FRICCION AND WEAR BEHAVIOR OF TI-W PVD COATING ON STEEL AISI 316L

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1. Introduction

With the most effective balance of carbon, chromium, nickel and molybdenum for corrosion resistance, AISI 316L austenitic stainless steel is widely used for high temperature, aggressively corrosive conditions and nuclear reactor applications. However, with a low hardness (200 HV) and an austenitic structure which cannot be hardened by heat treatment, there is no easy way to improve its wear resistance [1].

The PVD has aroused considerable interest in recent years since it permits the deposition of dense and compact coatings, leading to improved chemical and mechanical properties. This technique produces a wide range of coatings with high wear and chemical resistance at relatively low cost and through easy coating procedures [2]. In order to improve their surface properties, different types of coatings such as oxides, nitrides, carbides and "Diamond Like Carbon" (DLC) can be deposited trough this technique in order to improve wear properties [3], [4].

The aim of this study was to investigate Ti-W coating on AISI 316L by PVD in order to improve the sliding wear resistance of stainless steel 316L.

2. Experimental

Sample of AISI 316L stainless steel (0.03 C wt%, 16.7 Cr wt%, 9.5 Ni wt%, 2.9 Mo wt%, and Fe balance) with sizes 1.5 cm x 1.5 cm x 0.6 cm was used as substrate. The substrate was prepared metallographically and cleaned ultrasonically in an acetone bath for 15 minutes before of deposition. A R.F. magnetron sputtering system (13.56 MHz) and target Ti10W90 (99.99% pure) were employed to TiW interlayer deposition. The coating was synthesized using a pressure in the chamber of 0.19 Pa and applying power of 200 W, while Ar was used as precursor gas for plasma with flow of 20 sccm. The deposition times was selected in order to obtain a thickness of 300 nm.

The crystal structure was determined by X-ray diffraction (XRD) using an X-pert Pro Panalytical device operating in beam mode at 5°, with monochromatic line Kα of copper (1.540998 Å) working at 45 kV and 40 mA. The chemical composition of the interlayer was determined via energy-dispersive X-ray spectroscopy (EDX) with energy of 4 kV to 6 kV using a SEM MIRA3. Tribological studies were carried out using ball on disc method on the CSM instrument tribometer at a load of 1N, linear speed of 16 cm/s and sliding distance of 3m. Prior to wearing test, the coating and ball were ultrasonically cleaned in isopropyl alcohol for 3 min and then dried in the air. Stainless steel AISI 316 ball of 4 mm in diameter was chosen as the counterpart. Tribology experiment were conducted in ambient atmospheric condition at room temperature.

After the wear test, the 2D profile, 3D profile and wear loss of track on sample was measured by a Bruker Contour GT-K vertical scanning interferometer. The surface morphology of the coating was analyzed using a scanning electron microscope (SEM, Tescan/mira 3), operating at a voltage of 15 kV. Energy dispersive X-ray spectroscopy (EDS, X-MAX 50/Oxford Instruments) was used for elemental analysis of wear track.

3. Results and Discussions

The evolution of coefficient of friction (COF) on Ti-W coating and 316L substrate during the ball on disc tribological test at room temperature is summarized in Fig. 1. The COF of the Ti-W coating was lower than of the 316L substrate. Friction coefficient of the sliding system Ti-W/316 is 0,16 which increases to 0,4 while de sliding system of substrate has a significantly higher value in the range 0,5-1,5. The friction curve is unstable in case of substrate sliding system. This instability appears due to the large deformation occurring during sliding according to Fig. 6. The Ti-W coating presented a better anti wear properties with lower COF

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value than 316L substrate, however, it increased during wear stage, which could be attributed to an accumulation of wear products (debris) in the contact zone.

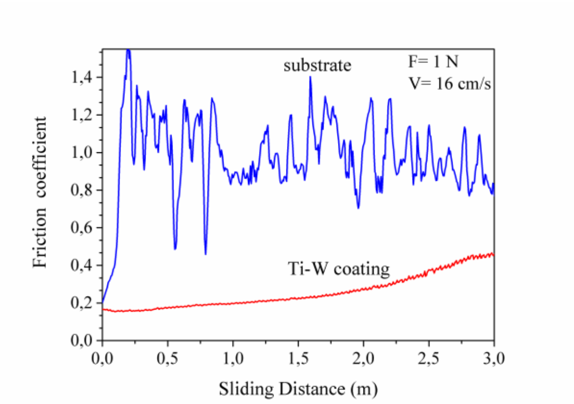

Fig. 1. *Friction coefficient of the Ti-W coating and 316L substrate*

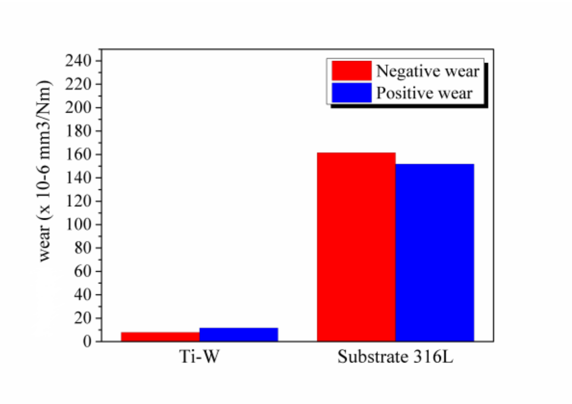

Fig. 2. *Wear rate of the Ti-W coating and 316L substrate*

The wear rate (mm^3/Nm) of the coating and substrate against sliding distance was calculated by the formulae used in literature [5],[6]. The results shown in Fig. 2. indicated that the wear rate of the Ti-W coating was higher than substrate. 2D wear profiles cross the sliding direction were obtained on the wear scars of the substrate and coating, under normal load of 1N the maximum wear depth of the Ti-W coating was approximately 0,03µm, much smaller than that of the 316L substrate approximately 5µm. This suggesting that the substrate under this normal load suffered a much severe wear. The drx shows the presence of two phases Ti y W, there is not formation of new peak indicating the absence of a new phase. The calculated network parameter for Ti and W was 0.28954 nm and 0.31137 nm respectively.

4. References

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