Reduction of Wear Effect for Copper- Silicon Alloy by Laser Treatment

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Abstract

Copper- silicon alloy was prepared by CNC machining into disc shapes with diameter 18mm and thickness of 3mm using CNC machine to obtain more accuracy dimensions .Grinding and polishing process were carried out for all samples, and conducted to Nd-YAG laser treatment. Laser conditions involved laser fluency of 500mJ, wavelength of 1064nm, and different number of laser pulses (20, 40 and 60 pulses). The samples were subjected to wear system measurements before and after laser treatment to calculate the wear rate with different situations. The results revealed that the wear rate was reduced by 15% after laser treatment.

Key words: copper-silicon alloy, laser treatment, wear rate

تقليل تأثيرالبلى لسبيكة نحاس – سيليكون بواسطة المعاملة بالليزر

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الخلاصة

تم تحضير سبيكة النحاس – سيليكون بواسطة التشغيل بمكائن CNC على شكل قرص بقطر 18 ملم وبسمك 3 ملم . استعمال مكائن CNC لغرض الحصول على دقة ابعاد اكبر . عمليات التنعيم والتلميع اجريتلكل النماذج وتم تعريضها الى المعاملة بليزر Nd-YAG . عوامل الليزر كانت بطاقة 500mJ وبطول موجي 1064nm وبعدد مختلف من النبضات الليزرية (20 ، 40 ، 60 نبضة) . تم فحص البلى بواسطة نظومة قياس البلى قبل وبعد المعاملة لغرض حساب معدل البلى . اظهرت النتائج ان معدل البلى انخفض بمقدار 15% بعد المعاملة الليزرية

1. Introduction

Laser beam was found to be widely spread used in several fields such as industrial, medical, research and etc. It made this technology a very distinguished compared to other sources of energy, and make it the traditional technology upon all other technology (and even modern ones) used in heat treatment process [1-3]. The laser surface processing can be classified according to the change in surface material synthesis into two kinds: First thermal process: in this process does not cause any change in the composition of the material surface like laser cutting, welding, tempering, annealing, melting, and hardening. The second types is the thermo-chemical process: in this process the metal will have change in metallic structure by adding another material so that the surface composition changes, such as laser cladding, and alloying. The advantages of the surface treatment process include flexibility and the possibility of treating small areas with leaving the other parts unaffected [4].

Recently, the laser has been used for the purpose of surface treatment of metal so it is considered as a method to improve the metal properties as roughness,

Hardness, resistance to corrosion and wear, etc. [5,6] . Wear is expounded to interactions between surfaces and specifically the and deformation on a surface as a results of removal mechanical action of the opposite surface.[7] . In materials science, wear is erosion or displacement and genuine site on a solid surface performed by the action of another surface. Wear of metals happens by the plastic displacement of surface and near-surface material and by the detachment of particles that kind wear. The dimensions of the generated particles might vary from millimetre vary all the way down to size associate with particle [8]. The interaction of laser light and its movement over the surface, fast heating of metal work items is achieved, and beyond that fast cooling down or extinguishing, and also the cooling rate, that in standard hardening defines extinguishing [9]. Under completely different completely different} laser-hardening conditions quite different surface-layer properties are obtained. a really robust connection of the chosen energy input, the kind of absorbent used the degree of overlapping, and therefore the mode of laser-beam steerage with the depth of the hardened path or layer, and therefore the through-depth profiles of micro hardness and residual stresses of the hardened path of material [10].

Many researchers have studied the improvement of the surface properties of metals and alloys by using laser such as Sameer R. paital [11] studied the Improvement of the corrosion and wear resistance of Mg alloys.

