EXPERIENCE IN HARDFACING OF PROPELLER SHAFTS AT THE PJSC KHERSON SHIPYARD

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The industrial experience in repair arc hardfacing of marine propeller shafts is described. Data on the upgraded hardfacing machine and on the peculiarities of selection of shafts with defects to repair them by the hardfacing technology are given.

Keywords: *arc hardfacing, modernized installation, propeller shaft, cyclic loading, wear, restoration, industrial experience*

At the marine and river ships the parts of many mechanisms and devices (propeller shafts, spindles, rudder pins etc.) operate under conditions of cyclic loading and effect of corrosion environment. Under the influence of aggressive environment and other factors the surfaces of the parts are subjected to corrosion, intensive wear, thus leading to coming out of order of parts. The propagation of surface cracks can result in unpredicted fractures at cyclic loading.

The ship propeller shafts, spindles, rudder pins relate to the category of critical ship parts which bear considerable alternating loadings during their service. They remain under supervision of the Russian Maritime Register of Shipping (RMRS) and high requirements are set to their restoration. This is the reason why NA «Mortekhsudoremprom» approved RD 31.52.82–88 «Ship propeller shafts. Restoration using electric arc hardfacing by pearlite and chromium-nickel steels».

At the «Kherson Shipyard» to make hardfacing of propeller shafts of diameter up to 400 mm under flux the installation is applied, mounted on the base of the machine RM 461E for gas cutting of pipes with smooth control of speed of shaft rotation and dependent movement of electrode along the element of a shaft (Figure 1).

Figure 1. Hardfacing installation on the base of machine RM 461E

The installation is equipped with hardfacing head from feeding mechanism of the semi-automatic machine PDG 508M and flux hopper (Figure 2, *a*). In capacity of power source the rectifier VS 630 is used. The hardfacing of the first (experimental) propeller shafts was carried out according to the program approved by RMRS.

Propeller shafts with wear, corrosion fractures, cracks and collapses around the cone, under linings and in the rest part of a shaft, as well as corrosion cavities and other surface defects which can be the sources of fatigue cracks initiation are subjected to restoration surfacing. The shafts having such defects of depth of not more than 5 % in the limits of calculative (according to RMRS regulations) diameter of a shaft are admitted to restoration. During the wear exceeding 15 mm per side the restoration of shafts using surfacing is not admitted. The surface of a shaft subjected to surfacing should be machined until complete elimination of defects and should not have traces of dents, corrosion fractures, cracks, laminations, non-metallic inclusions.

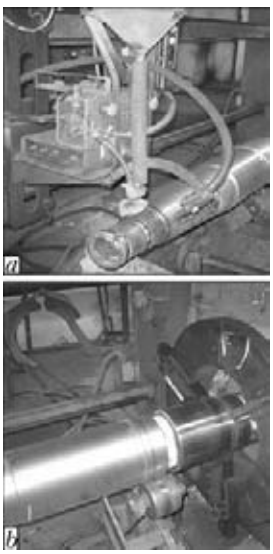

Figure 2. Hardfacing head of the installation (*a*) and shaft mounted in cartridge (*b*)

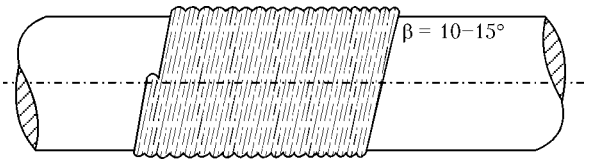

Figure 3. Scheme of one-pass hardfacing along the spiral line

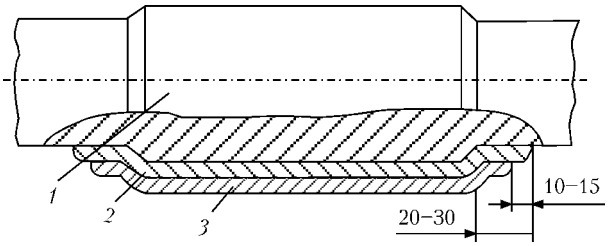

Figure 4. Scheme of performing anti-corrosion surfacing of shaft: *1* — base metal; *2* — low-carbon metal of deposited sublayer; *3* — high-alloyed austenitic deposited metal

The shaft prepared to surfacing is installed on wheel carriages, inserted into the cartridge (see Figure 2, *a*) and slightly clamped and then adjusted according to the level. After verification the shaft is finally clamped.

The run-out of deposited surfaces should not exceed 0.1 mm. The cartridge serves only for shaft rotation. The shaft should fit to wheeled carriages. It is prohibited to insert shaft into the cartridge using crane to prevent impacts of a shaft against the cartridge.

The restoration of worn surfaces is performed along the spiral line with overlapping of neighboring beads according to the scheme given in Figure 3.

To protect the propeller shafts and spindles, manufactured of conventional steels, from the influence of aggressive environment, their surface is deposited with lining of high-alloyed metal resistant against corrosion in sea water. The deposition of stainless corrosion-resistant layer of austenite steel on the propeller shafts, spindles and other parts should be performed only along the sublayer of low-alloyed steel (Figure 4). The sublayer of low-carbon steel is deposited using wire of grade Sv-08A, Sv-08AA under flux AN-348A or OSTs-45. The thickness of sublayer should be not less than 3–4 mm.

To obtain corrosion resistant layer the surfacing under the fluxes of grades AN-20 or AN-26 is applied using wire Sv-08Kh20N9G7T having high technological properties and providing high quality of deposited metal and, at their absence, the welding wires Sv-06Kh19N9T or Sv-04Kh19N11M3 are used. The thickness of corrosion-resistant deposited layer should be not less than 5.0–6.5 mm.

Figure 5. Propeller shaft as-assembled with screw

Chemical composition of wire Sv-04Kh19N11M3 and deposited metal, wt.%

Material	C	Mn	Si	Cr	Ni	Mo
Wire Sv-04Kh19N11M3	0.04	1.03	0.25	18.40	11.4	2.9
Deposited metal	0.07	–	–	16.07	10.0	2.9

To reduce the mixing of corrosion-resistant metal with low-carbon metal the first layer of austenite steel is deposited at the moderate conditions with low heat input at as lower as possible penetration depth of sublayer.

One of the deposited propeller shafts, as-assembled with a screw before mounting to the ship, is shown in Figure 5.

The investigation of stainless steel corrosion-resistant layer, deposited using wire Sv-04Kh19N11M3 under the layer of flux AN-26S to protect the propeller shaft of 200 mm diameter against corrosion in sea water, was carried out. The deposition was performed along the sublayer of low-carbon steel under the supervision of RMRS. To decrease mixing of corrosion-resistant metal with low-carbon metal of sublayer, the first layer was deposited using wire Sv-04Kh19N11M3 at moderate modes with low heat input at lower penetration depth of sublayer: I_w = 190 A; U_a = = 27 V; v_h = 24 m/h; electrode stickout 20 mm; shifting of electrode from zenith 14 mm; diameter of electrode is 2 mm.

During investigation of microstructure of fusion zone of corrosion-resistant deposited layer with sublayer of low-carbon steel no defects were detected. The results of chemical analysis of wire Sv-04Kh19N11M3 and the metal deposited by it are given in the Table.

The investigations showed that accepted technology allows conducting surfacing of propeller shafts with high quality and according to the requirements of RD 31.52.82–88.

In recent years at the «Kherson Shipyard» the hardfacing of more than 80 propeller shafts of different diameters of ships being in repair was performed.