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THE COMPARISION OF WEAR BEHAVIOUR OF PLASMA NITRIDED OF AISI H13 AND 722M24 STEELS UNDER DIFFERENT TRIBOLOGICAL CONDITIONS

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Abstract: *The wear behaviours of plasma nitrided of AISI H13 and 722M24 steels were compared using different tribological conditions after removed white layer from their surfaces. Because it has been gotten advantage to remove white layer from the diffusion layers. Test samples prepared from these materials which were plasma nitrided at different temperatures. Wear tests were carried out under dry and lubricated abrasive conditions at elevated temperatures between 50-200 ºC. Naturally, wear losses for dry conditions were higher than for lubricated abrasive conditions. And also, wear tests carried out on a general purpose wear machine having a special heating unit with disc-disc sample configuration. White layer on the plasma nitrided surfaces of their steels were removed before wear tests. Both materials have shown linearly similar wear losess at elevated temperatures. Diffusion layer of materials after plasma nitrided is important against to wear losses. These losses are dependent to the thickness of diffusion layers. Wear losses were decreased for thick diffusion layers while wear losses were increased for thin diffusion layers of both materials. Other properties for both materials of long term plasma nitrided, changing times from instable situation to stable situation were very short during wear tests.*

Keywords: *Plasma nitriding, wear, friction, H13 and 722M42 steels, elevated temperatures*

1. INTRODUCTION

There have been different kinds of coatings types such as, hard, wear-resistant coatings, including nitrides, carbides, carbonitrides and others. And also, they have been developed and successfully used in many industrial fields for surface enhancement [1, 2].

Plasma nitriding between above coating methods is a well established technology for surface modification of metal alloys, involving a complex interaction mechanism [3, 4]. The interaction of steel and nitrogen constituents yields the formation of different types of metallic nitrides, which provides helpful mechanical properties to the near-surface region of steel [5].

Wear resistance, the coefficient and surface roughnesses of plasma nitrided steels of AISI H13 and 722M24 have been investigated under the different conditions after white layer ground off from the surfaces. In this study, the goal of this study is to investigate the wear behaviour of both steels of plasma nitrided under the dry and lubricated abrasive conditions at elevated temperatures.

2. EXPERIMENTAL PROCEDURE

2.1. Materials

These steels are used in the manufacture of hot working tools, dies and gears in industry. During the working as frictional, there have been resulted some serious problem on the working surfaces of machine parts, such as, wear. For this reason, AISI H13 and 722M24 were chosen as test materials.

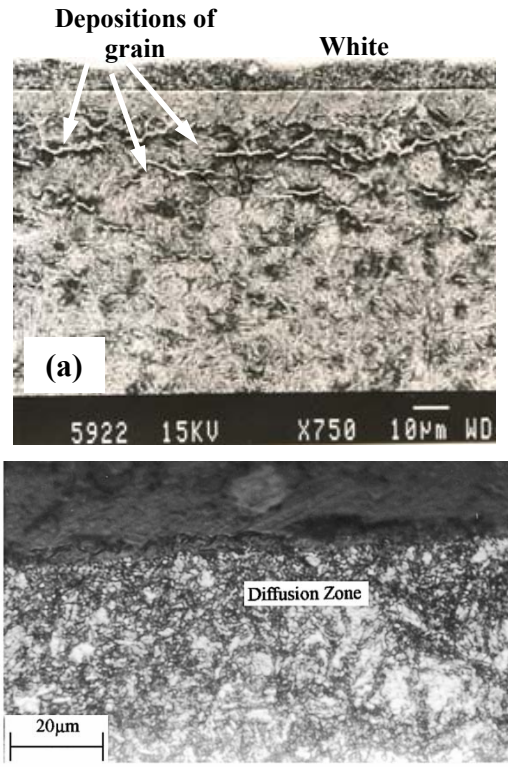


Figure 1. Microstructure of plasma nitrided steels. (a) H13 steel with white layer; (b) 722M24 steel without white layer [8,9]

The microstructures of plasma nitrided steels of H13 and 722M24 were shown in Fig.1. The hardness and depth of diffusion zone depend on the nitriding parameters such as treatment time and temperature together with material composition. It can be seen from Fig. 1 that there are precipitates at the grain boundaries. The hardness of the nitrided layer is a predominant function of treatment temperature.

