

As in the case of the diboride structure, no appreciable changes were detected in the structure of the $\text{MeB}_2\text{-EuB}_6$ composites. It may be assumed that the diborides block the action of sodium on the hexaborides, preventing it from breaking the grain boundaries in the composite material. These composite materials can apparently be recommended for use in contact with sodium up to 800°C for periods of up to 5000 h.

LITERATURE CITED

1. B. G. Arabei, V. I. Matveev, K. I. Frolova, and V. A. Smirnov, *At. Énerg.*, **29**, 295-298 (1970).
2. P. Hagemuller and R. Naslain, *C. R.*, **257**, 1294-1296 (1963).
3. F. Bertaux and P. Blum, *Acta Crystallogr.*, **7**, 81 (1954).

EFFECT OF DEFORMATION OF 12Kh18N10T STEEL ON PITTING CORROSION IN A MOIST MARINE ATMOSPHERE

É. M. Gutman, S. N. Davydov, and B. Yu. Lukin

UDC 620.194

Articles made from 18-10 type stainless steel (e.g., thin-walled corrugated compensators and metal hoses) are often used in a moist marine climate. Although pitting corrosion was observed on such steels in salt fog in [1], many works ([2], etc.) mention their high corrosion resistance in a marine atmosphere. However, resistance to pitting in electrolytes may be significantly altered by mechanical deformation [3, 4].

Study of pitting corrosion in the deformed steel under conditions approximating to natural conditions was a matter of practical interest. The specimens used were plates ($60 \times 10 \times 0.18$ mm) of 12Kh18N10T, as supplied and after annealing for 20 min at 950°C in a TVV-4 electric vacuum furnace at a residual pressure of $1 \cdot 10^{-4}$ mm Hg; x-ray microspectral analysis revealed no changes in surface chemical composition after annealing. Deformation was applied by an Mr-05-1 tensile test machine, the load being recorded by a tensometric bridge.

The routine for accelerated corrosion tests was selected with regard to [5], in which pitting was stimulated by ultraviolet irradiation. Corrosion tests 60 days in duration were carried out in a UAKK-4 universal corrosion chamber in an atmosphere of salt fog produced by spraying a 3% NaCl solution; the temperature was maintained at 45°C with 100% humidity for 10 h per day and the specimens were subjected at the same time to infrared and ultraviolet irradiation. The source of infrared radiation was a Silit rod, and the source of ultraviolet radiation a PRK-2 type mercury-quartz lamp. The integral intensity of radiation was $7.9 \cdot 10^2$ J/m²·sec. During the rest of the time there was no irradiation, the temperature was slowly reduced to 20-22°, and the humidity decreased slightly. The first hemispherical type pits appeared after 30 days, and then increased in number without appreciable changes in dimensions and shape (depth in the 60-70 μ range).

Six parallel experiments were conducted for each level of deformation. The number of pits was found by the paper replica method [6] (three replicas from each specimen), the results being processed statistically by analysis of variance at a significance level $p = 0.05$ and finding the confidence interval of the results for each level of deformations.

Microdistortions of the crystalline lattice of kind II were defined in a KROS-1 x-ray chamber in radiation from an iron anode at a tube voltage of 2 kV and a current of 3 mA. The repassivation potentials (the breakdown potentials were measured previously in [4]) were measured in 0.1 N sodium sulfate solution in a clamped-on three-electrode cell at room temperature (speed of increase in potential 1.44 V/h). The curves showing the relationship of the potential in the repassivation region to the degree of specimen deformation were obtained by dividing the anodic polarization curves at current density 1 mA/cm².

It is apparent from Fig. 1 that the density of pitting on annealed metal is considerably

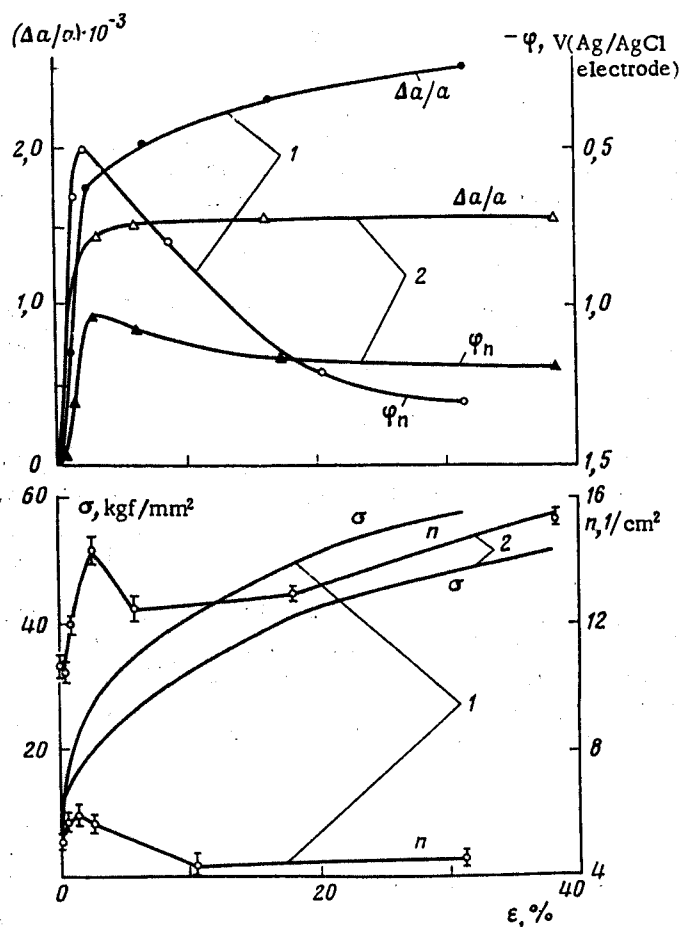


Fig. 1. Effect of degree of deformation ϵ (%) in 12Kh18N10T steel in the unannealed (1) and annealed (2) states on the repassivation region potential φ_p in 0.1 N Na_2SO_4 at current density 1 mA/cm², crystalline lattice microdistortions of kind II $\Delta a/a$, and pitting density n in tests in a moist marine atmosphere.

higher than on unannealed metal at all levels of deformation. The amount of pitting increases with an increase in the degree of deformation of both annealed and unannealed steel and reaches a maximum at the state of intensive strain hardening characterized by the most negative repassivation potentials; σ is the "stress-strain" diagram.

