6. As shown by the investigations, hybrid laser-arc welding allows producing the welded joints on low and medium titanium alloys with properties that are not inferior to properties of the base metal.

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CORROSION-FATIGUE STRENGTH OF 12Kh18N10T STEEL T-JOINTS AND METHODS OF ITS IMPROVEMENT

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Results of fatigue testing the T-joints of stainless steel 12Kh18N10T in air and in corrosion medium are given, and the effect of surface strengthening on improvement of strength properties and fatigue life of welded elements of hydrofoil wing ship assemblies is also determined.

Keywords: *arc welding, MMA welding, TIG welding, stainless steel, welded joints, corrosion medium, fatigue strength, fatigue life, surface strengthening, residual stresses*

The stainless steel of the austenite class of the grade 12Kh18N10T is widely used in manufacture of different welded structures which in process of operation are subjected to influence of the alternate loads. They include foil systems (FS) of foilcrafts (FC), rollers of heating furnaces of metallurgy enterprises, welded components of products of chemical and power machine building.

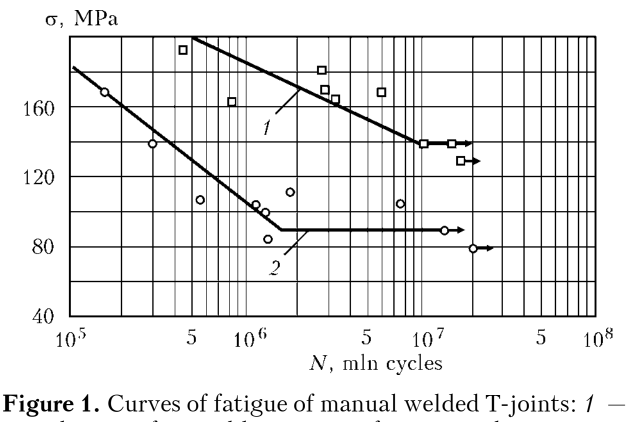

Figure 1. Curves of fatigue of manual welded T-joints: *1* — initial state after welding; *2* — after strengthening using BPS

In this study the results of fatigue tests of T-joints of steel 12Kh18N10T in air and sea water both in as-welded state, as well as after strengthening treatment applying ball-pin strengthener (BPS).

The experience of service of vessels of the type «Kometa» showed [1, 2] that in FS the cracks are formed on the planes of wings, at the places of joining the bracket with the wing plane, in brackets of propeller shafts. During operation under conditions of the Azov sea, the cracks in ships «Kometa» and «Kolkhida» are formed during 1.5–2 months after repair and after 2–3 weeks under the conditions of the Black Sea. They have to be eliminated by grooving and re-welding of defective places that is accompanied by significant expenses connected both with the repair itself, and also at taken the ship from the service in the navigation period.

The fatigue life of FS can be increased by the new constructive solutions or by technological operations, which include in particular the strengthening treatments which create compressive stresses in the surface layers [3, 4].

The purpose of this work is to evaluate the effect of strengthening treatment on the fatigue life and strength of FS of the ships of the «Kometa» type.

For this purpose the specimens with T-joints were manufactured of sheet rolled metal of steel

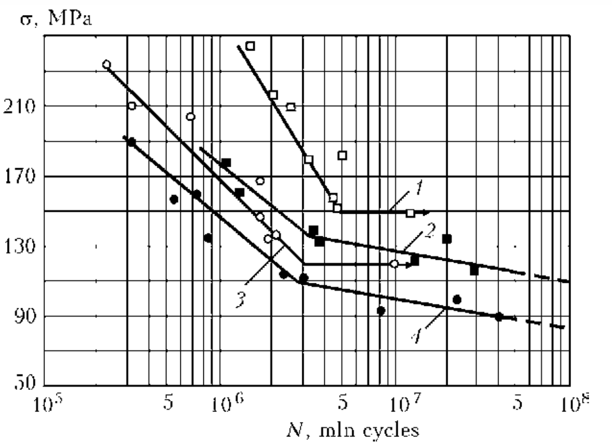

Figure 2. Curves of fatigue of TIG-welded T-joints: *1* — after strengthening applying BPS (air); *2* — after strengthening (sea water); *3* — initial state after welding (air); *4* — initial state (sea water)

12Kh18N10T of 12 mm thickness and welded using manual welding with electrodes EA-400/10U and also argon arc welding with filler wire Sv-04Kh19N11M3.

Steel 12Kh18N10T has the following chemical composition, wt.%: 0.09 C; 1.52 Mn; 0.71 Si; 18.4 Cr; 10.2 Ni; 0.19 Cu; 0.76 Ti; 0.08 S; 0.018 P, and mechanical properties σ_t = = 588 MPa; σ_y = 363 MPa; δ = 55 %.

The tests were carried out using resonance installations at console bending by a symmetric cycle. The frequency of loading was 35–45 Hz. The width of test part of the specimens was 100 mm [5]. The base of tests in air was 10^7, in corrosion medium (sea water) — $3\cdot10^7$ cycles. The fatigue strength obtained at this base was extrapolated according to the equation of the second region of a corrosion fatigue curve to base of 10^8 cycles [6].

In total six batches of specimens were tested, ten pieces in each one. Weld and near-weld zone of width of up to 15 mm on the both sides of a weld were subjected to strengthening. The fractured specimens of post-fatigue tests were used to manufacture sections on which the location of a crack as well as depth of strengthened layer were determined. In surface layers subjected to strengthening the microhardness of cold-worked metal was 3220–4240 MPa, whereas of non-cold-worked layer was 2460–3010 MPa, and depth of strengthened layer was 2 mm.

