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Application of Анк-18 Ceramic Flux for Restoration of the Crankshaft of the Ямз Engine

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Restoration of crankshafts of automobile engines of the ЯМЗ type by automatic surfacing with subsequent heat treatment in the conditions of car repair enterprises is difficult to implement due to the lack of powerful installations for hardening necks with high-frequency currents.In addition, crankshafts have reduced fatigue strength and often break during operation, which creates additional difficulties in developing the technology for their recovery.

In this regard, alloying fluxes and carbon wire were used for automatic neck surfacing, and alloyed solid and flux-cored wires were used to obtain the deposited metal with the required hardness and microstructure without pores and cracks. At the same time, mandatory mechanical hardening of the restored crankshafts was provided.

A ПСО-500 converter or selenium rectifiers of the ВСГ-3М type were used to power the surfacing installation. To obtain an idle voltage of 32 V and an arc of 25÷26 V, four rectifiers were connected into a block. The best formation of the rollers and the entire layer was obtained when powered by rectifiers.

Surfacing modes were tested on samples with a diameter of 85 mm from steel 50Г and 65Г and crankshaft journals ЯМЗ-236.

Table 1.

No. of sample series	Welding consumables (base metal, electrode wire, flux)	Weld metal characteristic	
		Hardness HRC	microstructure
1	Non-surfacing connecting rod journal of the crankshaft ЯМЗ -236	50 - 52	Troosto-martensite
2	Steel 50Г, wire Нп-70, mixture: 50% АН-348А with 50% АНК-18	42 - 46	Troostitis
3	Steel 50Г, wire Нп-2Х13, flux АН-348А	52 - 54	alloyed austenite
4	Steel 50Г and 65Г, wire ПП-3Х5Г2М with self-protection, open arc surfacing (without flux)	55 - 57	Troosto-martensite with carbide eutectic along grain boundaries
5	Steel 50Г and 65Г, wire Нп-70. ceramic flux АНК-18	54 - 58	Martensite with thin carbide eutectic along grain boundaries

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Numerous experiments have shown the possibility of several combinations of materials, when using which defects in the deposited layer were not observed and its hardness was quite high. All options can be used for surfacing various parts made of steel 50Г and 65Г (Table 1).

As can be seen from Table 1, the microstructure and hardness of the metal are the best when surfacing samples of series No. 4 and 5. However, when automatically surfacing necks with Нп-70 wire under АНК-18 flux, the results are more stable.

A distinctive feature of the use of АНК-18 flux in comparison with surfacing under alloying flux (АН-348А with an admixture of 2% ferrochrome No. 6 and 2.5% graphite), used at car repair plants to restore crankshafts ГАЗ-51 and ЗИЛ-164, is the need for a significant decrease in the speed of movement of the deposited surface and an increase in the step of surfacing. Only under these conditions, the deposited metal is well formed and the slag crust is easily separated.

Table 2. Welding mode for automatic hardfacing of crankshaft journals ЯМЗ-236

№	Parameter	Selenium rectifiers ВСГ-3М	Converters ПСГ-500
1	Open circuit voltage, V	30	40
2	arc voltage	25÷26	26÷27
3	The strength of the welding current, a	170÷ 180	160÷180
4	The inductance of the coils of the РСТЕ-34 inductor	10	-
5	Wire diameter Нп-70 (ГОСТ 10543-83), mm	1,6	
6	Wire feed speed, m/min	1,9÷2,0	
7	Surfacing step, mm/rev	5,9÷6,0	
8	Shaft revolutions when surfacing necks, rpm: connecting rod indigenous	 1,0÷1,2 0,9÷1,1	
9	Displacement of the electrode from the zenith of the part against the course of its rotation, mm	12÷15	
10	Thickness of the deposited layer, mm	2,0÷2,2	

When surfacing the journals of crankshafts ЯМЗ-236 in the reduced mode, the АНК-18 ceramic flux in combination with high-carbon wire provides high resistance of the deposited metal against the formation of pores and cracks. The resulting finely acicular martensitic microstructure of the shackle surface is known to be sufficiently wear-resistant.

