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Methods for Recovery of Keyways of Electric Motor Shaft

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Abstract. *The aim of the study is to develop a technology for the restoration of keyways in electric motor shafts. The statistics of the restored parts of the type of bodies of revolution at the repair enterprises of the Karaganda region are presented. Defects of keyways of electric motor shafts are given. Methods for restoration of keyway slots are described, as well as the features of these restoration methods. The traditional and proposed technologies for the restoration of keyways are presented. Optimal modes of surfacing during restoration of keyway slots are given. The values of hardness in the deposited layer and in the fusion zone of the keyway have been determined.*

Keywords: *surfacing, restoration, parts such as bodies of revolution, defect, motor shaft, keyway, hardness.*

Introduction

It is known that the processes of restoring parts are technically justified, economically justified, resource-saving, since they allow you to repeatedly use worn-out parts.

Today, domestic enterprises are forced to buy foreign equipment – more expensive with better ergonomic characteristics, due to the lack of several items of equipment of competitive domestic production. As a result, in modern conditions, the issue of technical service of imported cars becomes acute, given the lack of working design documentation, repair technologies, spare parts, which is very costly for enterprises.

One of the main groups of worn-out parts that are now being massively restored are the shafts of various machines and mechanisms. In machines arriving for repair, the parts to be restored reach 50%, while the cylindrical surfaces have more than 50% wear and damage from the total volume of the restored parts.

Machine-building and repair enterprises of the Karaganda region, restoring shafts of various mechanisms, spend a huge amount of resources on restoring the surfaces of the shafts, and therefore it is necessary to develop a resource-saving restoration technology that ensures the qualitative characteristics of the shafts, which is very relevant.

Research methods

When researching the issue, the data of the following enterprises of the Karaganda region were analyzed:

- LLP «Energozavod»;
- JSC «KaragandaEnergoRemont»;
- LLP «Barusan Makina Kazakhstan»;
- LLP «Kurylysmet» Production No. 1;
- LLP «Karaganda Turbomechanical Plant».

On the basis of statistical data, it was found that more than 60% of all repaired and refurbished parts are parts such as bodies of revolution (Figure 1).

Before the repair production of any enterprise, a very specific task is set to increase the volume of restoration and improve the technology for the restoration of worn-out machine parts with a minimum cost of resources and an increase in their service life. 50-60% of the manufacturing cost is the cost of restoring parts, and an increase in the volume of restoring can significantly reduce the cost of repairing machines. Therefore, it makes sense in this matter to consider the reduction in the number of operations when reconditioning shafts in comparison with the production of new parts and using the existing recovery technology.

Results and discussion

Most of the visited enterprises of the Karaganda region are engaged in the repair and restoration of electric motor shafts. Figure 2 shows the worn surfaces of electric motor shafts.

Worn shaft surfaces are repaired by hardfacing. Its popularity is based on the fact that it allows high-quality hardening of shafts, giving them new shapes, creating an additional layer on the surface with specific mechanical and physical parameters, and restoring the original geometric dimensions of a worn part.