The surface hardness is changed acccording to the plasma nitriding conditions. The high hardness values of AISI H13 steel were obtained for low nitriding temperatures between 500 and 590 ºC [6,7]. For example, the hardnesses obtained on H13 steels at 530 and 550 ºC nitriding temperatures for the same durations (i.e. 16 h) are 1300 and 1215 HV0.3, respectively. On the other hand, for 722M24 steel, surface hardness is reduced as much as 250 HV. Since the nitriding temperature is changed from 510 to 590 ºC. The maximum surface hardness of the test materials (i.e. without white layer) is determined between 1000 and 1100 and 690 and 900 HV0.3 for AISI H13 and 722M24 materials, respectively [6,7].

2.2. Wear tests

These steels are widely used in the manufacture of hot working tools, dies and gear in industry. Fort this reason, AISI H13 and 722M24 steels were chosen as wear test materials. After the materials in the shape of cylindrical bars were plasma nitrided at different temperatures for various durations [6,7], they were cut into dimensions of 23 mm in diameter and 10 mm in thickness. The white layers occurring on cylindrical surfaces of the sample in different thicknesses after the nitriding were ground off mechanically, using grit emery papers.

The removal of the white layers from the surface was controlled by optical microscopy (OP) studies on the sample. Optical microscopy studies were also performed for microstructural examination.

Structural and surface analyses of the samples before and after wear test were performed by OP, SEM and ED-X studies.

Wear tests were carried out on a general purpose wear machine having a heating unit with disc–disc sample configuration under lubricated abrasive conditions. Sample configuration is given in Fig. 2.

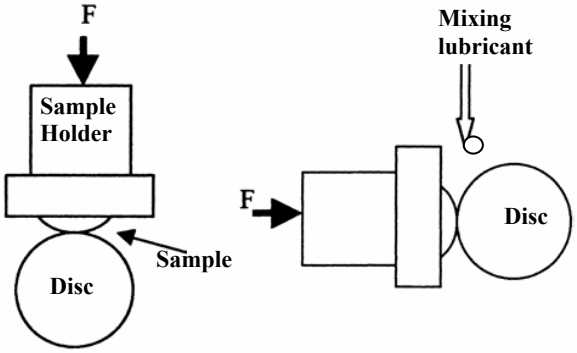


Figure 2. Wear test configurations; (a) Dry test and (b)Lubricated abrasive test [8,9].

The counterface wheel (lower disc) having 30mm outer and 20 mm inner diameters and a 13mm thickness was 100 Cr 6. The maximum surface hardness of the wheel was 63 HRC. The upper disc (test sample) was put into a sample holder after cleaning and weighing the wear couples, and they were inserted into the wear tester. The surface asperities were also recorded before and after tests.

The test samples were heated to the test temperatures of 50, 100, 150, 200 ºC under dry and lubricated abrasive conditions. A constant force of 125N was applied during the tests. The speed and duration of the test were 1 m/s and 1200 s under test conditions, respectively. The abrasive-containing lubricated tests were performed with 5% beach sand with a grit diameter of 106–150 mm in SAE 63 machine oil. The mixture of the lubricant was introduced into the friction zone by gravity with a flow rate of 22 mg/s while the lubricant was stirred continuously, so the abrasive particles did not remain at the bottom of the lubricant bath.

The test discs were capable of being indexed in several positions. Thus, several results could be obtained from each test piece. The test disc was

static under test loads while the wheel was rotated during the tests. The frictional forces were also recorded continuously during the experiments.

3. RESULT AND DISCUSSION

Wear tests were performed to compare under the dry and lubricated abrasive conditions after removed white layer from surface plasma nitrided. The results of wear losses of both conditions for AISI H13 and 722M24 steels are given in Fig.3, 4, 5 and 6.