Test results showed the following. The fatigue strength at tests of specimens made by the manual welding in air (Figure 1) increased from 90 to 140 MPa after strengthening, i.e. 1.5 times, the fatigue life at stresses 140–180 MPa increased 14–20 times.

Fatigue strength of specimens, made by argon arc welding, increased from 120 to 150 MPa at tests in the air, i.e. 1.25 times, and fatigue life

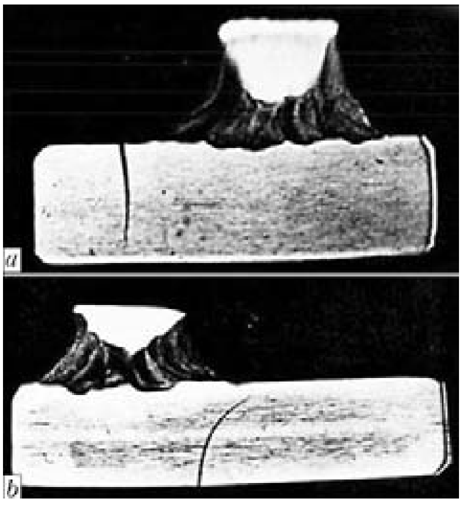

Figure 3. Location of fatigue cracks in welded specimens without strengthening (*a*) and after strengthening using BPS (*b*)

at stresses 150–230 MPa increased 4–8 times (Figure 2, curves *1*, *3*). The fatigue strength in corrosion medium on base of 10^7 cycles increased from 100 up to 127 MPa, i.e. 1.3 times (Figure 2, curves *2*, *4*), fatigue life at stresses 120–140 MPa increased 4–13 times; on the base of $3\cdot10^7$ cycles — from 93 to 120 MPa (1.3 times), fatigue life — 3–13 times; on base of 10^8 cycles (extrapolation) — from 83 up to 100 MPa (1.35 times), fatigue life at stresses 110–120 MPa — 14–30 times.

As is seen from Figure 3, on the specimen passed strengthening the crack initiated and propagated not in the place of weld transition to the base metal (as usual), but on the opposite side. Probably this fact was observed for the first time.

The above-given data are differed from those obtained by us earlier [7], i.e. the effect from inducing of compressive stresses in surface layers by plastic deformation is higher manifested on steel 12Kh18N10T than on steel 15G2FB, and on T-joints it was manifested to a larger extent than on the butt ones.

The results, given in this work, allow recommending the ship owners of FC to use the strengthening treatment using BPS to increase fatigue life and strength of FS of ships of «Kometa» type that will decrease the expenses for repair and increase the reliability of ships of this class.

CONCLUSIONS

1. Fatigue strength of T-joints of steel 12Kh18N10T, made by manual and argon arc welding, on base of 10^7 cycles was 90 and 120 MPa, respectively.

2. Corrosion-fatigue strength of 12Kh18N10T steel T-joints, made by argon arc welding, on base of 10^7 cycles was 100, on base of 10^8 — 83 MPa.

3. Plastic deformation using BPS increased the fatigue strength of steel 12Kh18N10T T-joints up to 140 and 150 MPa for manual and argon arc welding, respectively: fatigue life — 4–8 times for TIG-welded joints and 14–20 times for manual welded joints; corrosion-fatigue strength was increased up to 127 MPa on base of 10^7 cycles and up to 110 MPa on base of 10^8 cycles, i.e. 1.3 times; fatigue life at stresses 110–120 MPa was 14–30 times increased.

4. Hardening treatment of FC FS using BPS can be recommended to implementation at ship repair enterprises.

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INFLUENCE OF CONTENT OF IRON POWDER AND COMPOUNDS OF ALKALI METALS IN THE COMPOSITION OF ELECTRODE COATING ON THEIR SANITARY-HYGIENIC CHARACTERISTICS

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The dependence of the specific precipitations and chemical composition of a hard component of welding aerosol on content of iron powder in electrode coating was established. The effect of content of potassium compounds in coating of rutile and basic electrodes on their sanitary-hygienic characteristics was considered.

Keywords: *manual arc welding, electrodes, electrode coating, welding aerosol, coating composition, sanitary-hygienic characteristics, hard component, specific precipitations*

The manual arc welding with coated electrodes is challenging today and according to the forecasts of the specialists [1, 2] it will continue its existence due to a number of advantages, such as relatively moderate price of the process and consumable materials, possibility of welding in all positions and in hard-to-access places, lack of rigid requirements to welder skills. At the same time, already more than 50 years the searches for ways to improve the sanitary-hygienic characteristics of electrodes are being continued.

Table 1. Conditions of welding using coated electrodes of DZ series

Electrode index	U_w, V
DZ-0	26–28
DZ-1	26–28
DZ-2	25–27
DZ-3	24–26
Note. Welding current of 180 A.	

The factors were determined influencing the evolution of aerosol [3], which consists of a gas-like component of welding aerosol (GCWA) and a hard component of welding aerosol (HCWA). One of the main factors defining the level of specific precipitations and chemical composition of HCWA is composition of electrode coating as far as during heating and melting it is the main source of aerosol, i.e. 35–70 % of the total volume depending on the type of electrode coating [3, 4].

The iron powder, widely used in production of coated electrodes, allows enhancing labor productivity of welder, decreasing the cost of welding works, improving welding-technological properties of electrodes [5]. The increase of productivity is achieved due to increase of transfer