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EROSION OF Co-Cr-W ALLOY AND COATINGS ON ITS BASIS UNDER CAVITATION IN AND

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The average fracture rates (*V*s) were measured under the action of cavitation of a prototype of a Co-Cr-W alloy with a chemical composition close to stellite No.6, the components from which the alloy is made, and coatings obtained from a powder of the same chemical composition using plasma, which is generated by the plasma torch. It was found that the average rate of destruction (V_s) of chromium, cobalt, tungsten is equal to 3.5; 0.72; 0.56 μm/h, respectively, and Co-Cr-W alloy – 0.5 μm/h. After heat treatment of the Co-Cr-W alloy at a temperature of 1300 K for 3.6 ks, the V_s value decreases to 0.28 μm/h. The plasmatron coating is destroyed at a speed of 0.13 μm/h, and steel 15X11MF – 2.4 μm/h. Under the action of cavitation in a corrosive medium of a 3% aqueous solution of sodium chloride V_s, steel 15Kh11MF and Co-Cr-W alloy increase almost 2 times.

INTRODUCTION

Increasing the life of equipment that operates in conditions close to extreme, often associated with the use of existing or developed resistant materials or coatings based on them. Among such materials, a special place is occupied by cobalt-based alloys known as stellites. They have high wear resistance at normal and elevated temperatures, thermal resistance, high heat resistance and significant corrosion resistance in many aggressive environments. The most used for practical use, in particular to increase the life of dies, valves and gate valves when regulating the flow of superheated steam, valve seats of engines of heavy trucks are alloys under the grades No. 6, No. 12; F; what have the name stellites. The chemical composition, structure, and a number of physicomechanical characteristics of these alloys are presented in robots [1–4].

In [5–9], the effect of cavitation and water flows on samples from various alloys of the Co-Cr-W, Ni-Cr-W(Mo) type deposited using laser and arc methods was studied. To create a cavitation zone, a method similar to that described in ASTMG 32-10 [10] was used. As the base on which the alloys are deposited, steels of the SUS 303, 304, BS817M40, X9C2 type (GOST 5632) were used. Specific in a number of works was the use of the action of the cavitation zone on a sample through which surface ultrasonic waves (20 kHz) passed.

Given the peculiarity of the task of increasing the durability of the material in the conditions of its operation, there is a need to conduct appropriate studies on the use of the Co-Cr-W alloy in each case.

In order to be able to use the alloy to protect the surface of medium alloyed steels, in particular, 15Kh11MF steel, which is widely used in turbine construction, we studied the resistance of steel, alloy components and the manufactured Co-Cr-W alloy and plasmatron coating of the same composition. Under the action of cavitation and high-speed vapor-droplet condensate.

MATERIALS AND METHODS RESEARCH

To produce the Co-Cr-W alloy, cobalt K2 grade (GOST 123-2008), chromium obtained using the technology presented in [11], and tungsten using hot pressing technology [12] were used. Alloy samples were obtained using the technology of the precision casting method [1]. The coating was obtained using plasma, which is generated in a plasmatron [13] using powder of the EN1274: 2004-72 brand.

To obtain data on the destruction of samples under the action of cavitation on their surface, their preliminary preparation was performed. Samples 10×16×5 mm in size were cut out on an electric spark from a suitable casting. After mechanical polishing, electro polishing of, for example, chromium in phosphoric acid was carried out for 0.15 ks at a voltage of 20 V and current density of 2 A/cm^2. The surface roughness of the samples was 0.025 μm.

A study of the effect of cavitation on the surface of the samples was carried out at the MSV stand, the description of which is presented in [14]. The cavitation zone was created in water using an ultrasonic concentrator of an exponential profile, which is mechanically connected to a magnetostrictive transducer, which is electrically connected to an ultrasonic oscillation generator. Under the end of the concentrator, the amplitude of surface oscillations of which was 30±2 μm, and a frequency of 20 kHz, a cavitation zone was formed in which the test sample was placed at a distance of 0.5 mm from the concentrator surface. The destruction of the samples was recorded by weight loss. The accuracy of measuring weight loss is ± 0.015 mg. According to measurements of the dependence of losses on the time of the action of cavitation, the rate of destruction of the samples was determined.

