synchronizer assembly of about 4500 rubles, its replacement increases the cost of repair and operation of the vehicle as a whole.

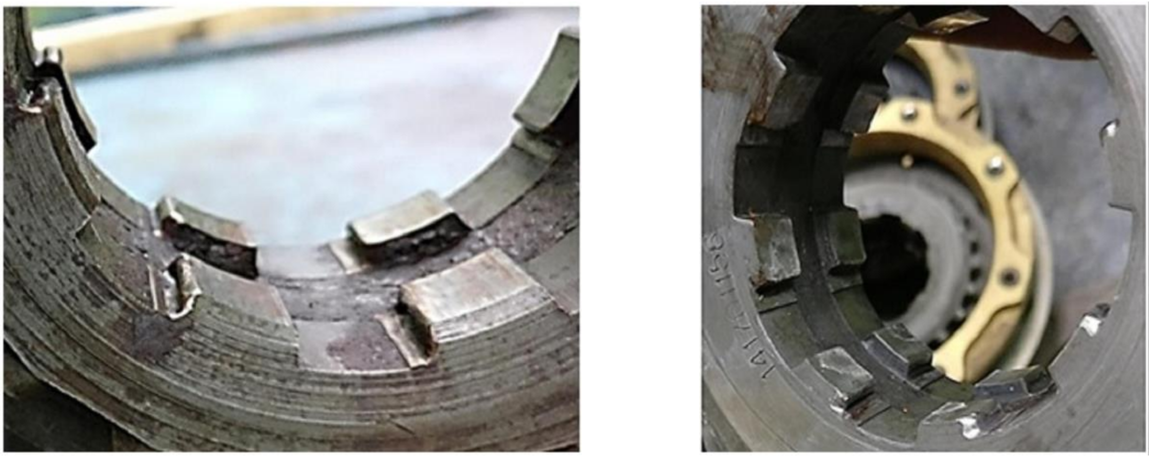

Fig. 1. Wear of internal splines of the synchronizer carriage of IV-V transmissions of KAMAZ gear change box

At the same time electric erosion machining is distinguished out of the many existing methods of processing parts due to its principle consisting in the ejection of particles from the metal surface by an electric discharge pulse. When copying the shape of an electrode or its cross-section the workpiece element in its shape is the inverse of the working surface of the tool. This operation is called broaching. There are methods of direct and reverse copying. With direct copying the tool is located above the workpiece, and with reverse copying it is below it. In process of electric erosion machining, the electrode is introduced into the part, ensuring the copying of the electrode [6,7]. This method is simple in execution and is widely used in industry - to produce holes of various shapes, shaped cavities, profile grooves and grooves in hard alloy parts, for tool hardening, for electric copying, grinding, cutting, etc.

The use of an electric erosion machining is associated with such basic advantages as:

- high accuracy and quality of processing;
- the use of cheaper, easily processed materials for manufacturing of the tool;
- processing of very hard materials;
- the ability to handle any current-conducting metals and alloys regardless of their physical properties.

At the moment, various electric erosion copying and broaching machines of both domestic and foreign production with manual control or with numerical program control are widely used in industry. Depending on the model the machine's productivity varies from 70 to 1100 mm^3 / min, the surface cleanliness is on average R_z = 80 ... 320 μm for roughing work and Rz = 20 ... 40 μm for finishing work, the surface roughness parameter at finishing regimes R_a = 0, 08 ... 3.2 μm with a processing accuracy of 0.003 to 0.04 mm. As it can be seen from the parameters of the resulting surface in most cases the parts do not need further processing.

Taking into account the peculiarities of the technology of electric erosion machining, its application is possible when restoring the slit surfaces of the synchronizer carriages.

Both in production and in the used recovery methods, after the machining of the carriage a heat-hardening step is performed [4,5]; it helps to create a surface with a high hardness of HRC 55, which is impossible initially due to the complication of machining. The electric erosion machining allows to process metals with any hardness of the surface, which simplifies the technology of spline joint

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restoration leading to surfacing of worn splines with a wire of high hardness, for example, 51 HFA (hardness is HRC 50-55), and further electric erosion machining of welded surfaces.

Orenburg State University together with the Naberezhnye Chelny Institute (branch) of KFU has developed and patented a method for restoring the surfaces of the synchronizers carriage with an electric erosive machining [8], the scheme of which is shown in Fig. 2.

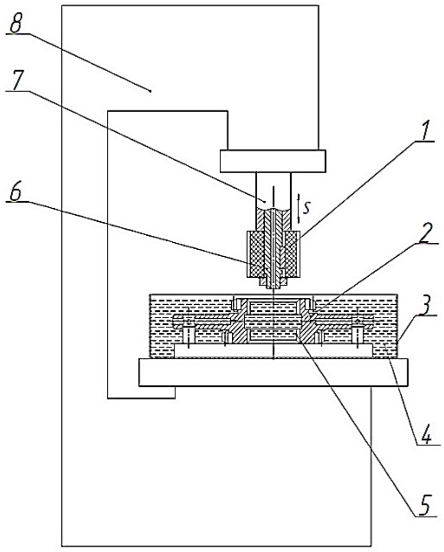

Fig. 2. Scheme of restoration process using the electric erosion machining of the worn out surfaces of synchronizer carriages:
1 - a template graphite electrode tool; 2 - the synchronizer carriage; 3 - bath; 4 - cooling liquid; 5 - weld layer of high hardness; 6 - electrode holder; 7 - the spindle of the machine providing the translational movement of the template electrode-tool; 8 – electric erosion machine tool

It is necessary to produce a template graphite electrode tool 1, for example graphite NK1, with a surface in the form of a copy of the interface surface of the response part (spline surfaces of the carriage), which is installed in the spindle 7 of the electric erosion machining, for example 4A611C. On the worn surface of the slots of the synchronizer bracket (piece No. 142.1701151), surfacing with 51 HFA wire or similar in carbon dioxide is performed, after which the part is immersed in a bath 3 filled with a cooling liquid (low-molecular hydrocarbon fluids of different viscosity) 4. In accordance with the characteristics of the welded high-hard material 5, the operating modes of the machine 8 are adjusted to provide the required dimensions, shape and surface cleanliness. In the process of electric erosion machining, current flows to the template electrode tool through the electrode holder. The processing of the welded high-hard material occurs with the translational motion of the template electrode tool, which provides the spindle of the machine. Thus, the surface of the teeth or slots of the synchronizer carriage is restored to the nominal size, desired shape and cleanliness of the surface of the finished part.

The technical result of the proposed methods is to provide the possibility of multiple restorations of the surface of the teeth or slots of the synchronizer carriage without machining to the nominal size, desired shape and surface cleanliness.

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The proposed method of restoring the carriages of synchronizers of KAMAZ gearboxes using electric erosion machining is a promising and less resource-intensive method in comparison with the existing recovery methods used. With minor improvements (selection of operating modes of the plant and manufacturing of the necessary graphite electrodes), this method is applicable for the restoration of any parts having spline joints.

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