TEST METHODS AND PROPERTIES OF MATERIALS

CORROSION RESISTANCE OF SINTERED SULFIDIZED IRON-BASE MATERIALS


The extensive employment of sintered iron-base bearing materials calls for a full knowledge of their physicochemical properties. Insufficient information is available at the present time in the literature on such an important property of antifriction materials as their corrosion resistance [1,7,8].

The present investigation was undertaken with the aim of determining the influence of alloying additions and porosity on the corrosion characteristics of one of the new iron-base antifriction alloys containing zinc sulfides and graphite, and to establish its operating (storage) life in various aggressive media. The presence of sulfides is known to improve substantially the antifriction characteristics of such materials and, at the same time, to reduce slightly their corrosion resistance [2,4].

Specimens made of sintered porous iron of grade PZh2M, to GOST 9849-61 standard specification, the iron-graphite material ZhGr3 (iron with 3% graphite), and the sulfidized iron-graphite material ZhGr3Tss4 (iron with 3% graphite and 4% zinc sulfide in the charge) were investigated. To compare the corrosion resistance of materials with interconnected or closed pores, a study was made of the behavior of ZhGr3Tss4 alloy specimens with different porosities, as well as specimens of the same alloy impregnated with oil or paraffin wax.

Specimens, in the form of bars 3 × 4 × 40 mm in size, were produced by pressing and sintering. The charge was prepared from powders passed through a No. 01 sieve. The specimen porosity after sintering was 20 ± 1%. Sintering was performed for 90 min at 1080 ± 10°C in a dried-hydrogen atmosphere (dew point −55°C). The structure of the sintered materials consisted of pearlite with 2-4% cementite. To investigate the influence of density on the corrosion resistance of the ZhGr4Tss4 material, specimens 10 × 10 × 60 mm in size, with porosities of 6.5, 15, 25, and 30%, were prepared under the same conditions. (The specimens of 6.5% porosity were produced by double pressing and sintering.)

Corrosion-resistance tests were conducted in a special chamber (Fig. 1) enabling marine conditions (spraying, mist, high humidity) to be simulated. The chamber consists of the stainless-steel shell 17, within which are placed all the auxiliary devices necessary for the operation of the apparatus. The space in the Perspex jar 8 is provided for suspending specimens from special holes in the shield 7. Water or an aggressive solution is poured into the container 5, from which it is transferred, by means of the eccentric 2 into the reservoir 12. The solution is heated with the element 11 and splashed or sprayed with the rotating impeller 16. The chamber is hermetically closed with the cover 15 by means of the screws 9. The temperature in the chamber is maintained at 40 ± 3°C, the humidity being 98%.

Tests were carried out in mains water vapor and in a spray of 3% aqueous NaCl solution, and in addition under atmospheric conditions (outdoors).

The corrosion resistance of the materials was evaluated from changes in the electrical resistivity and weight of specimens. It should be noted at this stage that the method of studying the corrosion of porous materials on the basis of their weight gain lends itself only to comparative evaluation, because some corrosion products may be lost from the specimen surface during testing. The method based on the removal of corrosion products by means of various reagents is altogether unsuitable for the testing of porous materials. In view of this, tests on porous specimens were conducted until the appearance of distinctly visible corrosion spots. Before weighing, specimens were thoroughly washed in alcohol to remove the electrolyte from the pores and then dried in a vacuum. In tests on specimens with closed porosity (total porosity of 6.5%) as well as on specimens impregnated with paraffin wax, corrosion products were removed from their surface.
with a reagent containing 50% HPO₃, 2% SnCl₂, and water. Before testing, the specimens impregnated with paraffin wax were rubbed with emery paper and degreased with alcohol.

The electrical resistivity of specimens was determined with the aid of an MD-6 bridge. The results quoted are mean values of measurements on three specimens.

The results of the electrical-resistivity measurements were employed to evaluate, by the technique proposed by Skorokhod [3], the size of interparticle contacts \( \xi \), i.e., the ratio of the contact size to the particle size:

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\xi = \frac{\rho_{C1}}{\rho_C},
\]

where \( \rho_{C1} \) is the electrical resistivity of a material of zero porosity (cast or forged) and \( \rho_C \) is the electrical resistivity of specimens with imperfect contacts, reduced to zero porosity.* It is assumed here that all oxide films on the surface of the iron particles have been entirely reduced and that the electrical resistance of specimens is determined by the electrical resistivity of the material and the size of interparticle contacts.

Figure 2 illustrates the variation, in the course of time, of the weight gain \( \Delta P/P \), electrical resistivity, and interparticle-contact size of specimens in various media. The results presented show that a spray of 3% NaCl solution produces the most severe corrosion attack. This is due to the fact that, by dissociating into ions, salt particles give rise to the formation of soluble products (for instance, FeCl₂ instead of Fe(OH)₃ and Fe(OH)₂ in water).

The highest corrosion resistance is exhibited by specimens made of pure iron. A slightly lower resistance to corrosion attack is shown by the iron-graphite material, which may be attributed to the heterogeneity of its surface, resulting in the appearance on this surface of areas with different electrode potentials [2]. The surface of iron-graphite specimens constitutes a multielectrode system composed of numerous microcells. Even less corrosion resistant compared with iron is the sulfided iron-graphite material. The intensified corrosion of such sulfur-containing materials is due to the dissolution of ferrite under the action of cathodic sulfide inclusions [2].

Examination of the kinetics of variation in the electrical resistivity of the ZhGr3Tss4 alloy with interconnected and closed (curve 5) porosities leads to the conclusion that the corrosion of porous sintered materials occurs mainly at the interparticlecontacts. This may be attributed to the fact that such contacts constitute sites of defect concentration, which facilitate the propagation of corrosion processes [8]. In addition, the amount of liquid adsorbed per unit surface in the pores is greater than on the external specimen surface, which is due to the phenomenon of capillary condensation.

Thus, the corrosion of porous sintered materials may be visualized as two parallel processes – destruction of the interparticle contacts (curve 1) and corrosion of the actual material (curve 5), which take place at different rates.

Figures 3 and 4 present the results of an investigation into the influence of porosity on the corrosion of the ZhGr3Tss4 alloy in a 3% NaCl solution spray. At porosities above 13-15%, the corrosion of this material is directly proportional to its degree of porosity. With increasing density of the material, the number of interconnected pores sharply drops and, at a porosity of 6-7%, practically all the pores are closed. The corrosion of such specimens may be regarded for practical purposes as the corrosion of dense material.

The corrosion resistance of the actual ZhGr3Tss4 material was determined, under different conditions, on specimens of 6.5% porosity, as well as on specimens impregnated with paraffin wax. In this connection, *The electrical resistivity of iron-graphite materials of zero porosity was taken to be equal to the electrical resistivity of pearlitic gray cast irons of similar chemical composition: 15 for ZhGr3, 18 for ZhGrTss4, and 9.5 \( \mu \Omega \)-cm for the iron [6].