A study of vapor-droplet erosion was carried out at a special bench [14], in which steam-water condensate was supplied through a nozzle with an outlet diameter of 1.3 mm at a pressure of 1.5 MPa. The velocity of the droplets that collide with the surface of the sample was 440 m/s. Failure was also determined by measuring the weight loss of the samples over a specific action time of the condensate.

The study of electrochemical corrosion was carried out using a potentiostat PI-50-1. Polarization curves were obtained at a rate of change of potential of 1 mV/s. Changed the potential three times in the forward and

reverse direction. For comparison, a chlorine-silver electrode was used. The measurement results are converted to a normal hydrogen electrode.

EXPERIMENTAL RESULTS

The values of destruction under the action of cavitation of samples from materials that are part of the Co-Cr-W alloy are shown in Fig. 1.

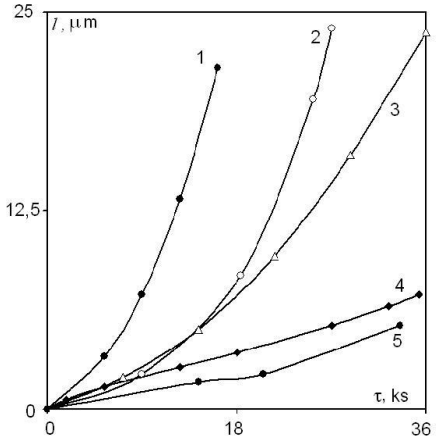

Fig. 1. Kinetic curves of fracture of samples under the action of cavitation: 1 – steel 20X13; 2 – Cr, undo-ped; 3 – steel 15X11MF; 4 – Co; 5 – W, polycrystal

Using the kinetic curves of Fig. 1, the average fracture rates (V_s) were calculated for the time interval of cavitation action equal to 36 ks (10 h). Correspondingly, for steel 20X13 the speed is about 4.87 μm/h, for Cr – 2.83 μm/h, steel 15X11MF – 2.4 μm/h, Co – 0.78 μm/h, W – 0.56 μm/h It can be seen that the 20Kh13, 15Kh11MF steels used in turbine construction have a value of destruction rates that are comparable to the destruction of chromium, which is a significant part of them. The specific nature of the destruction of undoped and doped chromium is illustrated by micrographs of the destruction zones shown in Fig. 2.

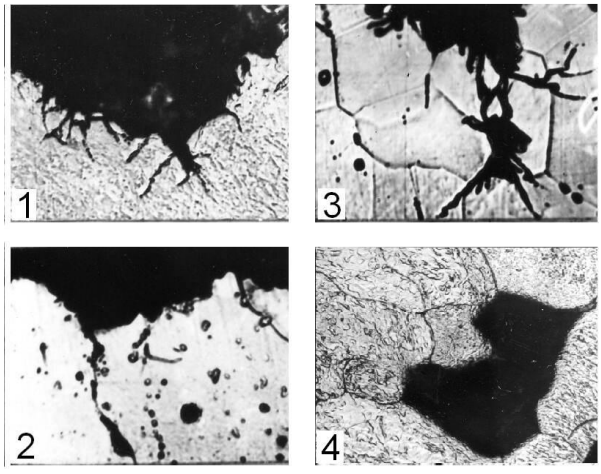

Fig. 2. Micrographs of the zone of destruction of chromium (1-3) and the surface of the tungsten polycrystal after the action of cavitation for 10 ks: 1 – Cr unalloyed; 2 – Cr doped with La, Ta, V; 3 – Cr doped with La, Fe; 4 – W. Magnification 400

Microphotographs (see Fig. 2, f. 1-3) show that the alloying of chromium does not significantly change the nature of its destruction. The fracture process is associated with the simultaneous propagation of cracks along grain boundaries and in the body of grains between structural defects. At the same time, tungsten is destroyed at the location of inclusions (see Fig. 2, f. 4).