By employing a extremely intense beam of light generated from never-ending wave diode-pumped ytterbium laser synthesized a corrosion and wear resistant of atomic number 13 coating wealthy in Al12Mg17 intermetallic part by direct melting of atomic number 13 precursor powders on AZ31B Mg alloy substrates. The result of this kind of coating on the corrosion and wear resistance of the Mg alloy has been investigated within the current study. In general, improved corrosion resistance was ascertained for the optical device processed samples and rapprochement. In 2014, Haitham T. Hussein et al [12] have increased mechanical properties, wear resistance, and Vickers hardness of aluminum alloy by optical maser treatment.

The samples were transact by using Nd: YAG laser of energy 780 mJ, wavelength 532 nm, and period time of eight ns. Damage behavior of the samples were examine for all samples before and when transact by the Nd: YAG laser. Additionally, the dry wear experiments were administered by sing pin-on-disc technique. The results showed that the dry wear rate was cut when laser hardening with associate enhanced Vickers hardness values.

2. Experimental Procedure

2.1 Sample preparation

Copper –silicon alloy samples were prepared by cutting into disc shapes with diameter 1.8 cm and thickness of 0.3 cm using CNC machine to obtain more accuracy dimensions .Followed by removed the protrusions. The samples were cleaned and washed by distilled water and acetone and then drying in oven at 50 ^{o}C

.All samples were grinding with different silicon carbide paper grades and polished to obtain same surface roughness. Final step all prepared samples were placed in desiccator to avoid any contamination desiccator.

2.2 Chemical Composition

The chemical composition of these samples has been measured by X-Ray fluorescence techniques (Foundry Master Xpert). The elemental composition of the alloy used in this work as shown in table (1):

Table (1): Chemical composition of Copper – Silicon alloy.

Element	%
Magnesium	0.01
Calcium	0.03
Iron	0.07
Zinc	0.15
Silicon	0.42
Nickel	0.10
Copper	Balance

2.3 Laser setup:

Pulsed laser are used to harden a wide range of metal components.in this work Nd:YAG laser type (Q-Switched YAG laser system (Figure (1)) Germany product, with pulse duration (9) nanosecond , different laser energy and spot size of laser beam 2.2 mm, the sample placed at 10cm from laser probe.

Fig (3.3): Nd: YAG Laser setup

2.4 Calculation of wear rate

The wear rate has been taken with different parameters such as normal loads and sliding speed. Wear rates were measured by weight loss method. In this method the specimen was weighed before and after wear test to determine the net weight loss Wear rate was calculated according to the following equation.

$W.R = \frac{w}{\pi dmt}$ in (g/cm)

Where W.R: wear rate, w: net weight loss, d: sliding diameter and t: sliding speed (rpm).

3. Results and discussion

Wear rate values were measured at different normal loads and different number of laser pulses and fixed laser fluency of 500 mJ. The following figures (2-5) represent the wear rate as a function of sliding time at different normal load. These figures exhibited the behavior of wear rate under different laser pulses. At the beginning of the sliding time the values of wear rates for all samples under test increase up to sliding time of 10 min due to the separation of the junctions between the shaft and the samples. After sliding time 10 min the wear rate decreasing due to the flattening of the samples and to work hardness these reasons will be lead to reduce in wear rate values. This behavior can be attributed to work hardening of surface layers due to plastic deformation induced by laser wave's treatments.