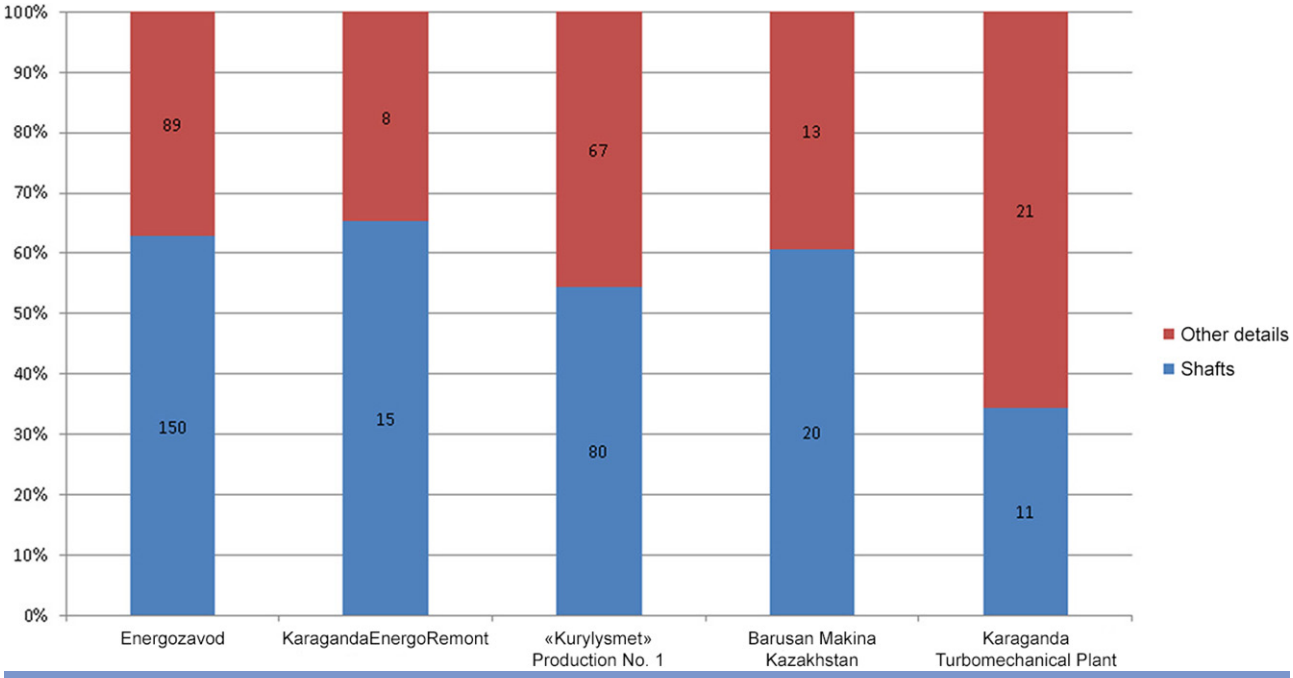


Figure 1 – Parts remanufactured at machine-building enterprises of the Karaganda region (2020)

During the restoration, machine-building and repair enterprises of the Karaganda region use such surfacing materials as:

- wire CB-08G2C, CB08;
- electrodes MP3, T-590;
- wires of the EESAB OK Tubrodur 35 GM SAB OK Tubrodur 35 GM brands; ESAB OK Tubrodur 60 GM.

The composition and characteristics of the used surfacing materials are presented in Table 1.

The table shows that the hardness of the used surfacing materials is in the range of 285÷800 HV.

The wear and tear of the keyways, as well as the wear of the key itself, is one of the main reasons for the rejection of electric motor shafts. It was found that the grooves are the most worn out places of the shafts and are the most difficult to restore. Figure 3 shows the defects of the keyways.

A typical technology for rebuilding the keyways of electric motors is based on an annular submerged arc surfacing along with the entire journal and then cutting the groove on the other side of the journal with an offset of 90°-120°.

The disadvantage of this restoration method is the significant consumption of surfacing material, which is necessary to fill the groove itself, and to cover the entire shaft journal, which is economically unprofitable. Also, heating along the entire neck leads to its warping, after which the shaft needs to be straightened.

Also known is a method of local restoration of the keyway by cold welding using Superior Metal – a two-component epoxy composition Loctite 3478. The disadvantage of this method is the large forced deformation of the base metal and the adhesive layer, reaching 60-70%. In this case, it is necessary to perform additional operations in order to reduce forced deformations, such as: preheating of parts to 300°C or heating of compression punches to 400°C; preliminary compression of the part around the power punch.

Another way to repair the keyway is by setting a stepped key after expanding and deepening the keyway by milling. However, such repairs do not provide high accuracy and quality of the connection.

Taking into account the shortcomings of existing technologies, an attempt was made to develop a resource-saving technology for restoring the keyway with the provision of quality characteristics.

Table 2 shows the typical technology used at JSC «Karagandaenergoremont» and the proposed technology.

The proposed technology has been tested experimentally.

To carry out experimental studies, a cylindrical sample was made of steel 45. A groove with a size of 28×10 mm and a length of 80 mm was milled on a rod with a diameter of 40 mm (Figure 4).

The keyway was welded using a 30Kh18N10 flux-cored wire using a Kemppi Kempact Mig 2530 semiautomatic device.

Experimentally, the optimal surfacing modes have been established for the following parameters: voltage 27V and wire feed speed 6 m/min (Figure 5).

The surfacing of the keyway was carried out with additional shielding with CO_2 gas. Surfacing was carried out in multi-layer, beads.

