Wear Properties of AISI 4140 Steels Modificated By Using Pulse Plasma Technique

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Abstract

In this study, the microstructure and wear properties of pulse plasma treated AISI 4140 steel was investigated. The surfaces of the samples were modified by using plasma pulse technique. The only one battery capacities (800mF) and two different sample plasma gun nozzle distances of 50mm, 60mm, 70mm, 80mm and different number of pulse were chosen for surface modification. XRD analyses were done for all samples. Wear test was done in CSM-linear wear test machine with 0.15 m/s constant sliding speed under 5N, 7N, and 9N loads for 200 m. It was observed that friction coefficient and wear value were changed in accordance with load. Friction coefficient values of modified specimens were lower than that of non-modified ones. Wear resistance was increased in modified samples. Worn surfaces of specimens were studied by SEM, EDS analyses techniques. Modification layer was formed on surface (in Fig.1a).

Key words: Pulse-plasma, surface modification, wear resistance

2. Introduction

It is known that the treatment of metals and alloys by high intensive ion, electron, plasma and laser flows is accompanied by surface heating (often higher than melting temperature) with subsequent rapid cooling of surface layer with approximately 10^{10} K/s rate. The appearing temperature gradients and doping of target during treatment procedure lead to structure-phase transformation in near-surface layer and to corresponding changes of mechanical properties such as hardness, wear resistance, corrosion resistance[1-3]. The using of compression plasma flows has a number of advantages: high plasma parameters in the flow, the possibility of surface layer doping by plasma working substance, short treatment duration, thick (up to 60 mm) modified layer.

In pulse plasma, an increase in the diffusion coefficients at a highrate elasto-plastic deformation is caused by an increase in the mean concentration of vacancies, which is in excess of the equilibrium one [4].

The pulsed-plasma technology allows a simultaneous, in one treatment pulse, realisation of different methods of affecting the workpiece surface: elasto-plastic deformation, impact by sound and pulsed magnetic field, heat and electric-pulse treatment, and deformation of metals and alloys during reversible ($\alpha+\gamma$) transformations. High power density of the flow (up to 10^7 W/cm^2 at the point of contact with the workpiece surface) makes it possible to perform

treatment in air atmosphere with no surface preparation. Treatment with a high-energy density flow of alloying elements causes no changes in geometric sizes of workpieces.

Depending upon the composition of the high-energy density flow, the surface layer can have high anti-friction properties, as well as high heat, wear and corrosion resistance. However, Pulse plasma has no line-of-sight restriction and retained dose problem characteristic of conventional ion beam implantation. It is therefore an excellent surface modification technique to treat complex-shaped industrial components [6].
In this study, cheaper and more heavily used in industrial surface properties of AISI 4140 steel with improved pulse plasma system you find in expensive and difficult availability of steel instead of groups investigated.

We have done wear tests: to 200m, 0.15 m/s speed 5N, 7N, 9N load device and a linear abrasion wear tests were performed under the CSM. Change of the load applied to samples after the abrasion test has changed the amount of the friction coefficient and wear was observed. The friction coefficient decreased 2-fold increase in wear resistance of steels was modified surfaces.

3.Experimental Procedure

In this study, AISI 4140 steel industry has a large surface area of use has been modified with pulsed plasma technology aims to improve the surface properties of. Surface properties of this steel type commonly used in a long, laborious without further heat treatment is cost-effective to develop the selected target. The chemical composition of the AISI 4140 steel in Table1, CNC machines in the cylindrical rod 22cm in diameter 10mm in height so that all the specimens cut from the same extent. Pulse plasma samples prior to any pre-treatment was applied. Pulse plasma process conditions applied in Table 2. " W" (tungsten) is used as the consumable electrode in this study.

Tablo 1.Chemical composition of 4140 steel

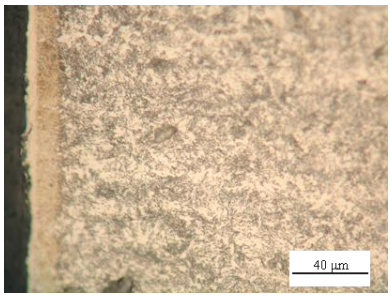
%	C	Si	Mn	P	S	Cr	Mo
AISI 4140	0.40	0.30	0.70	0.035	0.035	0.98	0.27

Tablo2. Pulse plasma parameters

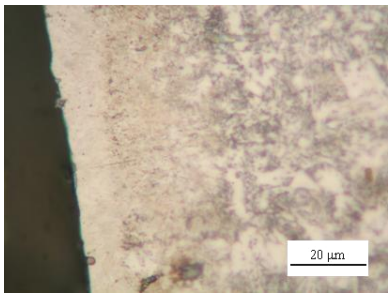
Sample No	h (mm)	Between the nozzle and samples(mm)	Number of pulse	Battery capacity, (mf)
1	10	70	15	800
2	10	70	10	800
3	10	70	5	800
4	10	80	15	800
5	10	80	10	800
6	10	80	5	800
7	10	60	15	800
8	10	60	10	800
9	10	60	5	800
10	10	50	15	800
11	10	50	10	800
12	10	50	5	800

Pulse plasma modified surfaces of the specimens in the method of linear wear device with CSM 0.15m/sn speed for the road 200m 5N, 7N, 9N wear test was performed for loads. The average air temperature 32°C during the experiments. Humidity is around 50-60%. Both the wear surfaces and wear products, SEM (different magnifications) and EDS analysis was conducted. Later, calculations and interpretations to help you wear a Perthometer MAHR surface roughness were measured with the specimens after wear.