The results of investigations of the destruction of a Co-Cr-W type alloy under the action of cavitation on the samples without their preliminary heat treatment and after it and upon the action of vapor – drop condensate on the samples are shown in Fig. 3.

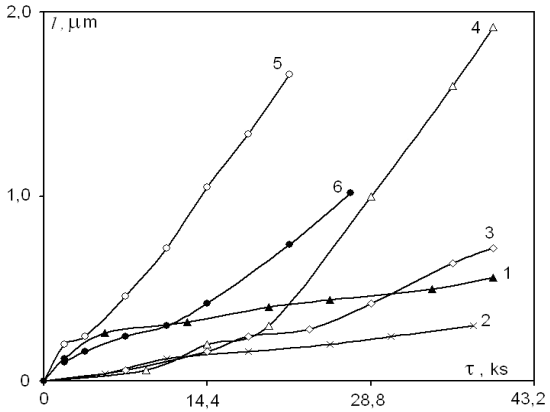

Fig. 3. Dependence of the average fracture depth (l, mm) of Co-Cr-W (1, 2, 4), W (3, 5) samples, coatings (6). Under the action of cavitation without heat treatment (1, 6), after heat treatment (2, 3), after the action of a vapor-droplet flow (4, 5). A decrease in (4) by 2.5 times, (5) by 10 times

An analysis of the results presented in Fig. 3 shows that after exposure of the Co-Cr-W alloy samples at a temperature of 1300 K for one hour, the nature of the destruction of the samples under the action of cavitation does not change (cur. 1, 2). In this case, the fracture rates $V_п$ of the samples on the quasilinear parts of kinetic curves 1 and 2 are close and equal to $2.5 \cdot 10^{-1}$ μm/h, and V_s are different and, accordingly, equal to $5 \cdot 10^{-1}$ and $2.8 \cdot 10^{-1}$ μm/h The difference between V_s and $V_п$ indicates the influence on the value of V_s of the higher surface layers, which are destroyed first at the beginning of cavitation. After heat treatment of the samples, the resistance of the surface layers increases, and for the same sample the difference between the values of V_s and $V_п$ does not exceed 15%.

Coatings under the action of cavitation are destroyed much faster. The average rate of destruction is 1.36 μm/h, which is 2.7 times higher compared to the Co-Cr-W sample without heat treatment and this is due to the defective structure, in particular, column size and precipitates along the boundaries between them (Fig. 4).

Under the action of a vapor-droplet flow for 43.2 ks (12 hours) on Co-Cr-W alloy samples that are fixed to the steel surface by soldering, their average fracture rate reaches 5.2 μm/h. This is due to a significant increase in the load on the surface compared with the effect of cavitation. However, with different types of load, the kinetic fracture curves are similar. The heat treatment of tungsten under the same conditions (soldering of the plates) causes an increase in V_s to a value of 27.6 μm/h, which is much more compared to the effect of cavitation.

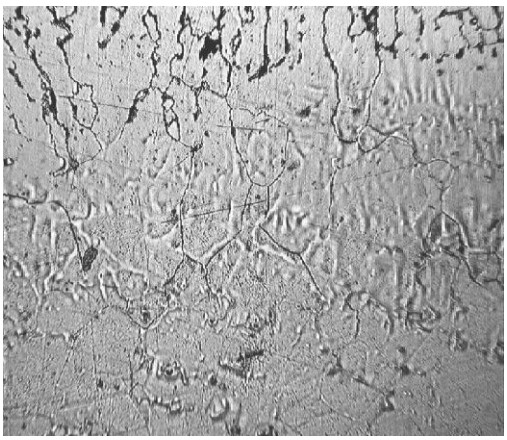

Fig. 4. Micrograph of the coating structure. Magnification 400

Under the action of cavitation on thermally untreated samples in a 3% aqueous NaCl solution, the V_s value for steel 15Kh11MF and Co-Cr-W alloy increases by 2 times. The results of measuring electrochemical corrosion in a 3% aqueous NaCl solution show that the alloy corrodes starting from a potential of –0.17 V and has a very narrow (~ 0.1 V) zone of the passive state. The corrosion resistance of the alloy is close to the corrosion resistance of 15Kh11MF steel.