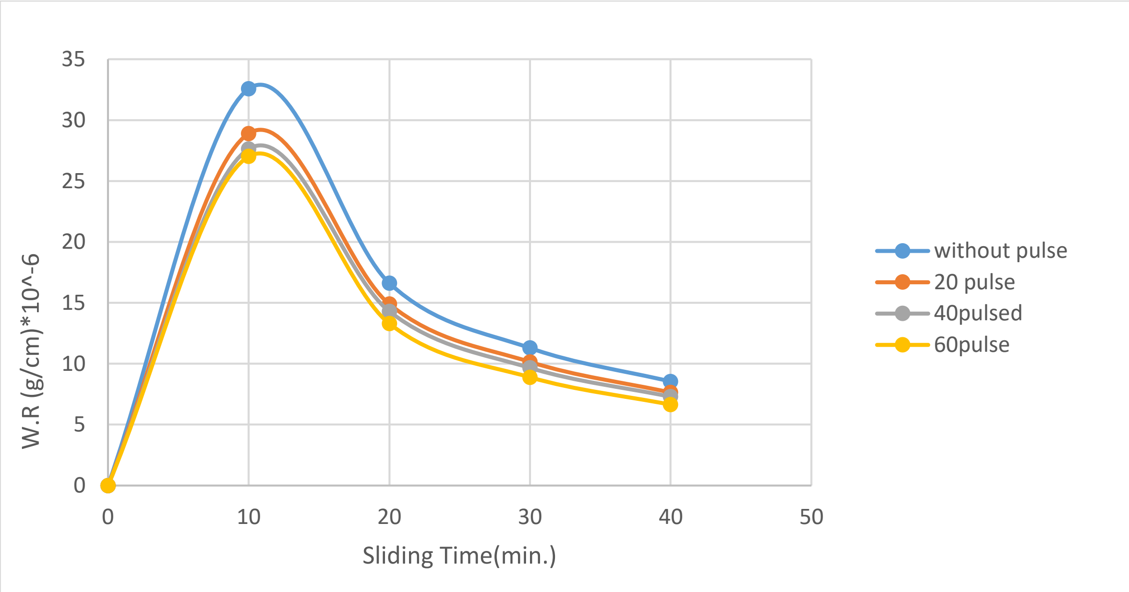

Figure (2): Wear rate versus against sliding time at (loads of 8 N, laser energy =500mJ/mm)

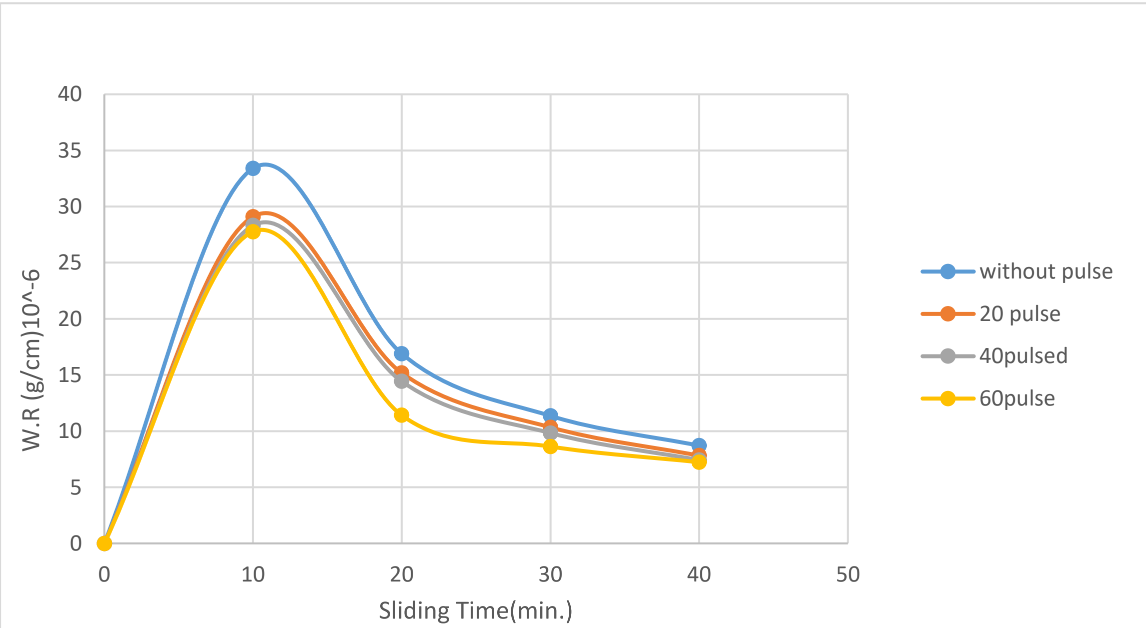

Figure (2): Wear rate versus against sliding time at (loads of 8 N, laser energy =500mJ/mm)

