THE APPLICATION OF CRN AND TIN COATINGS IN SLIDE BEARING KINEMATIC COUPLING PIN SURFACE LAYER MODIFICATION PROCESSES

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Abstract

This work presents the results of tribological stand tests of slide bearings with pins modified with CrN and TiN coatings and pins with a TiN-steel 46Cr2 and CrN-steel 46Cr2 „ring" structure. The „rin" structure samples features materials with different tribological properties in the form of rings on the pin slide surface. Such a structure is obtained when covering the 46Cr2 steel pin base with a discrete layer of TiN or CrN, using the PVD method. The stand tests of frictional couplings have been performed for the frictional kinematic coupling pin with modified surface layer and CuPb30 and AlSn20 alloy bearing liner slice. During the tests the tribological couplings were lubricated with Castrol magnatec engine oil (5W/40). The tests were performed on a T-05 tribological tester. The test results demonstrated the tribological advantageous using the "ring" structure samples in the frictional couplings. The tests demonstrated that the friction forces and the bearing material quantity wear were the least for couplings with CrN steel, 46Cr2 and nitrogen hardening, and the largest for TiN pin couplings. Modification of the CrN pin surface layer has a beneficial impact on reducing frictional resistance, and temperature reduction in the friction area as well as reduction in bearing alloy wear.

Keywords: *TiN, CrN, wear, sliding friction, surface treatment*

1. Introduction

The performance properties of the frictional slide couplings depend on the constructional material used and technology applied during the production process. The tribological properties of the frictional coupling form the resultant of the coupling construction and properties of the cooperating surfaces, and indirectly of the frictional coupling elements surface layers' condition. The surface layer may be shaped by technological processes through the correct material selection used for these elements and technology applied for the surface treatment. A correctly shaped surface layer ensures optimal tribological operational properties thus providing reliability and durability of the construction. The variety of operational conditions and load under which the slide couplings work, their construction and type of predominating wear form the basis for material selection and coupling elements surface treatment application [2, 4, 7]. Currently numerous methods are used in producing the surface layers which protect against tribological wear, however particularly advantageous properties feature those coatings obtained with the application of the PVD method [1, 5]. These coatings feature a high degree of hardness of the structures, resistance to wear and corrosion and good fatigue properties depending on the technological preparation of the base.

The surface layers featuring adequate tribological properties play a significant part in the operation of the slide coupling in a combined friction environment. The primary factors used in the suitability assessment of the obtained surface layer are: hardness, wear resistance, fatigue and corrosion resistance and the value of the friction coefficient [7]. The scope of the tests performed was to determine the impact of the technologically developed surface layers of the pin on the friction conditions alternation in slide couplings working in a combined friction environment.

2. Experimental details

For the purpose of the tests 46Cr2 steel ring pin samples were produced. TiN and CrN coatings and TiN-steel 46Cr2 and CrN-steel 46Cr2 ring structure surface layers were applied on the cylindrical surface (Fig. 1). The sample production technology was determined by the PVD coating manufacturer: the process lasted 40 minutes and was performed at 260°C at the ion chamber pressure of $p = 1.2\cdot10^{-2}$mbar for the TiN coating and $p = 3.5\cdot10^{-2}$mbar for the CrN coating. 38CrAlMo5-10 steel ring samples were also prepared and given nitrogen hardening for 6 hours at 530^0C in a Hydrogen - Nitrogen atmosphere. Counter samples were cut out of the CuPb30 and AlSn20 bearing alloys. During the tests, the tribological couplings were lubricated with Castrol GTX Magnatec API SL/CF, SAE 5W/40 engine oil.

