IOP Conf. Series: Materials Science and Engineering **387** (2018) 012046 doi:10.1088/1757-899X/387/1/012046

Improving the adhesive strength of the babbit layer of sliding bearings

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Abstract. The possibility of increasing the adhesion of the babbit coating applied by means of casting on the bearings inserts by preparing of the surface of the bearings inserts by processing with help of cathode spots of vacuum arc discharge is shown. At the same time, the vacuum purity of the surface is provided and a roughness with a partially-regular micro relief is created. In addition, it is possible to increase the adhesive properties of the coating by applying a vacuum arc method of deposition of a thin sublayer of the coating material.

The development of modern turbine construction requires new technical solutions that determine the possibility of increasing the efficiency, reliability and technological effectiveness of turbine plants. This is especially true for power engineering, where sliding bearings are widely used as turbine bearings – the most responsible products, the failure of which entails the failure of the entire unit. To reduce wear, and therefore increase the service life of the bearing, an anti-friction material is applied to its surface. Babbits are used as an anti-friction material, for example, B83 [1]. Babbit B83 stamps consists of 6 % copper, 10 to 12 % antimony, the rest is the tin. The basic technology of coating deposition of babbit on the bearings is casting. In the manufacture of bearings babbits is poured to the heated inserts (250 ^{0}C) at a temperature of 450–480 ^{0}C. The level of casting technology is low, as evidenced by statistics on unscheduled and emergency failures of sliding bearings [2].

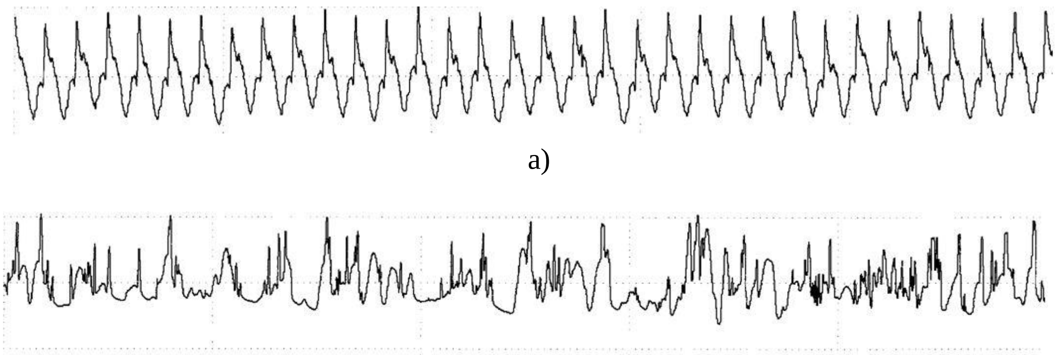
When using casting technologies (siphon casting, centrifugal casting) to obtain an anti-friction layer, the following problems arise: the liquation of alloying elements, progressing with increasing of layer thickness, a high tendency to defects such as shells and pores. Also, due to the low cooling rates, an unfavorable structure is formed during the crystallization of babbit [3]. Some improvements are observed when using turbulent casting. However, this technology does not solve the problem with low strength of babbit layer adhesion to the base. To increase the adhesion strength, it is known of using such technological methods as milling of end or spiral grooves, recesses, cuts, application of copper coating to the surface of the bearings inserts before tinning with tin, use of alternative methods of applying babbit coatings, for example, plasma spraying and surfacing [4]. A significant disadvantage of babbits is also the fact that with increasing temperature they reduce all the indicators of mechanical strength, especially fatigue resistance.

The aim of this work is to develop vacuum ion-plasma methods for preparing of the surface of the bearings inserts to provide high adhesion of the babbit coating applied by casting.

With proper preparation of the surface of the bearings inserts and its filling with babbit, a strong connection of babbit and metal should occur along the entire surface of the bearings inserts, which significantly increases the adhesive strength of the coating with the substrate. Therefore, before applying babbit must be removed from the surface of the bearings inserts all existing contamination. Another factor that increases the adhesive strength of the coating with the substrate is to provide a given surface roughness with a regular or partially-regular microrelief. In addition, high adhesive properties of the coating can be provided by creating a thin diffusion layer at the interface substrate-coating and a subsequent thin coating from the coating material (babbit). The implementation of the above-mentioned directions of increasing the adhesive strength of babbit coatings can be provided by the treatment of the surface of the bearings inserts by the cathode spots of vacuum arc discharge and subsequent treatment of the surface by the accelerated flows of metal plasma.

The method of vacuum arc cleaning of the metal surface or the method of cleaning the surface by the cathode spots of the vacuum arc provides a complete cleaning of impurities such as rust, scale, residues of technological grease and others and allows for precision dimensional surface treatment, and contributes to effective visual and technical surface defectoscopy. Cleaning is carried out by means of a vacuum arc discharge burning between the surface of the processed product, which is a cathode, and an anode in a vacuum chamber, in which a lot of fast-moving cathode spots are formed, localized in the places of accumulation of contaminants, oxide films and removing them until the main material of the processed product is completely exposed.