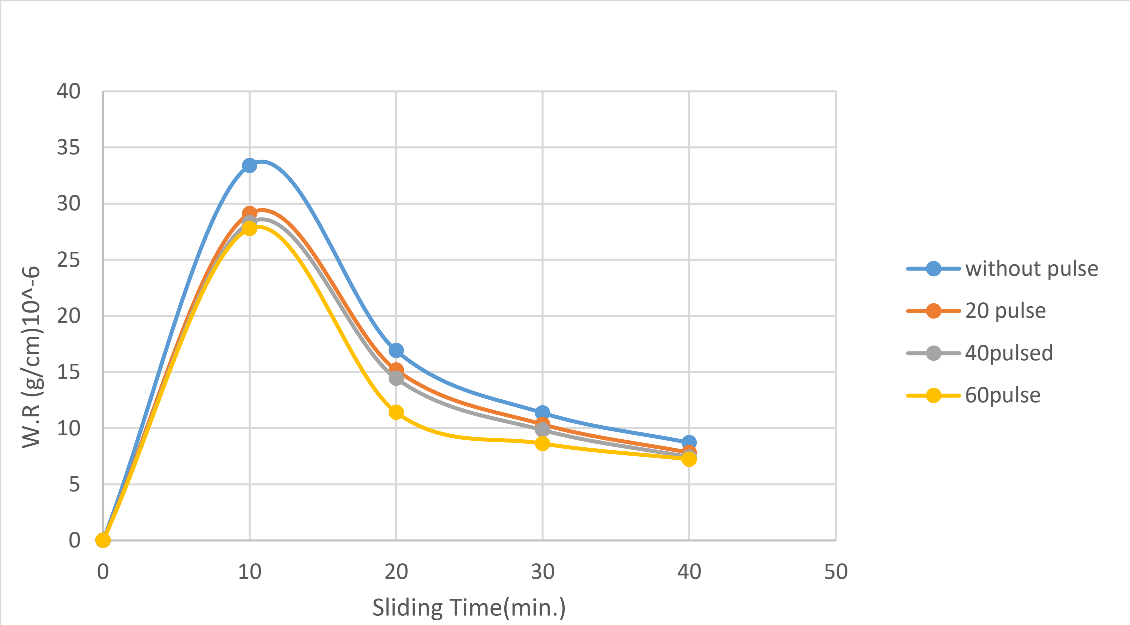

Figure 3: Wear rate versus against sliding time at (loads of 12 N, laser fluency =500mJ/mm)

