TECHNICAL INFORMATION

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METALLOGRAPHIC FEATURES OF HYDROGEN EMBRITTLEMENT OF WELDED JOINTS OF PLATINUM

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In the production of platinum articles some parts are stamped from sheets of platinum of grade 99.93 and welded by the argon arc method. When these parts were tested in a hydrogen medium gas leakage occurred along the welded joints.

When the causes of seal failure were examined in [1] by analyzing the hardness, some metallographic signs of hydrogen embrittlement were detected but not described. The method of metallography of defects is widely used for the investigation of causes of disruption in metallic articles [2]. For example, in [3] the method has been used to detect dangerous stress concentrators (defects due to corrosion-hydrogen embrittlement) in cadmium-plated disk springs. In the present work we will describe and substantiate metallographic signs of hydrogen embrittlement of welded joints of articles fabricated from sheet platinum.

It is possible that hydrogen charging of a welded joint occurs due to dissociation of moisture contained in argon, which is a catalyst for hydrogen charging in a melting metal [4]. The solubility of hydrogen in platinum is increased substantially at the temperature of the liquid metal (the melting

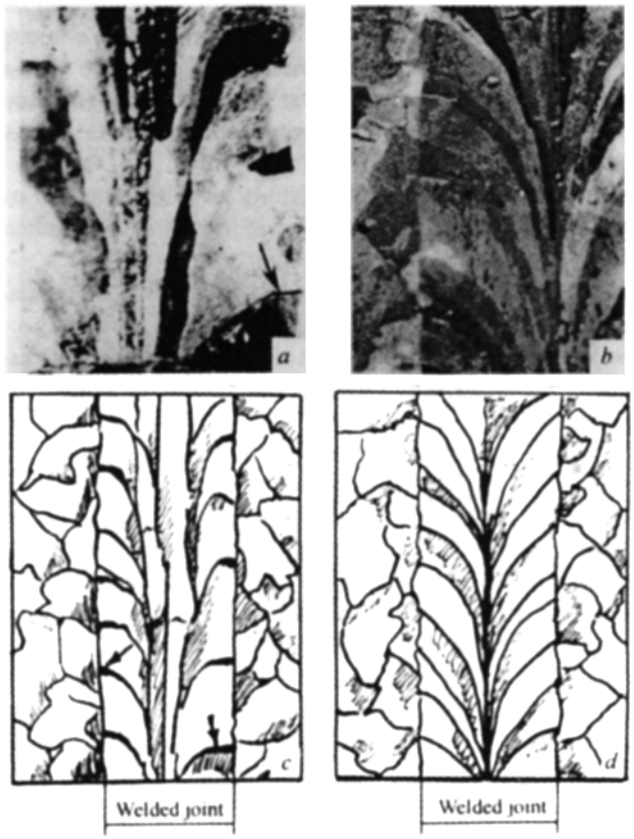

Fig. 2. Microstructure of welded joints in platinum articles disrupted (*a*, *c*) with cracks (shown by arrows) and undisrupted (*b*, *c*): *a*) × 28; *b*) × 22; *c*, *d*) diagrams.

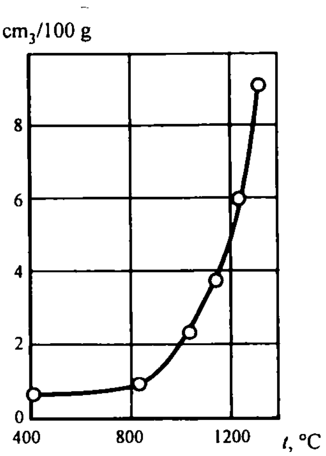

Fig. 1. Solubility of hydrogen in platinum as a function of the temperature.

