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Effect of laser Peening on the Microhardness and Roughness of Al-7277 alloy

Abstract- The purpose of the study conducted was an analysis of the influence of pulse density per area unit of LSP on (7277AL Alloy) regarding the surface characterization, roughness achieved and microhardness. The samples, which were used in this investigation, are 7277Al Alloy. Specify the laser parameter used in this study effect on sample surface properties were studied. Such as laser energy, and laser pulses number the results reveal that the microhardness enhancement by 80%, while the surface roughness increased by 69% when laser energy of 360mj and the number of laser pulses of 100 pulse were applied. X-ray fluorescence analyses and optical microscope were carried out for all samples.

Keywords- The Laser Shock Wave, Micro hardness, Surface Roughness, Nd: YAG Laser.

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1. Introduction

The operated aluminum alloys in aircraft, automotive, marine and construction industries, in the past four decades, due to their inexpensive, good avoirdupois force ratio and high corrosion resistance [1-3]. Among the broad mixture of surface treatment explored for enhancing the properties of materials, laser surface medications were created around 35 years back in the USA with specific application to improve some mechanical properties [4]. Two processes need in laser surface treatment, which only needs filler material as alloying and cladding, and processes, which need produced heat such as melting and hardening [5]. Even more as of late, surface treatment advancements have turned out to be more pivotal in the industry to cut expenses and keep away from the requirement for extravagant materials [6].

Laser surface treatment methods can classify into two types: The first process of thermo-chemical that changes the composition of the surface such as laser cladding, alloying. The second process that thermal with no change of surface components such as transformation hardening, annealing, laser cutting, melting, and welding [7-8]. Microhardness and compressive stress of surface can improve by laser penning without coating and surface roughness a slight increase. Microstructure evaluation proved that there was none near-surface solidification [9]. Dissimilar to other laser applicants, LSP is the process for

treating materials mechanically without any thermal impacts [10]. The power and height of the transparent layer are the LPS parameters that may change. In this work, water tends to confine the energy and raise this due to water is employed, the translucent overlay is employed to confine the plasma expansion [11-12]. LSP is the generation of plasma when the interaction of laser light with the specimen, which produces shock waves and shifts the plastic of atomic planes in the material [13]. Pulse pressure intensity against the base metal, different parameters of LSP can evolution of Microhardness, roughness, microstructure, wear resistance and friction coefficient. Their effect shows that increases of roughness after LSP; no ablation was observed; the microstructure has no remarkable variation; hardness and increases on the wear resistance as the pulse density increases. Hussein et al. [14] were studied the effect the mechanical properties of laser treatment on, Vickers hardness and roughness of aluminum alloy. They treated a sample by employing Nd: YAG laser of energy 780mj, duration time eight ns, and wavelength 512 nm. Moreover other researchers [12,15, 16] also were scrupulous the increment of surface roughness and the microhardness with the increment of energy of laser pulse and the thickness was an effect of the confining layer on surface roughness and microhardness for various alloys. Therefore, the aim of this paper is improved the microhardness and surface roughness for all samples. The purpose of the

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study conducted was an analysis of the influence of pulse density per area unit of LSP on (7277AL Alloy regarding the surface characterization and roughness achieved and the microhardness.

2. Experimental Methods

I. preparation of Sample

The samples were prepared of aluminum alloys 7277AL Alloy Using circular shapes with a diameter of 10 mm and thickness of 5 mm by using a turning machine. Before laser treatment, the samples were polished with metallographic paper with various grades of roughness ranging from (220, 320, 400, 600, 800, 1000, 1200 and 2000) μm then polished by diamond paste with lubricated liquid on cloth paper, followed by washing by deionized water (DDDW) and ethanol.

II. Chemical composition analysis

Using X-ray fluorescence (XRF) to analysis the chemical composition for all samples model Oxford Instruments (Foundry Master Xpert).

III. Experimental setup

Using Q-switched Nd-YAG, to induce the shock waves, repetition-rate 2 Hz laser with a wavelength of 1064 nm, a pulse duration of about 10 ns, the number of the pulse from 25 to 100. The energy of laser was changed from 150 mJ to 360 mJ. The experimental setup is shown in Figure 1.

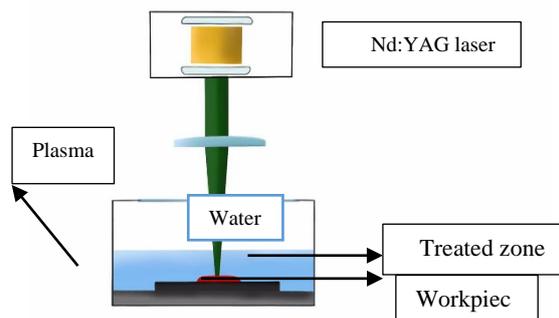


Table 1: Chemical composition of Alloy type 7277AL Alloy

Element	Al	Zn	Mg	Fe	Si	Cu	Mn	Ni
Wt%	89.8	3.9	1.9	1.3	1.2	0.9	0.4	0.2
	6	9	9	6	5	0	1	6
Wt%	0.23	0.1	0.0	0.0	0.0	0.1	0.0	0.0
Sigma		6	5	8	7	0	6	7

II. The effect of laser influence

1) Micro-hardness results

Vickers hardness method was employed to measure the micro-hardness for all specimens

Figure 1: The experimental setup

IV. Measurements of micro-hardness

The hardness of all samples were measured with the help of Vickers hardness testing machine model (VHS-1000) made in Germany, in Metallurgical Laboratory \ Applied Sciences \ University of Technology. The measurement was made with a 5N load along 30 sec. Three measurement readings were taken and averaged to one value require establishing a suitable microhardness profile in the hardened layer and consequently, a reliable microhardness variation. The surface hardness was measured before and after sample treatment. Microhardness was measured at the impact center of the laser spot.