To compare between dry and the abrasive-containing lubricated sliding wear tests, the wear tests were performed at elevated temperatures. Tests results both wear tests were shown exactly different trends. H13 and 722M24 steels were given linear wear values after tests. But, wear tests for H13 samples were obtained different values than 722M24 samples at 200 ºC. The reason can be oxites where formed on the surfaces that they are showed wear resistance. Main reason can be thin or thick diffusion layers. Wear loss determined high that thin diffusion layer of H13 was removed by lower disc. However, wear losses for thick diffusion layer of both steels were obtained low. For dry sliding wear conditions, wear losses of 722M24 samples were higher than H13 samples as shown in Fig.3 and 5.

Main differents of wear losses for both steels are coming from different hardnesses. Surface hardnesses of thick diffusion layers were decreased low at elevated temperatures for others.

The samples of double plasma nitriding and long time plasma nitriding are not shown more differences by wear losses. White layer removed from the surfaces are given useful properties for dry sliding and, mainly, lubricated abrasive sliding wear conditions. During the friction, white layer is fallen out of surfaces and formed sub surfaces cracks at elevated temperatures.

At elevated temperatures, the curves of wear losses for both steels go down. It means that wear losses are decreased for both steels under the lubricated abrasive conditions, as shown in Fig.4 and 6. Weight losses for both materials in spite of the lubricated abrasive particles and increasing temperatures were resulted lower than dry sliding conditions. In the present studies, the lubricated abrasive was not effect more for nitriding surfaces without white layer. Besides, weight losses were decreased with lubricated abrasive and the various temperatures. These losses can be changeable according to the abrasiv particle sizes.

The times from unstable to stable cases for lubricated abrasive wear conditions during the sliding wear are lower than dry sliding wear conditions for short and long plasma nitriding samples of H13 and 722M24.

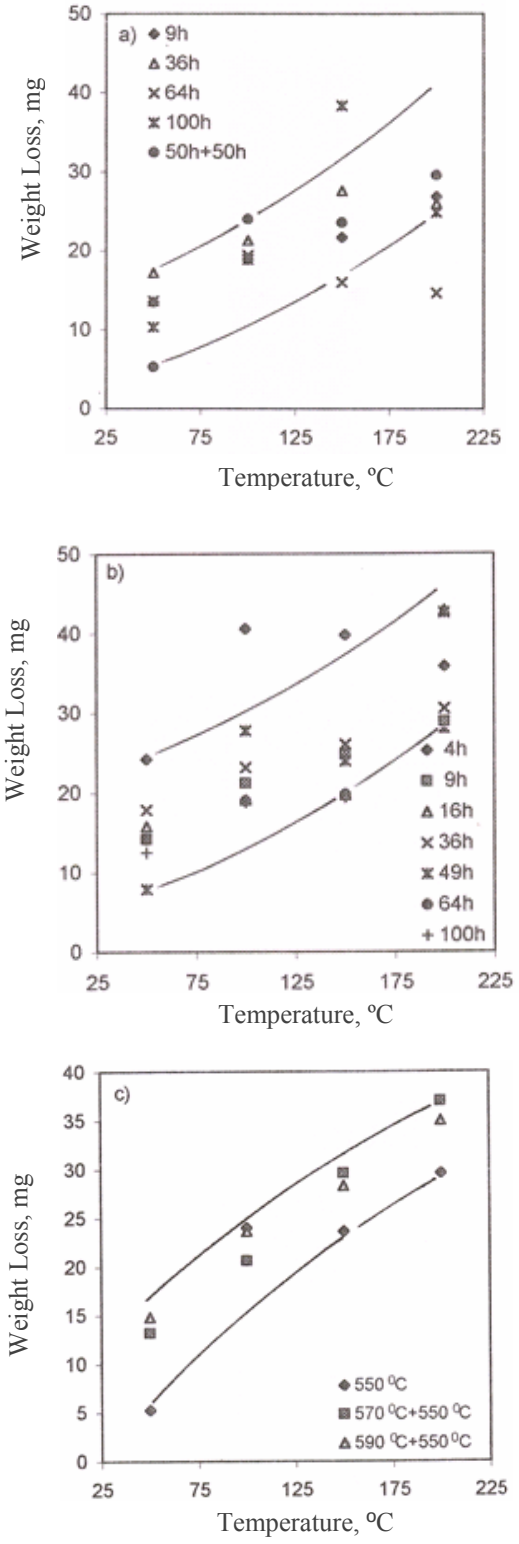
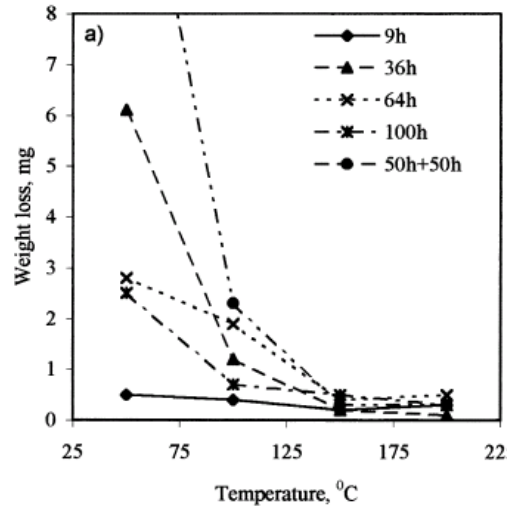
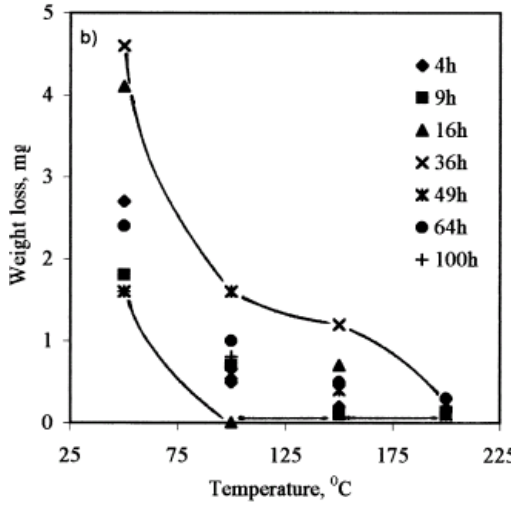