After solidification, a thin slag crust formed on the surface of the deposited bead (Figure 6), while each surface of the previous layer was thoroughly

Figure 2 – Typical defects of electric motor shafts

Table 1 – Composition and characteristics of surfacing materials

Wire brand, electrode	Mass fraction of elements in the deposited metal, %				Weld metal hardness
	C	Mn	Si	Cr	
ESAB OK Tubrodur 35 GM	0,21%	1,40%	1,10%	1,47%	285-395 HV (30/40 HRC)
ESAB OK Tubrodur 60 GM	0,67%	0,78%	0,71%	5,33%	626-832 HV (55/62 HRC)
CB-08G2C	0,05-0,11	1,80-2,10	0,70-0,95	≤0,2	179-208 HV
MP 3	0,1	0,5-0,8	0,2	-	285-395 HV (30/40 HRC)
T 590	3,2	1,2	2,2	25,0	800 HV (61 HRC)

cleaned from slag.

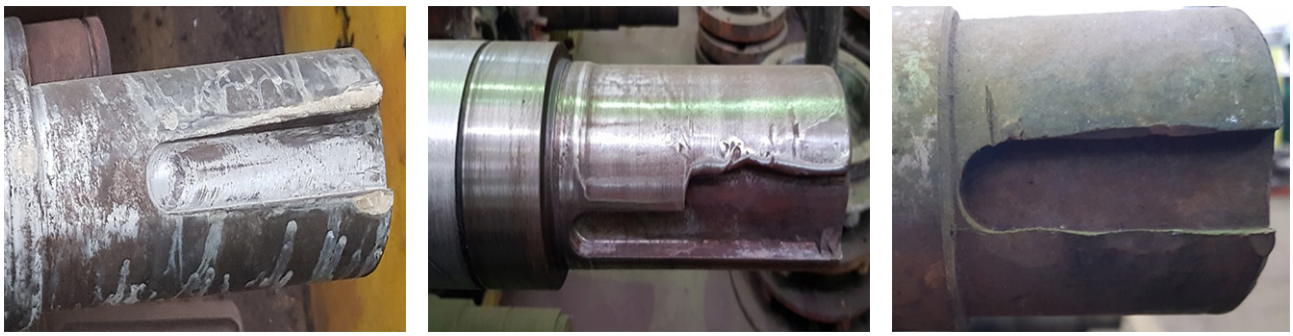
After surfacing, samples were made to determine the hardness of the deposited layer, the hardness in the mixing zone and the hardness of the base metal (Figure 7).

Each measurement was carried out three times. The arithmetic mean values of hardness are presented in the Table 3.

Since the deposited layer is sufficiently hard both with the traditional technology and with the proposed one, and it is also necessary to ensure the accuracy characteristics of the keyway, the development of a special end mill is required, which requires additional research.

Conclusions

As a result of the studies of existing restoration technologies, it was revealed that the main problem in the restoration by surfacing of surfaces with keyways is a strong heating of the shaft, which causes warping



a) b) c)

a) wear of the keyway in width; b) a cut of the side surface of the keyway; c) crushing, nicks on the side surfaces of the keyway

Figure 3 – Defects of keyways

Table 2 – Technologies for restoration of keyways

Typical technology	Proposed technology
Cleaning	Cleaning
Welding the keyway	Semiautomatic surfacing of a keyway
Annular surfacing of the semi-automatic shaft journal in CO_2 shielding gas with electrodes or flux-cored wire C-08-G2C	Not required
Air tempering furnace (24 h)	Air tempering furnace (24 h)
Restriking shaft	Not required
Not required	Grinding the weld-on keyway
Machining the journal of the shaft or the entire shaft	Machining a groove with an end or disc mill
Cutting a new keyway on the opposite side of the shaft journal (90°-120°)	Not required
Control of tolerances for parallelism of the keyway relative to the axis of the part and for its symmetry, roughness	Control of tolerances for parallelism of the keyway relative to the axis of the part and for its symmetry, roughness

