RADIATION MODIFIED ION-IMPLANTED BALLS OF BALL BEARINGS

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Abstract. A radiation-modified ion-implanted ball of 1/4 inch diameter ball bearings made of 440C steel was investigated. The tuning modification was carried out by ion beam-assisted/enhanced deposition (IBAD / IBED) methods. The surface of the samples was coated with a nanosize multilayer coating of VN-TiN- ... VN (11 layers with a thickness of 100 nm each layer, an energy of 30 keV and a fluence of ~10^{17} ions / cm^2. Hardness of the Modified Ion-Implanted Balls of Ball Bearings is more than the hardness of the original steel by 1.8 times. The results of the study show that IBAD / IBED methods can be used as an effective tool for improving the parameters of ball bearings.

1. Introduction

Various commercial processes of the production of new construction materials with improved mechanical parameters for the construction of various purpose items and devices with sophisticated operation parameters have found wide commercial application today. Among alternative methods of construction materials development for various purpose facilities and units with improved operation parameters quite successful are such innovation radiation technologies, as ion bombardment. Among them direct ion implantation (II), ion beam mixing/ (IBM), ion beam-assisted/enhanced deposition (IBAD/IBED), plasma source ion implantation (PSII) should be mentioned [1,2].

Radiation technologies are free from the limitations of equilibrium thermodynamics (exceed of impurity solubility limits, low temperature of the process, new phase nucleation and growth, etc). Therefore these methods, substantially differing from equilibrium thermodynamics conditions enable formation of modified surface composition layers of metals and alloys in equilibrium, non-equilibrium, metastable and nanocrystalline states [3-5].

Successfully proved method of ion beam assisted deposition is used to modify (hardening) nanosize surface layers of the balls for ball bearings with decreased friction features, made of 440 C steel. The process of ion-induced processing is used at the final stage of ball bearings making and does not change the rest bulk of the balls, their construction and bearing production processes. Applied radiation technology of balls modification is based on general theory of accelerated particles interaction with a solid body. Therefore, numerous complicated radiation processes, nano-physical phenomena and conditions of ion-induced processing of construction materials in many aspects define hardening and friction coefficient decrease in modified balls.

2. Materials and Experimental Methods

A martensitic stainless steel ball of ball bearing with¼" diameter was used as the starting material. Table presents chemical composition of hi-tech, high-alloy stainless steel 440C in percentage.

Grade		*C*	*Mn*	*Si*	*P*	*S*	*Cr*	*Mo*
440C	*min*	*0.95*	*-*	*-*	*-*	*-*	*16.00*	*-*
	max	*1.20*	*1.00*	*1.00*	*0.040*	*0.030*	*18.00*	*0.75*

The tuning modification was carried out by ion beam-assisted/enhanced deposition (IBAD / IBED) methods. The surface of the bullet was carried out by the nanosize multilayer coating VN-TiN- ... VN (11 layers with each layer thickness 100 nm 30 keV energy and fluence 10^{17} ion/cm^2.

Development of measuring procedures and study of microhardnes of initial (unprocessed) and radiation-modified ion-implanted 1/4'balls of ball bearings, made of 440C steel. A special ball-form specimen holder was designed and fabricated for measuring microhardness of balls of 1/4" diameter. A procedure for ball-form speciment microhardness testing was developed. Microhardness was tested using SHIMADZU Dynamic Ultra Micro Hardness Tester, DUH-211S.

Mechanical hardness was tested by microindentation under various loadings and constant deformation rates. The loads onto the indenter varied from 100 mN up to 1996 mN, which enabled microindentation at the

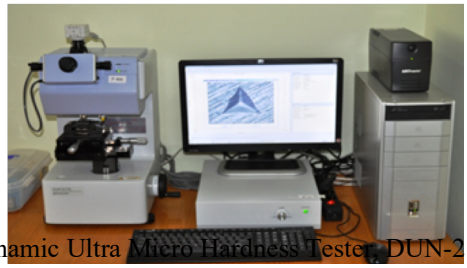

Fig.1. Dynamic Ultra Micro Hardness Tester, DUN-213S

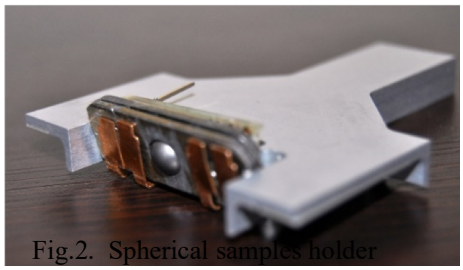

Fig.2. Spherical samples holder

depths of 350 nm up to 2000 nm. The following indentation parameters were selected for nicrohardness testing: loading speed – 13.324, $mN \cdot sec^{-1}$ at loads up to 200 mN, while at loads above 70.067, $mN \cdot sec^{-1}$, hold time at load -5, sec, hold time at unload - 3, sec and test count -5.

Nanomorphology of initial and ion-implanted samples was investigated on CMM-2000 microscope. Holder for spherical samples was created for scanning tunneling microscope CMM-2000.

Measurements were carried out on the scanning tunneling microscope, with high spatial resolution. Measuring range on the X and Y axis does not exceed $0.3\text{-}2x10^4$ nm, and on the Z axis $0.2 – 2x10^4$ nm. Measurement error is 10 nm ±10%.

Coefficient of dry friction the initial and modified samples was studied by non*destructive* pin on disc method [6].

Conclusions

Developed process and balls with improved strength by 1.7-1.8 times and friction coefficient can find application in the production of various purpose ball bearings with improved operation parameters. Radiation Modified Ion-Implanted Balls of Ball Bearings will be applied at the final stage of ball bearings manufacture, leaving unchanged the remaining bulk of the balls, structure and of ball bearings production processes.

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