When developing a technology for restoring ЯМЗ-236 crankshafts, it is most important to increase fatigue strength, since even when surfacing necks and fillets under АНК-18 flux, the strength of fillets is reduced by 20-25%. This is due to a sharp difference in the structure and hardness of the deposited and base metal.The samples were tested for fatigue strength, the deposited metal of the fillets of which had a structure and hardness close to normalized steel 50Г. Such a metal lends itself well to plastic deformation, which makes it possible to effectively harden it with work hardening.

Comparative fatigue test results at 5 millioncycles of non-surfacing and deposited, non-hardened and hardened samples of steel 50Г, simulating the connecting rod journals of the ЯМЗ-236 crankshafts, are given in Table. 3.

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Table 3.

No. of sample series	Characteristics of necks and fillets	Fatigue strength limit, kg/mm^2
1	Unwelded	12
2	Fillets deposited with Нп-30ХГСА wire under АН-348А flux, necks - with Нп-70 wire under АНК-18 flux. After surfacing of fillets, heating up to 60÷650C, air cooling	12
3	The same, but with hardening of fillets	23
4	Fillets deposited with Нп-30ХГСА wire under АН-348А flux, necks - with Нп-70 wire under АНК-18 flux, fillets were not hardened	11
5	The same, but with hardening of fillets	28
6	Fillets deposited with Св-08 wire under АНК-18 flux, necks - with Нп-70 wire under the same flux, fillets were not hardened	11
7	The same, but with hardening of fillets	25

Table 4.

№ series of segm ents	Characteristics of segments	Place of hardening	Number of cycles to failure (thousand) at a stress of 27 kg/mm^2	Place of destruction	Fatigue strength limit, kg/mm^2
1	Not deposited nye	Unstrengthened nye	160	On the fillet of the crankpin	8,5 – 13,5
2	Not deposited nye	Fillets of connecting rod and main journals	>10 million.	Not collapsed	28
3	Welded	Fillets of connecting rod and main journals	487	On the fillet of the crankpin	16
4	Welded	Crankpin fillets	412÷462	Along the fillet of the root necks	15

As can be seen from Table 3, when restoring ЯМЗ-236 crankshafts, surfacing of fillets and necks with hardening of fillets can be used (samples of series No. 5 and 7). Options for surfacing samples of series No. 4 and 6 do not provide the necessary strength of parts, and options No. 2 and 3 are more difficult than the others and the effect of their use is smaller.

Other methods of surfacing and hardening of fillets are also being developed. At this stage of research, it can be considered a more technological option for surfacing specimens of series No. 7, in which Св-

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08 wire (ГОСТ 2246-60) is used for surfacing fillets and spring Нп-70 (ГОСТ 10543-63) for necks and in both cases flux АНК - 18.

It should be noted that the fatigue strength of the journals is higher than that of the crankshafts by about one and a half times, and sometimes more, depending on the thickness of the cheeks and other structural elements.

Comparative tests were carried out for fatigue strength of sections of full-scale crankshafts ЯМЗ-236 (Fig. 1), the connecting rod journals of which were restored by automatic surfacing from selenium rectifiers in the mode given above. The fillets were welded under АНК-18 flux with Св-08 wire, necks - with Нп-70 wire under the same flux.

The samples were tested for bending in the plane of the knees at 10 million cycles.To determine the nature of the fracture, two samples of each series were tested for endurance at a stress of 27 kg/mm^2, which is more than the fatigue strength limit by 13.5÷18.5 kg/mm^2 (Table 4). Table 4 shows that it is possible to harden the restored ЯМЗ-236 crankshafts only along the fillets of the connecting rod journals.At the same time, the fatigue strength of the deposited crankshafts (series No. 3 and 4) is approximately 11÷17% higher than that of the non-surfaced ones (series No. 1). The microstructure of the deposited metall (Fig. 2) is a finely acicular martensite with fine carbide eutectic along the grain boundaries. The metal of crankshaft journals with such a microstructure is known to be the most wear-resistant. There are no cracks, pores or other defects in the deposited layer.

The hardness of the deposited necks is uniform and is equal to HRC 57, and for fillets at the beginning of neck surfacing HRC 43 and at the end HRC 40.

ЯМЗ-236 crankshafts are hardened with a percussion tool in the form of a chisel with a rounded working part by 1/2 or 2/3 of the fillet radius. The edges of the openings of the oil channels were reinforced with a special beard. The blows were applied with a metalwork or pneumatic hammer.

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