3. Results and Discussion



a)



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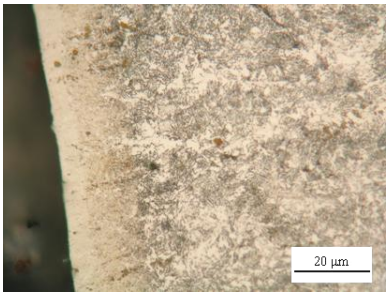

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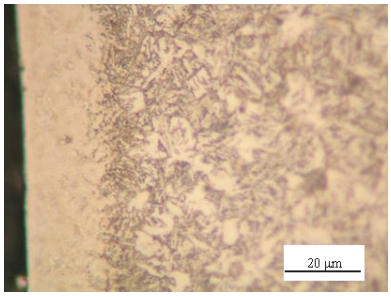

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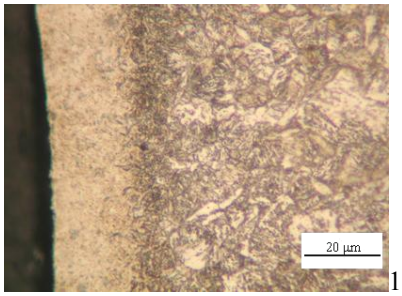

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e)

Fig1.Micrograph cross-section of modified samples a)2, b)5, c)7, d)8, e)11

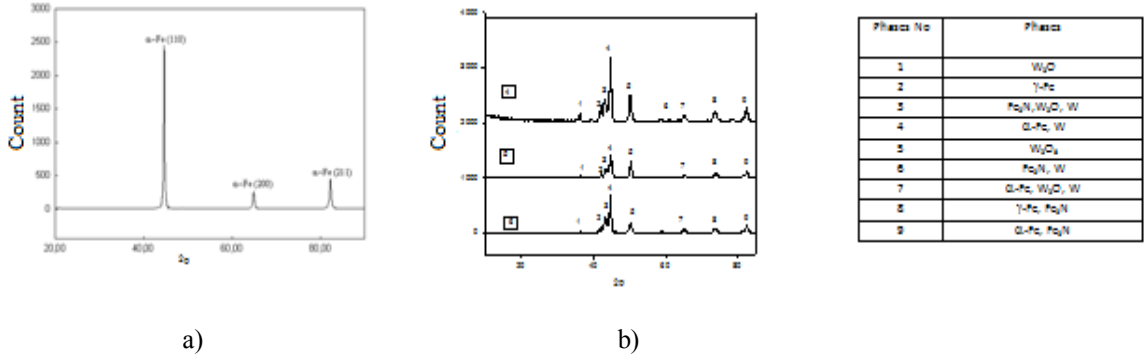
Fig. 1 shows optic micrograph cross-sections of the modified AISI 4140 steel sample. Evidence of severe plastic deformation is present in the treated surface layer, where microstructural morphology differs from that in the matrix. It was obvious from the microstructural examination that the modification layer, the diffusion layer and, at the bottom, the substrate can easily be seen due to contrast of light. The modification layer can be detected due to contrast of light.When the specimen-nozzle distance increases, the thickness of modificated layer decreases due to decreasing effect of plasma as seen in the results.

Another cause for this decrease is the ionized gasses exhausted from nozzle and they cannot reach to surface of specimen clearly and homogeneously[7-9].

Fig. 2 shows X-ray diffraction profiles of the untreatment and modified samples by pulse plasma technology. The Bragg diffraction peaks of the modified layer were broadened compared to that of the matrix, which can be attributed to the grain refinement effect and the lattice distortion on the atomic-level. Samples contained strong diffraction peaks for the Fe phase,as well as weak diffraction peaks of $Fe_{2-3}N$ and Fe_4N.

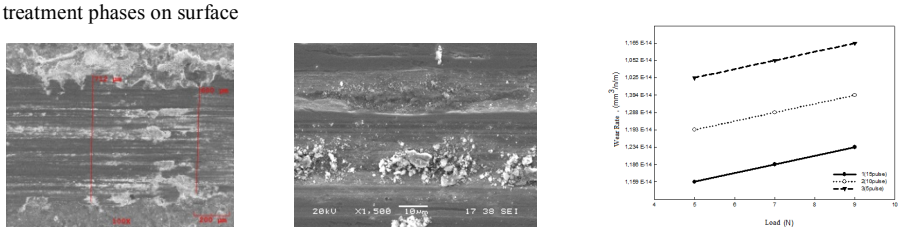
In addition, the pulse plasma technique can clearly improve the surface hardness. The surface microhardness value of the modified AISI 4140 steel was measured to be 1000HV0.05, which equals 5 times the associated value of the untreated substrate.

Fig.3. The compound layer can be identified easily under metallographic examination. The detailed thickness of the modified layers for different proses parameters. As the number of pulse and increased, the compound layer thickness increased.



a) b)

Fig 2.a) X-ray diffraction pattern obtained from the surface of the pulse –plasma treatment phases on surface, b) after pulse plasma treatment phases on surface



a) b) c)

Fig.3 a)after wear testing, wear scar on surface, b) SEM of worn surface, c) pulse effect to wear rate

After wear testing, SEM analyses were done all of samples surface. Especially, the plastic deformation was done in worn surface in Fig 3b. The groove was occurred in surface. The number of pulse affected to wear rate of samples surface. The wear resistance modified samples increased.

Results

The new phases were occured in modified surface by pulse plasma treatment. The hardness values of specimens exposed to modification treatment are 4 to 6 times greater than that of untreated specimens. Also, the wear resistance 2-3 times increased.