Figure 3. The variations of weight loss of 722M24 steel with wear test temperatures under the dry conditions tests. Nitriding temperatures: (a) 550 ºC; (b) 570 ºC and c) Nitridind times = 50+50 hours [8].





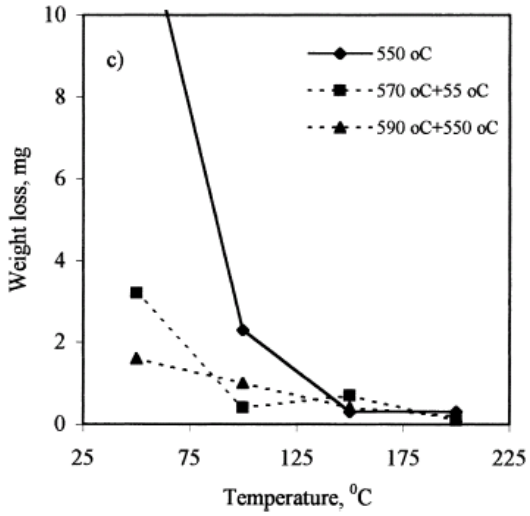
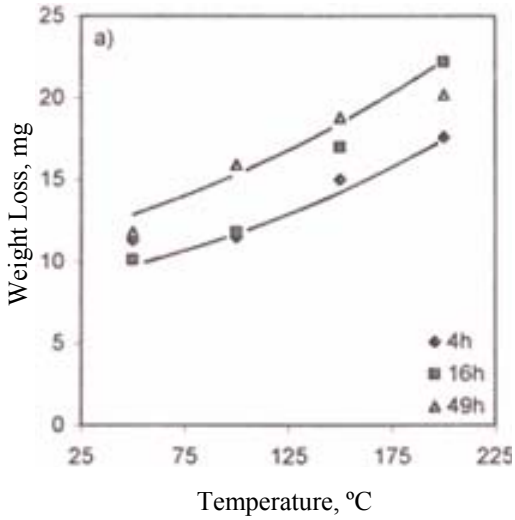


Figure 4. Weight losses of 722M24 with test temperature. Nitriding temperature: (a) 550 ºC; (b) 570 ºC; (c) double temperature nitrided, under lubricated abrasive conditions tests [8,9].



