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Change of composition and structure of diffusion chrome coating during friction

Z.Z. Sharifov, F.R. Bashirov

Azerbaijan State Marine Academy, Marine Engineering and Shipping
Baku, Azerbaijan, Z. Aliyeva street, 12, e-mail: scherifov.z@gmail.com; Fuad_bashirov@hotmail.co.uk

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Abstract
The paper studied the behavior of the composition and structure of the diffusion of chromium coatings in sliding. It was found that the strain in friction generates the secondary structure of chromium coatings and as a result of the deformation effect wear is accelerated due to separation of the coating.

Introduction

Treatment of composition and structure of diffusion chrome coating during friction is considered in the article. It was determined that in the chrome coating deformation created during friction forms the second structure and exploitation created as a result of deformation accelerates wear and tear. Coating of stable and safe coatings by diffusion method is widely spread in the industry and this is conditioned by useful increase opportunities of operational characteristics of articles in comparison with base of material. Coating characteristics are determined by distribution of alien element, feeding with gas and oxidation of materials. Taking into consideration the large tendency of chrome to oxygen and nitrogen, the chrome coatings will subject to oxidation. The first and second works are devoted to electron-microscopic investigations of structure of gasothermic coatings. Small number of such investigations is connected with complication of preparation of analysis object. The structure of surface and structure of layers near it after the friction is not learnt completely.

Aim and Objectives

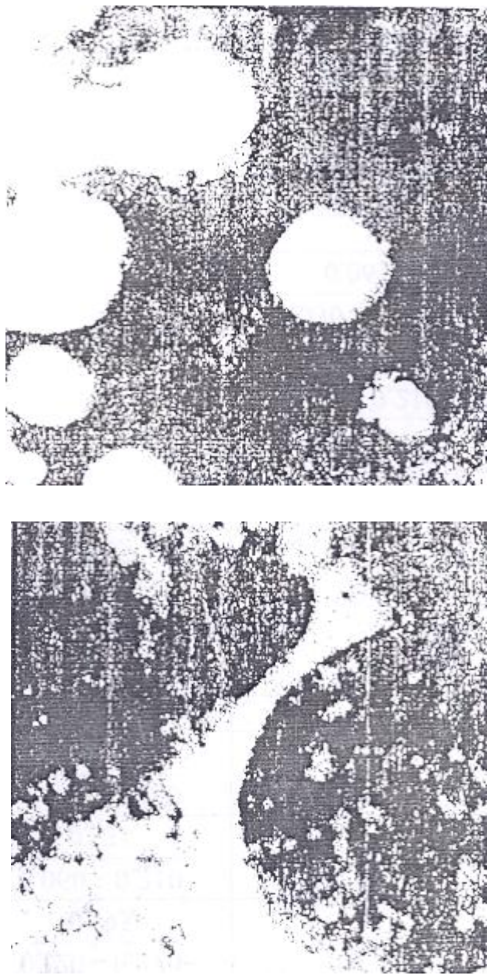
That is why the structure of diffusion chrome coating in primary condition and after the friction have been investigated in this section. Chromium plating operation is done in solid medium. Feeding composition and feeding regimes are given in previous works [1, 2]. Bedding and as counter body material cast-iron of A-WP-CrNiMo mark is taken (A – class, WP – high-duty cast iron). Piston rings of vessels' Diesel engines are made of such cast-iron. Authors have investigated the structure of coatings by electron microscopic method in examples tested in friction mechanism, within unheated friction condition during 10 hours in 1 MP load, at a speed of 15 m/s sliding. Authors have studied the phase composition by oje-electron microscopic method.

The chemical analysis showed that the amount of oxygen reaches 2–3% (mass) nitrogen and carbon 0.1–0.2%. The micro structure of such coatings consists of connection of disk shaped grains. Matrix consists of polycristallic creations being of equal size grains of 0.1–10 μm. The phase composition of electrons corresponds to HMK cage close to chrome parameters. This composition is characteristic both for coarse and small grains and they create the layers of small disperse material among coarse grains. Sometimes characteristic enlargement of small grains is observed around coarse grain. The border of grains is smooth enough, but it is impossible to find out the striped contrast and it is conditioned with the high gathering of defects in the grains and around them. In the chrome coating the defects are disposed heterogeneously, the mean density differs locally, but it does not exceed 10^9–10^{10} sm^2. The large part of grains has the dislocation structure of compact and twist shape, and close to them the clusters created the dislocation of fringe type and compactness of following defects are observed (Fig. 1b). There is a compactness of small dislocation loops in some grains of 0.1 μm size (Fig. 1c). The loops are usually disposed unequally on volume of grain; their density is decreased to the centre, but near the boundaries it is so high that the individual loops are not seen. In small size grains the density of defects often exceeds 10^{10} sm^2; in this case it is impossible to choose the individual defects equal contrast of speckled form is observed.

a) b) c)

Fig. 1. Electron microscopic structure of the diffusion chrome coating of iron-cast base

The characteristic feature of detraction sight is the pulling down the reflexes (the radial pulling down of matrix phase – diffusion flashes and weak reflection around intensive reflexes). Such diffusion effects [4, 5] are usually connected with the presence of transitional condition of excessive feed solid solution or their prevention of destruction. Besides reflexes of matrix phase, weak reflexes not concerned to the solid solution in the chrome base are observed. They are identified as metastable tetragonal Cr_3O_4 if they are concerned to the chrome oxide. Side by side with matrix surface structure anomaly is found out. Two or more met surfaces may be differed. On the individual fields of the first coating, existence of great number of small circle (up to 1 km) shape pores are seen (Fig. 2a). Many pores are connected with the second phase separation (oxides). By means of rough grounding coating it was found out that the oxides are crumpled not only in the pores but in the boundary of grains too. The numerous fields of micron size between grains of matrix phase are second type of anomaly.



a) b)

Fig. 2. Some anomaly in the primary structure of diffusion chrome coatings

They consist of small pores of solid solution not to be subjected to identification, oxides and mixture of heterphase phases (Fig. 2b).