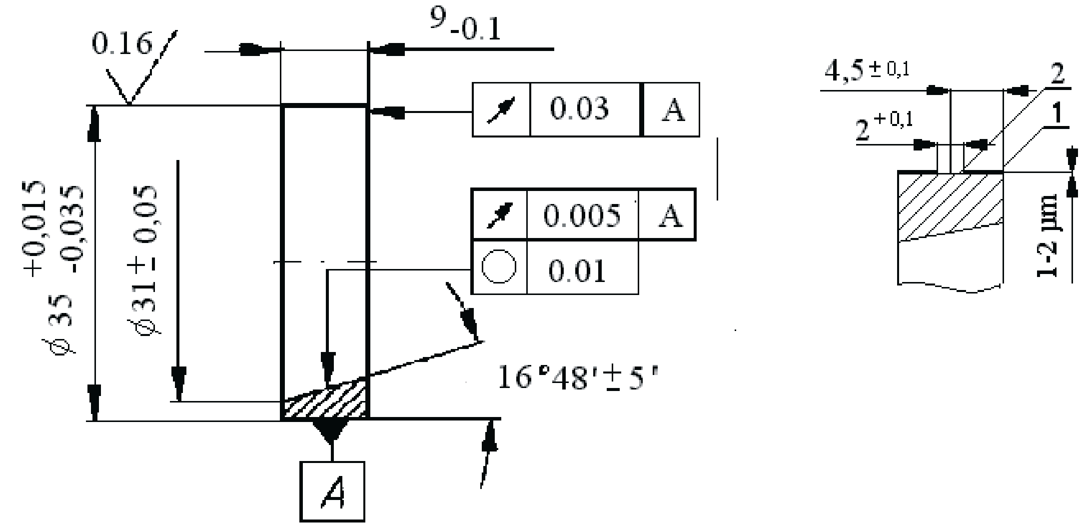

Fig. 1. The shape and dimensions of "ring" structure samples: 1 - coating, 2 - 46Cr2 steel sample material

The test program comprised recording of the frictional forces and wear of the bearing alloy of the slide coupling under starting conditions as well as during fixed operational conditions. The slide coupling starting conditions were determined within the rotational speed ranging from 0 to 500 rpm and time t = 10 sec at determined unit loads of p = 10, 15 and 20 MPa. The tests were performed in determined frictional environment at present load parameters; fixed pin rpm n = 100 rpm, and variable unit loads of p = 10, 15 and 20 MPa. The tests were performed in Radom on a T-05 MCNEMT tribological machine, in a split roller-pad contact arrangement [6].

3. Results and discussion

In the combined friction environment it is important to determine the commissioning moment as it defines the frictional resistance occurring during the slide coupling pin movement initiation. The obtained frictional force values are unique for each tested kinematic pin-bearing couplings, however general relations between the assessed values can not be determined (Fig. 2). The recorded frictional force values demonstrated its increase together with the frictional coupling load increase. The lowest frictional forces, regardless of the bearing liner material, are characteristic for kinematic couplings with CrN-steel 46Cr2 surface layer pins. In couplings with pins with TiN surface layers the lowest frictional forces have been recorded with CuPb30 bearing liner alloy.