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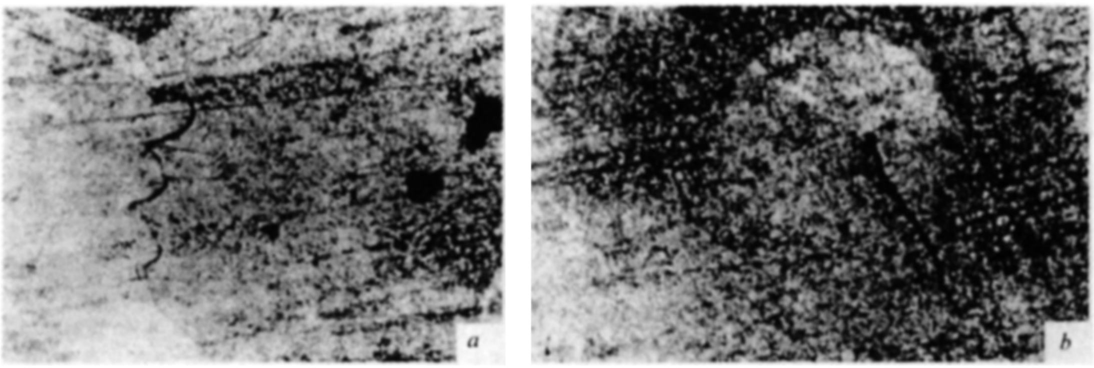

Fig. 3. Porosity and swelling of grain boundaries in a welded joint in a platinum article disrupted in a test by the mechanism of hydrogen embrittlement (*a*) and a crack from a hydrogen collector in a welded joint of disrupted platinum article surrounded by a weakly etched zone of plastic deformation (*b*). × 170.

point of platinum is 1773°C). In accordance with [5, p. 843] we plotted the dependence of the solubility of hydrogen in platinum as a function of the temperature (Fig. 1). It can be seen that above 800°C the solubility increases rapidly.

A metallographic analysis showed that the macrostructures of welded joints of fit articles (nondisrupted) and rejected articles (due to a sealing failure) differ substantially (Fig. 2).

The structure of welded joints in rejected articles exhibits longitudinal crystals parallel to the welded joint with cracks between crystals in the weld root (Fig. 2*a*, *c*). In the structure of nondisrupted articles no longitudinal crystals or cracks were encountered (Fig. 2b, *d*). This morphology of the structure of welded joints seems to correspond to the intensity of heat removal and the degree of overheating of the molten metal.

In the microstructure of disrupted articles we discovered signs of hydrogen embrittlement (microscopic polished sections were etched by aqua regia consisting of one part nitric acid and three parts hydrochloric acid at 60 – 80°C for 15 – 20 min).

Figure 3*a* presents the porosity of the weld in a disrupted article and the swelling of grain boundaries. Such swelling of grain boundaries caused by hydrogen embrittlement had been observed earlier in disrupted disk springs [3]. Swelling of grain boundaries in platinum can be explained, for example, by the data presented in [5, p. 842], in which it is stated that "it seems quite probable that only absorption along boundaries occurs in platinum."

In disrupted articles the structure of the weld contains coarser grains (250 μm) than that in nondisrupted articles (177 – 250 μm).

We detect an original metallographic feature of hydrogen embrittlement in the microstructure of nondisrupted articles, namely, a crack from a hydrogen collector located at the center of a disk-shaped (round) weakly etched zone (Fig. 3*b*). It seems that the nature of this disk is as follows. Accumulation of hydrogen in the collector creates a high pressure, and the metal around the collector is cold-hardened, forming a spherical zone. Overstress breaks the metal with formation of a crack issuing from the collector and emerging on the surface of the part, where hydrogen penetrates too. The cold-hardened zone on the microsection looks like a disk due to the weak etching.

In [1] hydrogen embrittlement of welded joints is demonstrated by the elevated hardness relative to the base. Another factor demonstrating hydrogen saturation of a weld may be the high stress in the metal and the shift of the crack sides discovered by us in disrupted articles.

Thus, we can infer that hydrogen embrittlement of welded joints of platinum with formation of cracks is caused by an elevated porosity, swelling of grain boundaries, and cracks emerging from collectors surrounded by a round weakly etched zone of plastic deformation.

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