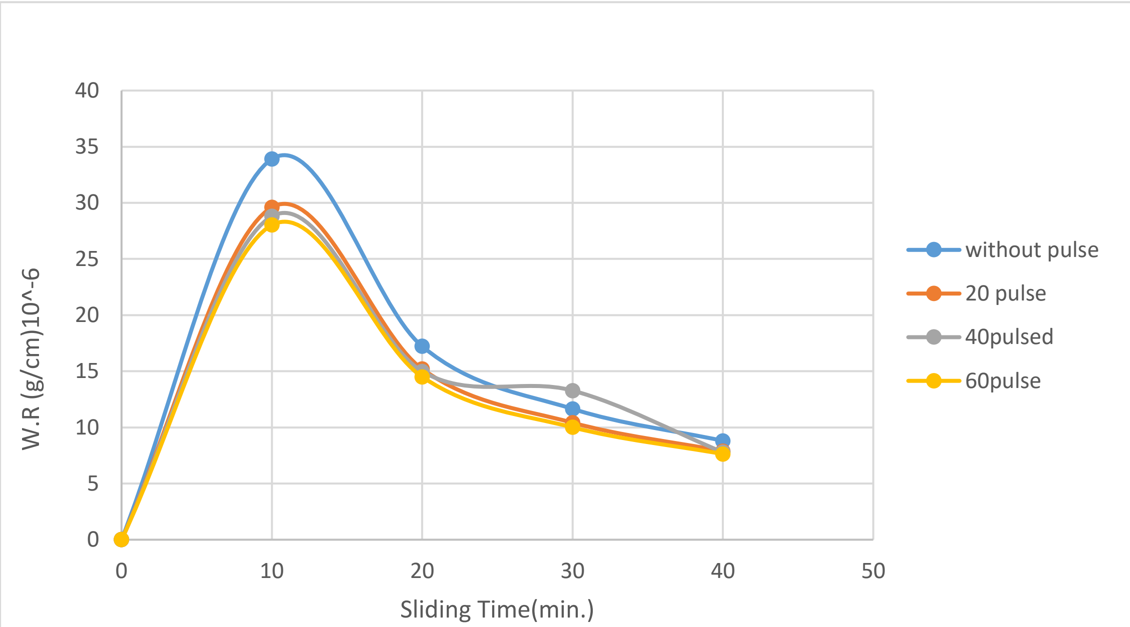

Figure 4: Wear rate versus against sliding time at (loads of 16 N, laser fluency =500mJ/mm)

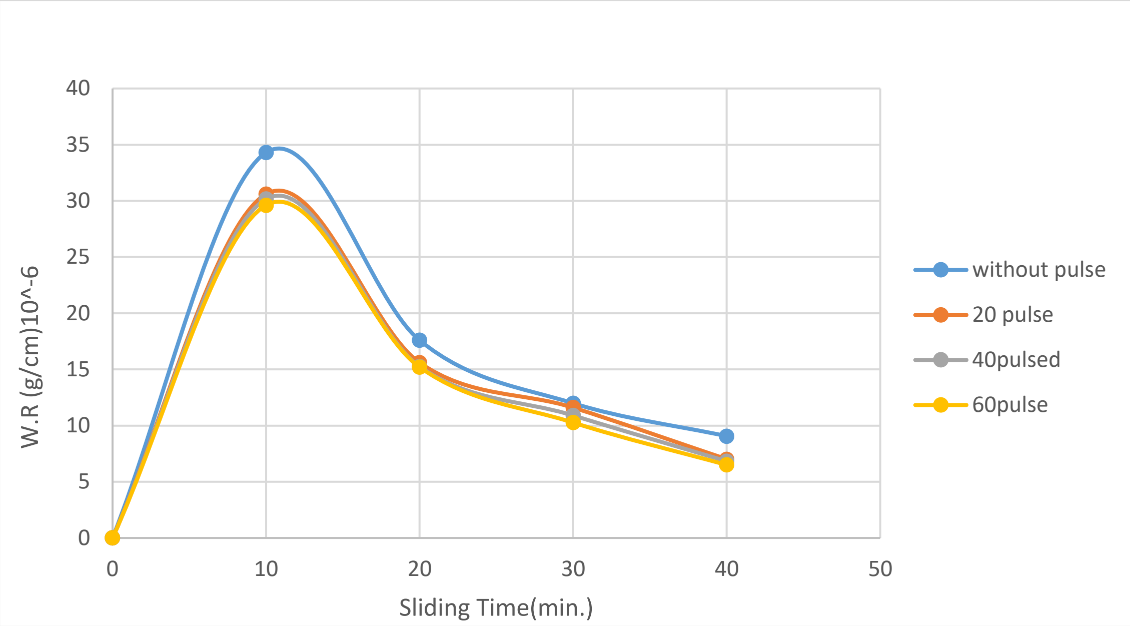

Figure 5: Wear rate versus against sliding time at (loads of 20 N, laser fluency =500mJ/mm)

4. Conclusions

The major conclusion can be demonstrated that the wear rate for laser treated samples is reduced by 15.5% at laser number pulses of 60 pulse, laser fluency of 500 mJ/mm and under normal load of 20 N. This means that the laser treatment enhanced the wear resistance and give us more surface hardness by economic and nondestructive tool.

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