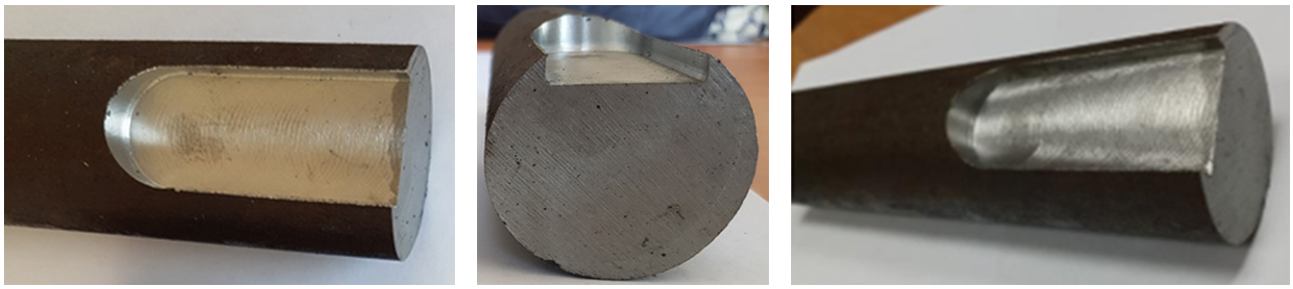


Figure 4 – A sample of a part with a keyway open on one side with a radius exit

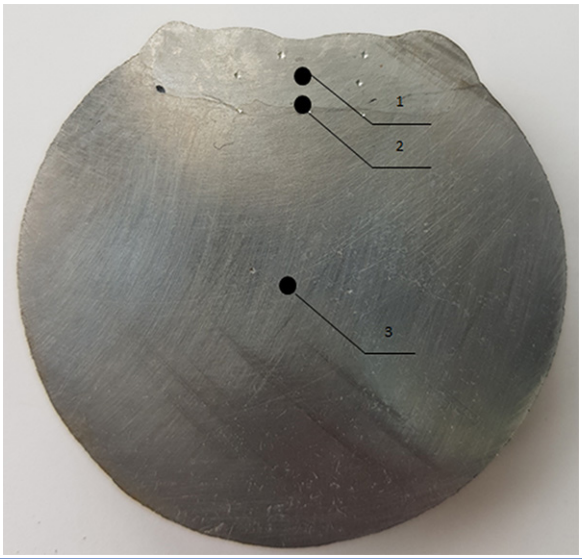
and a change in the structure of the surface layer of the metal.

When controlling the hardness of the deposited layer, it was found that the hardness of the deposited layer is 337-372 HV, which subsequently causes difficulties in the subsequent machining of the deposited surface of the keyway.

Therefore, further research should be carried out in terms of the development of a special tool for machining the overlaid keyways, as well as the method of processing the keyway after surfacing and establishing optimal cutting conditions when processing the keyway after surfacing.

Figure 5 – Parameters of surfacing mode

Figure 6 – Surfaced keyway



1 – main deposited layer; 2 – fusion zone; 3 – base metal

Figure 7 – Sample for testing hardness

Table 3 – The arithmetic mean values of hardness

Sample zones	Deposited layer (2 mm from the fusion zone)	Fusion zone	Base metal (steel 45)
Hardness value, HV	337	372	262

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Электр қозғалтқыштарының біліктеріндегі кілтек ойықтарын қалпына келтіру әдістері

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Аңдатпа. *Зерттеудің мақсаты – электр қозғалтқыштарының біліктеріндегі кілтек ойықтарын қалпына келтіру технологиясын жасау. Қарағанды облысының жөндеу кәсіпорындарындағы қалпына келтірілген айналу денелері типтес бөлшектердің статистикасы келтірілген. Электр қозғалтқыштарының біліктеріндегі кілтек ойықтарының ақаулары келтірілген. Кілтек ойықтарын қалпына келтіру әдістері, сондай-ақ, осы қалпына келтіру әдістерінің ерекшеліктері сипатталған. Кілтек ойықтарын қалпына келтірудің дәстүрлі және ұсынылған технологиялары берілген. Кілттек ойықтарын қалпына келтіру кезінде балқытудың оңтайлы режимдері келтірілген. Балқытылған қабат және кілтек ойығының балқу аймағындағы қаттылық мәндері анықталды.*

Кілт сөздер: *беткі қабат, қалпына келтіру, айналу денелері, ақау, қозғалтқыш білігі, кірме жол, қаттылық сияқты бөліктер.*

Способы восстановления шпоночных пазов валов электродвигателей

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Аннотация. *Целью исследования является разработка технологии восстановления шпоночных пазов валов электродвигателей. Представлена статистика восстанавливаемых деталей типа тел вращения на ремонтных предприятиях Карагандинского региона. Приведены дефекты шпоночных пазов валов электродвигателей. Описаны способы восстановления шпоночных пазов, а также особенности этих способов восстановления. Представлены традиционная и предлагаемая технологии восстановления шпоночных пазов. Приведены оптимальные режимы наплавки при восстановлении шпоночных пазов. Определены значения твердости в наплавленном слое и зоне сплавления шпоночного паза.*

Ключевые слова: *наплавка, восстановление, детали типа тел вращения, дефект, вал электродвигателя, шпоночный паз, твердость.*

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