Studies have shown that under the processing conditions typical for surface cleaning, there are no structural-phase changes in the properties of the product material. At the same time, a change in the nature of the surface roughness relief was found (figure 1). In figure 1(a) is shown the initial profile of the surface of detail from steel 20GL, and figure 1(b) – profile of the surface after vacuum-arc cleaning. The arithmetic mean deviation of the Ra profile for the initial surface was 2,944 μm, for the surface after cleaning – 2,561 μm.



a)

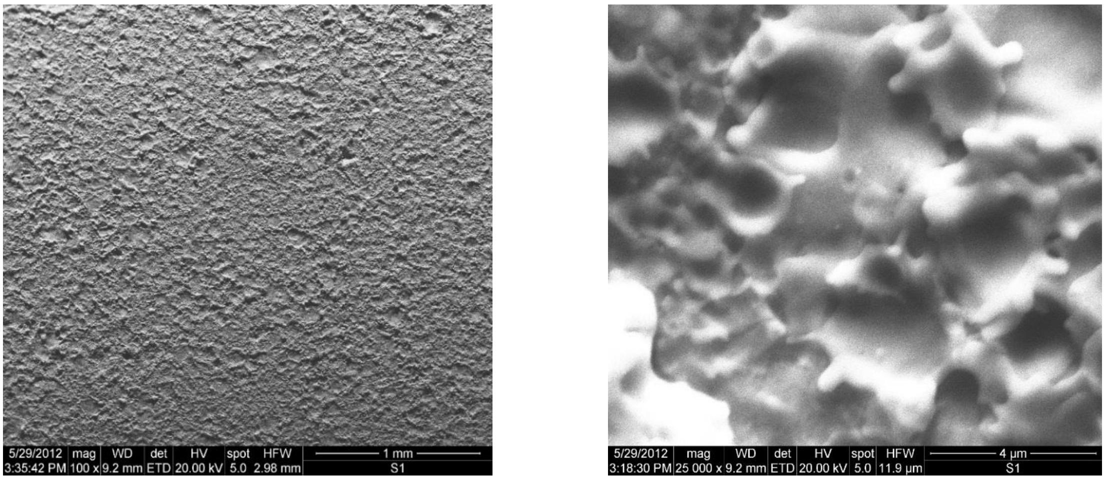
b)

Figure 1. Surface roughness profile: (**a**) – initial; (**b**) – after cleaning.

The initial sample (without cleaning) has a regular profile with approximately equal dispersion of protrusions and depressions. The surface subjected to vacuum-arc treatment is uniformly covered with depressions (figure 2(a)).

At higher magnification (figure 2(b)) it is show that depressions have the shape micro-pocket. This surface is consistent with the definition of micro-relief elements of concave shape. The studies show that the vacuum arc treatment of the surface of materials due to the impact on it of the cathode spot of the vacuum arc can be used to create a regular micro-relief in the form of micro-pockets to improve the adhesive properties of babbit coatings applied to such a surface. As the babbit has been used the babbit B83 stamps.

As a bearings inserts for the application of babbit a sleeve made of steel 20 with an external diameter of 100 mm and an internal diameter of 70 mm was used. Cleaning of the inner surface of the sleeve with the simultaneous creation of a microrelief was carried out in the vacuum chamber of the installation. The bushing was a cathode and was connected to the negative pole of the welding rectifier. Inside the bushing was inserted graphite rod, which served as the anode. Surface cleaning was carried out in the pressure range from 1 to 10 Pa at a vacuum arc discharge current of 100 A.



a) b)

Figure 2. The topography of the surface after vacuum-arc cleaning: the increase in (**a**) – ×100, (**b**) – ×25000.

The creation of a diffusion layer and a transition layer with a thickness of about 5 µm between the substrate and the babbite coating, which was subsequently applied by casting, was carried out with the using of the traditional technology of vacuum arc deposition. As the cathode of the vacuum arc evaporator, a babbit cylindrical ingot was used, which was placed inside the bushing. Thus, the so-called cylinder vacuum-arc evaporator was created.

The adhesion of babbit layer to the substrate was determined by the ring shear method [5]. Pressure on the babbit ring was carried out by a punch. Pressure on the babbit ring was carried out by a punch. Measurement of forces was carried out using a mechanical dynamometer. The results of the researches are presented in the table 1.

Table 1. Results of measurement of adhesion properties.

Surface preparation and material of deposition layer	Average load to failure, N
Chemical cleaning - tinning by tin - babbit	5400
Cleaning by cathode spots with the creation of microrelief - tinning by tin - babbit	6800
Cleaning by cathode spots with the creation of microrelief – babbit	6600
Cleaning by cathode spots with the creation of microrelief - diffusion layer of babbit - tinning by tin – babbit	7500
Cleaning by cathode spots with the creation of microrelief - diffusion layer of babbit - transition layer of babbit – babbit	7200
Cleaning by cathode spots with the creation of microrelief - diffusion layer of babbit - transition layer of babbit - tinning by tin - babbit	7800

The results presented in table 1 allow us to draw the following conclusions:

1. Cleaning of the surface by the cathode spots of the vacuum arc with simultaneous creation of a microrelief on the surface in comparison with the chemical preparation of the surface provides an increasing of the adhesive properties of the babbite coating by about 26 %.

2. Babbit, deposited on the surface of the bearing insert, treated by the cathode spots of a vacuum arc, without tinning by tin slightly inferior in the adhesion of the babbit deposited on the surface with pre-tinning.

3. The diffusion layer produced during ion bombardment of the surface is promotes the increase of babbit adhesion.

4. Tinning by the tin slightly improves the adhesion properties of a babbit coating in comparison with the case where the babbit is deposited on the transition vacuum-arc layer of babbit.

5. The maximum adhesion is obtained for the case of "Cleaning by cathode spots with the creation of microrelief - diffusion layer of babbit - transition layer of babbit - tinning by tin - babbit ", but it is necessary to take into account the economic efficiency of the process. Perhaps, the process of "Cleaning by cathode spots with the creation of microrelief - diffusion layer of babbit - tinning by tin – babbit" may be more economically feasible.

References

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