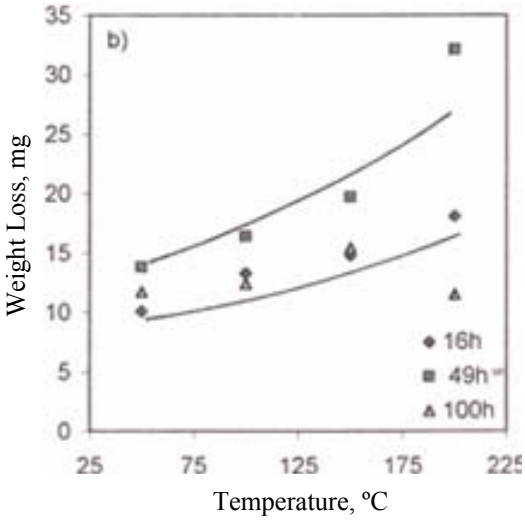


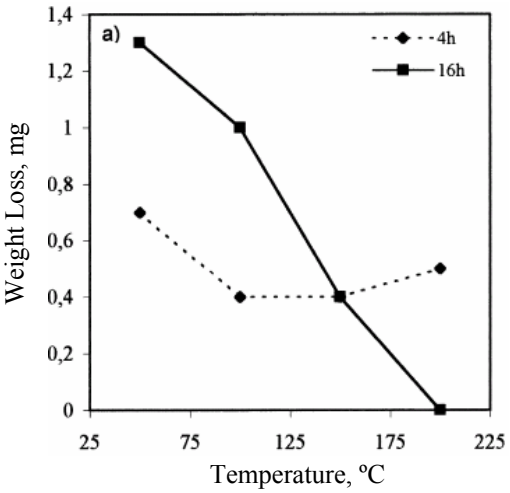
Figure 5. The variations of weight loss of H13 steel with wear test temperatures under the dry conditions tests. Nitriding temperatures: (a) 530 ºC; (b) 550 ºC [8]

Worn surfaces of both sliding wear tests were obtained different as shown in Figs.7 and 8. Fig.7 and Fig.8 show worn surfaces under the dry and lubricated abrasive sliding conditions for 722M24, respectively.

Under the lubricated abrasive conditions, weight losses of 722M24 steel were obtained higher than weight losses of H13 steel as dry sliding wear conditions at elevated temperatures as shown in Figs.4 and 6.

4. CONCLUSIONS

Wear tests were performed to compare under dry and lubricated abrasive conditions after removed white layer from the surface of plasma nitrided. The following conclusions can be derived from the results presented in this work;



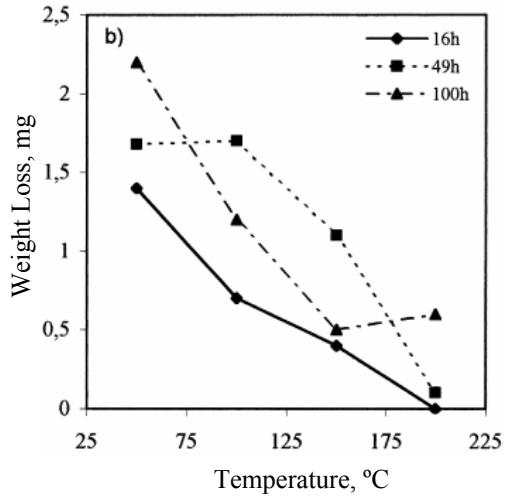


Figure 6. The variations of weight loss of H13 steel with wear test temperatures under the abrasive-containing lubricated conditions tests. Nitriding temperatures: (a) 530 ºC; (b) 550 ºC [8,9]

1.Tests results both wear tests were shown exactly different trends. H13 and 722M24 steels were given linear wear values after tests under dry sliding conditions.