In the study of the coating, it was found that the potential for the onset of corrosion is –0.1 V, and the interval of the passive state reaches +0.3 V, which is much larger compared to a bulk sample.

FINDINGS

1. For the time interval of the action of cavitation, which corresponds to the quasilinear fragment of the kinetic curve for the alloy, the erosion rates of its heat-treated and untreated samples equalize and amount to ~ 2.5 10^{-1} μm/h.

2. Under the action of cavitation on the plasmatron coating, which is similar in composition to the Co-Cr-W alloy, its average fracture rate is 2 times lower than that of 15Kh11MF steel, and coating can be used to protect the steel surface.

3. Under the action of cavitation in a medium of a 3% aqueous NaCl solution on unprocessed bulk Co-Cr-W samples, the average rate of their destruction increases by 2 times.

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ЭРОЗИЯ Co-Cr-W-СПЛАВА И ПОКРЫТИЯ НА ЕГО ОСНОВЕ ПОД ДЕЙСТВИЕМ КАВИТАЦИИ

В.И. Коваленко, А.А. Клименко, Л.И. Мартыненко, В.Г. Маринин

Измерены средние скорости разрушения (V_s) при действии кавитации на опытный образец из сплава Co-Cr-W, по химическому составу близкого к стеллиту №6, компонентов, из которых сплав изготавливается, и покрытия, полученного из порошка такого же химического состава, с использованием плазмы, которая генерируется плазмотроном. Установлено, что средние скорости разрушения (V_s) хрома, кобальта, вольфрама равняются 3,5; 0,72; 0,56 мкм/ч соответственно, а сплава Co-Cr-W – 0,5 мкм/ч. После термообработки сплава Co-Cr-W при температуре 1300 К на протяжении 3,6 кс величина V_s уменьшается до 0,28 мкм/ч.

Плазмотронное покрытие разрушается со скоростью 1,3 мкм/ч, а сталь 15Х11МФ – 2,4 мкм/ч. При действии кавитации в коррозионной среде 3%-го водного раствора хлорида натрия V_s стали 15Х11МФ и сплава Co-Cr-W возрастают почти в 2 раза.

ЕРОЗІЯ Co-Cr-W-СПЛАВУ ТА ПОКРИТТЯ НА ЙОГО ОСНОВІ ПРИ ДІЇ КАВІТАЦІЇ

В.І. Коваленко, О.А. Клименко, Л.І. Мартиненко, В.Г. Маринін

Виміряно середні швидкості руйнування (V_s) при дії кавітації на дослідний зразок із сплаву Co-Cr-W за хімічним складом близького до стеліту №6, компонентів, із яких сплав виготовляється, і покриття, одержаного з порошку такого ж хімічного складу, з використанням плазми, що генерується плазмотроном. Установлено, що середні швидкості руйнування (V_s) хрому, кобальту, вольфраму дорівнюють 3,5; 0,72; 0,56 мкм/год, відповідно, а сплаву Co-Cr-W – 0,5 мкм/год. Після термообробки сплаву Co-Cr-W при температурі 1300 К протягом 3,6 кс величина V_s зменшується до 0,28 мкм/год. Плазмотронне покриття руйнується зі швидкістю 0,13 мкм/год, а сталь 15Х11МФ – 2,4 мкм/год. При дії кавітації в корозійному середовищі 3%-го водяного розчину хлориду натрію V_s сталі 15Х11МФ і сплаву Co-Cr-W зростають майже в 2 рази.