Annealing resulted in enlargement of the austenite grain (from 0.02 to 0.45-0.5 mm) and additional evolution of carbides with subsequent coagulation. The carbide particles contribute to pitting due to a local increase in the mechanochemical activity of the austenite matrix at the contact with the hard inclusion [7]. In microsections ($\times 200$) the sites of pit formation were clearly associated with the carbide segregations; no pitting occurred on specimens quenched at 1050° in water and having no carbide segregations in the austenite grain. Deformation had a greater stimulatory effect on pitting on annealed steel, in spite of the fact that grain enlargement and increased plasticity reduced hardening and cut down the residual microstresses, i.e., reduced the average mechanochemical activity for the grain somewhat. Surface roughness appeared in the later stages of deformation (beginning at 18%), due to easier slip in the annealed steel. Shears developed in the initial slip system and formed large steps on the surface (there was a clear deformation relief and a reduction in the class of surface finish from 8 to 4); the step edges caused an increase in the number of pits in the concluding stage of dynamic recovery.

The inflection points on the curves for microdistortions of kind II and the maximum pitting densities correspond to the same degrees of deformation (2% for unannealed steel and 2.5%

for annealed steel). A similar correlation was observed previously in [4] for statically loaded specimens in electrolyte.

The intensity of the microdistortion accumulation process may vary for different deliveries of steel because of the sensitivity of the dislocation substructure and of certain other characteristics to fluctuations in the content of constituents and impurities (e.g., there are great differences in the tendency to austenite grain growth in different deliveries of steel of the same brand). Thus, in [4] the inflection in the curve for residual stresses of kind II and maximum pitting density occur at a deformation of 8%.

The region of the most dangerous degrees of work hardening from the point of view of pitting corrosion should therefore be ascertained experimentally when choosing a technology for the manufacture of articles by plastic deformation.

LITERATURE CITED

1. Vincens 5-eme Colloq. reg. Chim. Sider. Marseille (1969); Paris (1971), Nos. 21-22 [cited in Referativnyy Zhurnal "Korroziya i Zashchita ot Korrozii," No. 6 (1972), 6K156].
2. I. L. Rozenfel'd, Atmospheric Corrosion of Metals [in Russian], Izd. Akad. Nauk SSSR, Moscow (1960).
3. L. I. Freiman, Ya. M. Kolotyarkin, and A. Ya. Givental', Zashch. Met., 2, 286 (1966).
4. É. M. Gutman, E. V. Budilova, and B. Yu. Lukin, Zashch. Met., 11, 731 (1975).
5. L. I. Freiman, L. Ya. Kharitonova, and Ya. M. Kolotyarkin, Zashch. Met., 7, 594 (1971).
6. A. Randak and F.-W. Trautes, Werkstoffe Korrosion, No. 2, 97 (1970).
7. É. M. Gutman, Mechanochemistry of Metals and Protection from Corrosion [in Russian], Metallurgiya, Moscow (1974).

CORROSION OF SHIPS' HULL STEELS IN THE SEA OF JAPAN

A. V. Samostrel'ova, V. A. Polovin,
and G. A. Goncharova

UDC 620.193.27

Among the seas which wash the shores of the USSR, the Sea of Japan most closely resembles an ocean in the corrosive action of its water [1, 2].

Tests were conducted under natural conditions in the Zaliv Petra Velikogo.

Specimens of hull plate steels St. 3sp, 09G2, 10KhSND, and of high-manganese steel measuring 350 × 250 mm were shot-blasted or pickled in a 15% solution of inhibited hydrochloric acid, followed by neutralizing, washing in running water, and drying. The specimens were degreased with ethyl alcohol and weighed with an accuracy of up to 0.001 g; they were exposed to the sea in April, at the end of June/beginning of July, and in December. Specimens of the same plates were put on comparative tests in the Black Sea at the same seasons and in the same holders. The tests were conducted from 1972 through 1974 with complete constant immersion in the sea at a depth of 0.3-2 m from the surface. Specimens taken out after 1 year were excluded from further tests. Each point was obtained by reference to three specimens. The salinity of the water was 31-34‰, annual fluctuations in water temperature were from -1.8 to +25.1°C, the average annual temperature being 8.5°, the average dissolved oxygen content was 5.2-7.6 ml/liter, and the pH was 7.9-8.3.

After testing, the specimens were cleaned mechanically to remove encrustations and loose corrosion products and pickled in an inhibited 15% solution of HCl. The correction for loss of metal in pickling was made by simultaneously weighing pickled clean specimens of the same steel.

It is apparent from the data given in Table 1 that (all other test conditions being equal) the method of removing scale from the surface of the steel has practically no effect upon the speed of corrosion of hull steels in the sea.

Translated from Zashchita Metallov, Vol. 13, No. 5, pp. 594-596, September-October, 1977. Original article submitted June 21, 1976.