2. Wear losses for thick diffusion layer of both steels were obtained lower than harder and thin diffusion layer of H13.

3. The samples of double plasma nitriding and long time plasma nitriding were not shown more differences by wear losses.

4. The wear rates of plasma nitrided and white layer removed AISI H13 and 722M24 steels were decreased with test temperature involved in this study under lubricated abrasive conditions.

5.Weight losses for both materials in spite of the lubricated abrasive particles and increasing temperatures were resulted lower than dry sliding conditions.

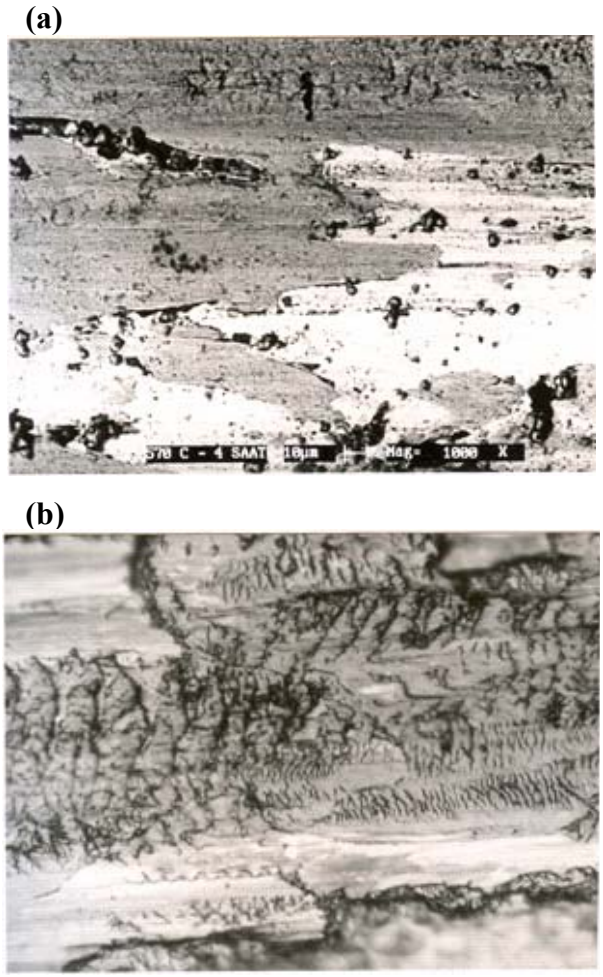


Figure7. Worn surfaces of plasma nitrided 722M24 sample at 570 ºC and for 4 h; (a) Test sample, SEM (BS-I) and (b) lower disc, OP (Magnification: X400)

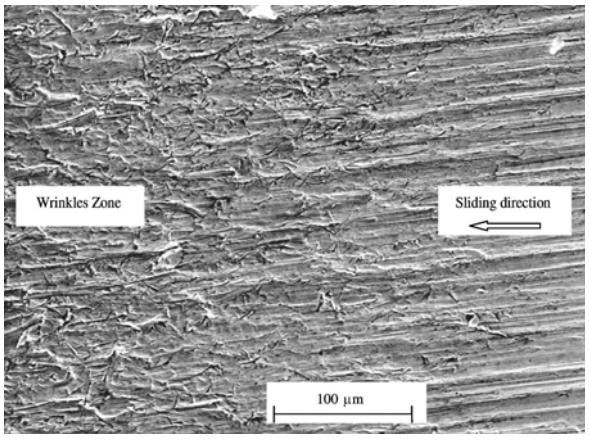


Figure 8. Wrinkles on the worn surface at the test temperature of 200 ºC (plasma nitrided 722M24 sample at 570 ºC for 4 h), under the lubricated abrasive conditions tests.

6. The nitrided layer produced for a short time exhibited lower wear rate with temperature than the layers produced for long times.

7. The lubricated abrasive was not effect more for nitriding surfaces without white layer. Besides,

weight losses were decreased with lubricated abrasive and the various temperatures. These losses can be changeable according to the abrasiv particle sizes.

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