Comparing the structural and local X-ray structural analysis, we shall get the results that the alloyed elements in the matrix are distributed equally enough. In all examples the main matrix phase is in the broken stage of excessive fed and hard solution. These diffractions show the great role of oxidation process in the formation of structural features of coatings. Revealing of separation of coarse and small pores is connected with creation of oxides, the formation of heterogeneous phase fields.

The second structures are created in the friction contact in the condition of boundary friction, created which supply the steady working mode [3]. The second structures, having the oxygen in the composition, may create both oxides and main metal excessively fed by the oxygen structures. The various amounts of oxygen and carbon were revealed in the primary condition and after friction by means of investigation of surface and around boundary layers of diffusion coatings by electron spectroscopic method.

The information in the table shows that the useful changes occur in the surface layer of material, linked in the friction process. The predominant process is its saturation with oxygen. On diffusion coating on chrome base, the oxygen amount in the surface layer increases four times, but on the cast-iron surface increases two times. Although the friction occurs in the carbon composition medium, after well wash and degassing the amount of carbon is in the primary level. Sometimes the gathering of mass of surface material on a counter body is remarked, in this case on the primary surface of contra-substance being of non-noted chrome and other elements in the contact fields are adopted.

Table 1. The amount of elements on the diffusion coating and contra-substance before and after friction depending on the place of analysis, % (mass)

Place of analysis	Coating				Contra-substance			
	Cr	Fe	O	C	Fe	Cr	O	C
Surface								
Primary	41	36	12	11	75	–	10	11
After friction	40	25	28	14	38	25	30	12
Distance below friction surface, μm								
0.5	42	28	18	12	40	17	28	13
3.0	45	35	10	11	62	–	13	11

The investigation of structure in the delicate surface layer after the friction by the pellucid electron microscope methods is difficult due to sufficient development of relief of surface. The method of continuous eruption by the opposite friction surface allowed to observe the deepest layers. Around the surface layers the three main microstructure conditions are revealed. The first is primary size grains and close to primary inside grain, but they have the high density of micro crashes. The second type is the primary size grains, but they are substructures sharply differed from primary ones: grains are filled with cloud shaped mass; the azimuth throwing of reflexes is characteristic for diffraction (Fig. 3a). The third type of structure is formed on the basis of primary grains as a result of fragmentariness. Fragments are of 0.2÷0.3 μm size. It is possible to choose the boundary of primary grain against a background of fragment boundary in the individual fields. This fact and also the occasional disposition of circle pores of primary structures in relation of fragments allow the consider that the fragments have the origin fragmentary structural deformation and appears on the base of primary structure, but it does not occur at a result of wear and tear of products and consolidation of oxidization (Fig. 3b).

a)

b)

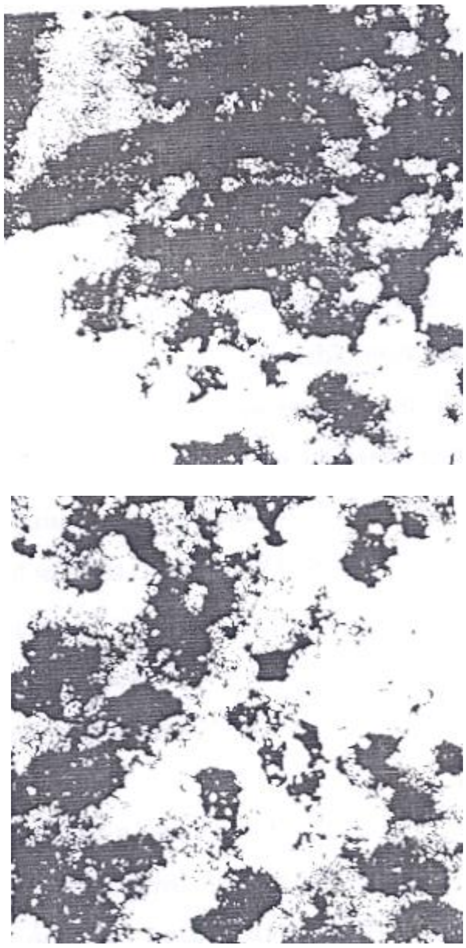


Fig. 3. The structural types of around boundary layers of chrome diffusion coatings after friction

Obtained structural characteristics show that if remarked oxidization processes are gathered in the most delicate surface layer, then the deformation processes are distributed up to 10 μm depths. The three structural types may prevail in the process of formation of layers. The main of them is moving deformation which allows finding out the second and third structural types. The second structural type may be considered as the beginning stage of the deformation of primary grain; and the second type may be considered as the stable structure. The first structural type is characteristic for the wear and tear fields. Fragmentary structure, on the chrome surface layer of coatings is subjected to the highest plastic deformation during friction.

The fragmentary base structure fact formed on the surface layer of diffusion coatings during friction shows the cyclic recurrence, temperature and hydrostatic pressure of process in the mutual contact influence places.

The greatest number of around-boundary layer of structure weakens the connection between the second structure and base of coating. The local moving deformation causes wear-and-tear and exfoliation of the second structure.

Conclusions

So, during the friction of chrome diffusion coatings the deformation processes result the formation of the second structures; they are on the depth of 10 μm and they are created by means of fragmentariness of the primary structure.

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