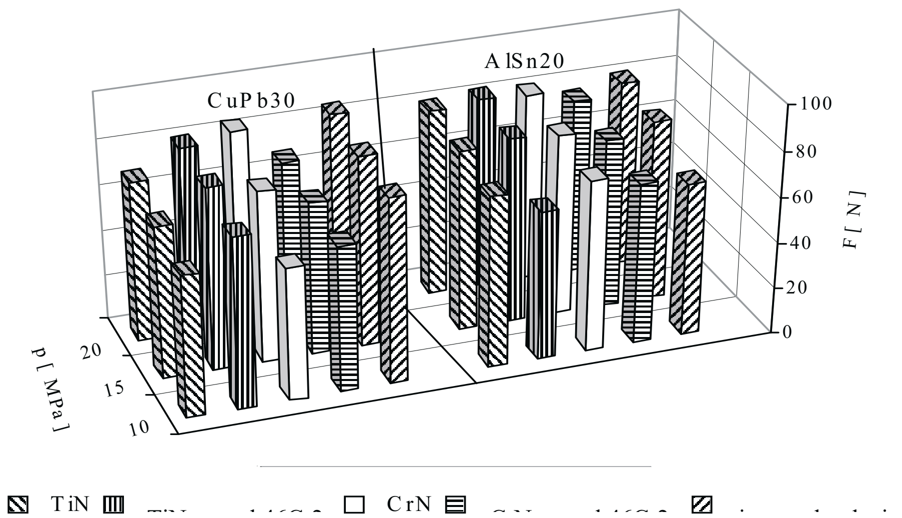

Fig. 2. Friction forces during frictional coupling movement initiation

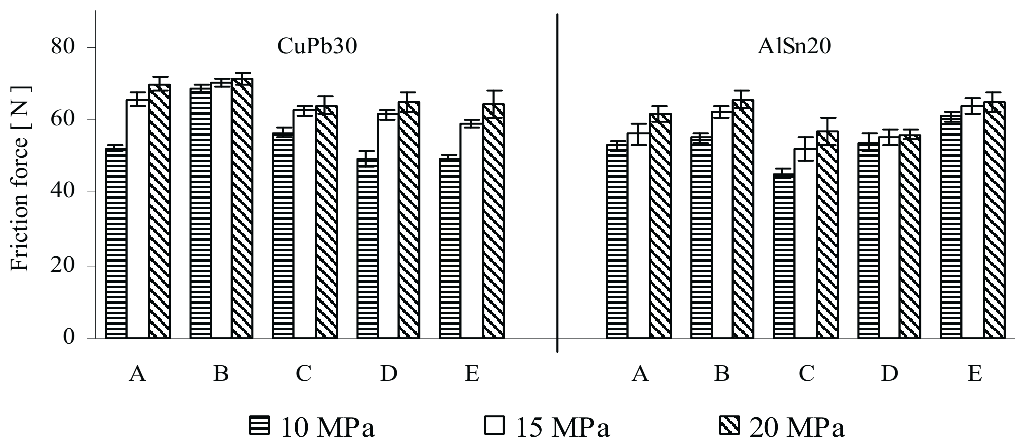

Fig. 3. Friction force in the function of kinematic coupling with surface layer pin load; A) TiN, B) TiN-steel 46Cr2, C) CrN, D) CrN-steel 46Cr2, E) nitrogen hardening

In the remaining pin-bearing liner frictional coupling arrangements the recorded values were similar and close to those obtained in frictional couplings with a nitrogen hardening pin. In the pin-bearing liner kinematic coupling determined operation conditions significant differences in the recorded frictional force values were observed (Fig. 3). The measuring results obtained during the tests showed that couplings with AlSn20 alloy bearing liner feature lower friction force values than couplings with CuPb30 alloy bearing liners. The lowest values were recorded in couplings with chromium nitride surface layer pins while a significant frictional resistance decrease occurred in AlSn20 alloy bearing liners. In CuPb30 bearing alloy couplings the frictional force is similar to that in nitrogen hardening couplings. The application of the TiN layer leads to an increase in frictional resistance regardless of the bearing alloy grade of the bearing liner.

The contact area temperature fluctuation analysis revealed that the application of AlSn20 bearing alloy leads to a temperature drop in the friction area with respect to CuPb30 alloy (Fig. 4). Decreasing the friction temperature to a level below the temperature recorded for tests with nitrogen hardening pins is important for the tested surface layer modified couplings with AlSn20 alloy bearing liners. In the tested frictional couplings with CuPb30 alloy bearing liners a similar temperature level was observed with the exception of pins with CrN surface layers. In this arrangement the highest temperatures in the friction area were recorded particularly in cases of a higher friction coupling load.

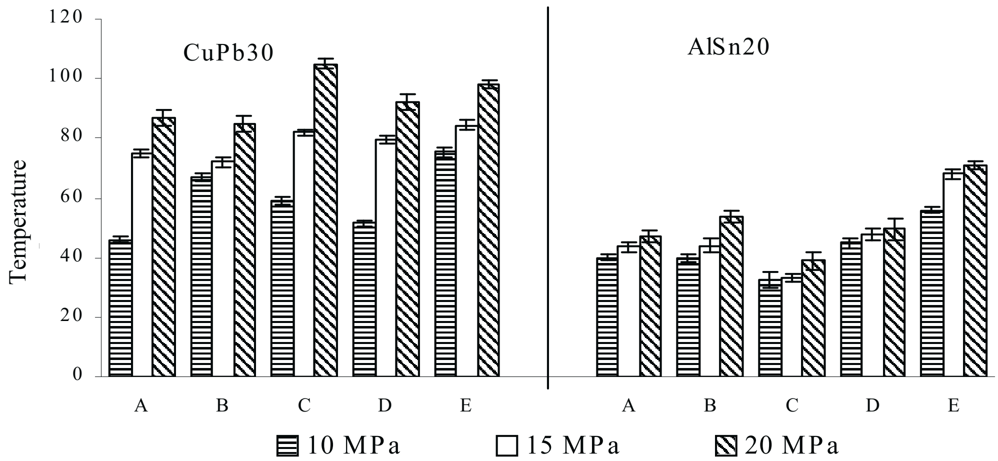

Fig. 4. The temperature in the friction area in the function of surface layer pin kinematic coupling load; A) TiN B) TiN-steel 46Cr2, C) CrN, D) CrN-steel 46Cr2, E) nitrogen hardened

