Analysis by Scratch Method of Coatings of AISI5115 and M31 Steels Coated with AlTiN and CrN Using PVD Method

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1. Introduction

AISI 5115 and M31 steels are frequently used in the production of guns. Improving wear resistances of these parts is important in order to have them function properly and work without any problem.

Scratch test methods are extensively used to identify mechanical characteristics such as breakage, damage and adhesion of surfaces of thin films and coatings [1].

2. Material and Method

16MnCr5 (AISI 5115) and 32NiCrMo145 (M31) cementation steels, which have structural function and are extensively used in moving parts of light guns, were taken as the base materials in the experiments.

Thermal processes were applied to these parts and they were coated with AlTiN and CrN using PVD technique (Table 1).

Table 1 Parameters of AlTiN and CrN Coatings.

Material	Coating	Basic Voltage (V)	Cathode Current (A)	Number of Cathode	Nitrogen Pressure (Torr)	Time (min.)	Temperature(°C)
M31 - AISI 5115	AlTiN	-180	50	3 Pcs. AlTiN (%66Al+ %33Ti)	$8x10^{-3}$	30	300
	CrN	-110	60	3 Pcs. Chrome (Pure)	$6,5x10^{-3}$	60	220

Cross-sections of experimental samples were scrutinized with scanning electron microscope (SEM) and coating thicknesses were measured. Besides, after the coating process surface roughness, hardness and elasticity module measurements were made.

Scratch tests were applied to the samples in order to determine the mechanical characteristics, such as breakage, damage and adhesion, of AlTiN and CrN coatings and the results were evaluated.

3. Results of the Experiments

In the experiments, the critical load (Lc_1) at which the first crack occurred, and the critical load (Lc_2) at which the coating broke were calculated [2]. The scratch images obtained with optical microscope, were evaluated together with acoustical emission graphics. The numerical data obtained from the experiments are given in Table 2.

Table 2 Coating Thickness, Hardness and Scratch Test Measurement Data.

Material	Surface	Coating Thickness Mean (µm)	HVIT Mean Vickers Hardness (HV-10mN)	Scratch Testing		
				Load (N)	Critical Load (Lc_1)	Critical Load (Lc_2)
AISI 5115	Uncoated	-	373,9963	-	-	-
	AlTiN	2,8	2903,99	30	6,5	23,5
	CrN	2,82	2649,24	30	6	19
M31	Uncoated	-	612,516	-	-	-
	AlTiN	2,4	2827,485	25	8	21
	CrN	2,20	2225,105	30	7	18

4. Evaluation

Hardness values of coated samples increase 3,3 to 7,7 times compared to uncoated samples.

After the coatings, although hardness of CrN coatings came forth at the expected value, hardness of AlTiN coatings resulted in a value 13 % less than the expected one.

The critical loads (Lc_2) for AlTiN coatings are approximately 23 % higher compared to CrN coatings for both of the base materials. The results are compatible with the hardness values obtained after the coatings. It was observed that the critical loads (Lc_2) were on the decrease as the surface roughness values of the same base materials decreased [3].

5. Summary

In this study, Adhesion Strength and Mechanical Failure Modes of AlTiN / CrN thin film coatings on AISI5115 and M31 steels, which were applied to improve surface characteristics of these steels, were examined by using the scratch method.

6. References

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