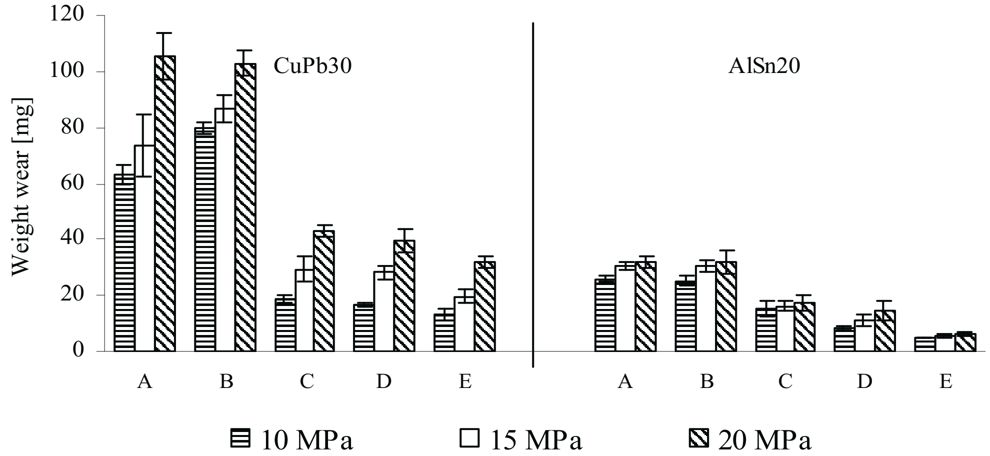

Fig. 5. Bearing alloy wear with respect to the surface layer type; A) TiN, B) TiN-steel 46Cr2, C) CrN, D) CrN-steel 46Cr2, E) nitrogen hardening

The CuPb30 and AlSn20 bearing alloy weight wear was also recorded during the tests. (Fig. 5). The test results revealed that the wear of the tested alloys depends significantly on the properties of the surface layers of the pins in the friction couplings. The results obtained allow one to state that the application of a “ring” surface layer of the pin has an impact on the change in the bearing alloy wear value. A significant reduction of wear in the bearing alloy with the band surface layer with respect to a homogenous layer was observed in a pin with a CrN layer with an AlSn20 alloy.

The bearing liner wear in this kinematic assembly is 20-40% lower than in a pin with a homogenous CrN layer in frictional couplings. The highest bearing alloy wear was observed in couplings with a TiN surface layer while the lowest bearing liner material wear occurred with an nitrogen hardening pin. However the use of the CrN-steel layer pin in couplings with CuPb30 bearing liners shows wear values close to couplings with nitrogen hardening pins. A similar tendency may be observed in couplings with AlSn20 bearing liners but in this case the bearing alloy wear doubled.

The changes may be explained as mutual reacting of the surface layers of the pin and the bearing liner and the occurrence of physical and chemical phenomena on their surfaces due to external forces. In this case the role of the lubricant, which while undergoing various transformations may advantageous friction conditions, is of significance. As a result of the frictional process the phenomena of transporting the bearing liner material to the pin surface or forcing hard pin wear particles into the bearing liner alloy surface may occur.

4. Conclusions

The following conclusions may be arrived at on the basis of the experimental tests performed and analysis of their results:

- the applied technologies make it possible to produce pins with durable band surface layers displaying tribological properties required for the frictional coupling pin operating in a combined frictional environment,
- it has been demonstrated that slide couplings with CrN-46Cr2 and nitrogen hardening band surface layers feature the least bearing alloy wear. However the highest wear has been recorded in couplings with TiN surface layers,
- modification of the CrN pin surface layer has a beneficial impact on reducing frictional resistance, and temperature reduction in the friction area as well as reduction in bearing alloy wear.

References

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