V. Measurements of Roughness of Surface

Measurements of roughness Surface to the all samples were performed by employing “Digital Surface Roughness Tester TR-220”. A summary of arithmetic means roughness measurements, Ra, with different energies of laser pulse. Surface roughness measurement was conducted for specimen with and without LSP treatment. Three measurements were taken at the center of the laser spot and averaged to one.

3. Results and Discussion

I. Chemical composition result

Technique of X- ray fluorescence was used to analyze composition of chemical of used Alloys as show in Table 1.

before and after the laser treatment. The average microhardness value before laser treatment is about 117 Hv. The measurements after laser processing were varied from 164Hv to 423Hv.

The effect of laser fluence on microhardness is shown in Figure 2. The increasing of laser shock processing pulse energy leads to further refined grain. Therefore, after LSP, the surface microhardness increase mainly due to grain refinement, dislocation strengthening, and the compression of plasma plume on sample surface.

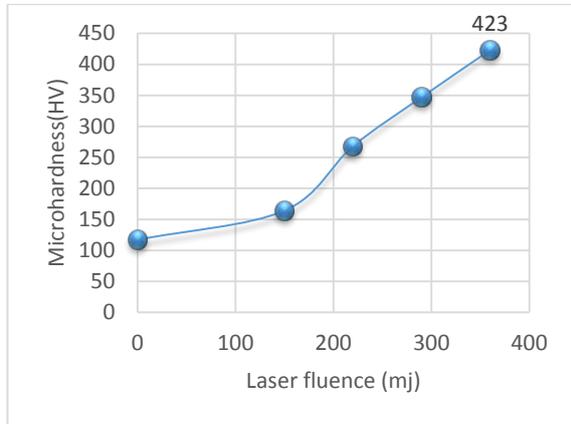


Figure 2: The micro-hardness as a function of laser fluence

2) Surface roughness results

Laser shock wave treatment was done to all samples before and after measuring surface roughness. The average surface roughness value before laser treatment for a 7277 Al sample about 0.109 μm and the measurements for the same samples after laser shock wave processing were varied from 0.364 μm to 1.129 μm . The effect of laser energy on surface roughness is shown in Figure 3. This behavior due to the ablation processes which are associated with laser shock wave processing at the samples surface that caused by the increased energy of laser pulse increase.

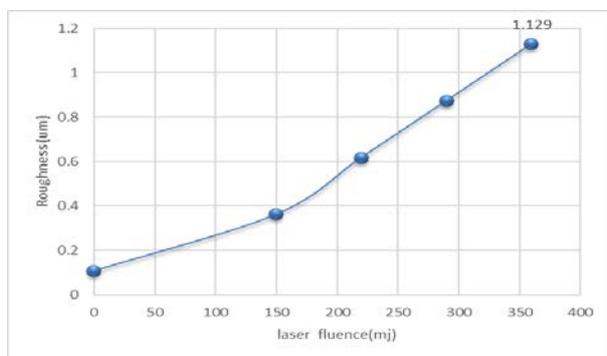


Figure 3: Surface roughness as a function of laser pulse energy

III. Effect of number of laser pulses

1) Micro-hardness results:

Laser shock processing was carried out at fixed conditions such as a laser energy of 290mj,

wavelength of laser 1064nm, and a pulse repetition rate of 2Hz. Figure 4 shows the relation between the microhardness and the number of laser pulses that shown the increasing of microhardness for 7277Al sample from 117 Hv before laser shock processing (LSP) up to (486 Hv) after laser treatment. Because of the pressure of induced plasma on sample surface increased when the pulses number increased and this lead to increasing in microhardness.

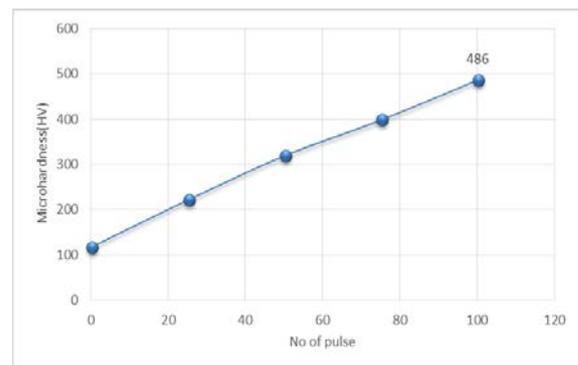


Figure 4: Micro-hardness as a function of laser pulses number

2) Surface roughness results

The increasing of laser pulses led to increase of surface roughness as shown in figure 5. The values of surface roughness increase up 3.34 μm of 7277Al samples were increased by four times when the pulses numbers of laser increased from 0 to 100 pulses.

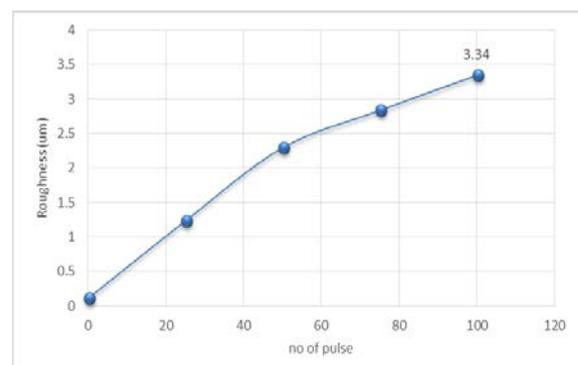


Figure 5: Surface roughness as a function of number of laser pulses

4. Conclusion

1)The microhardness increased by 80% for 7277Al samples when the laser energy increased from 0mj (without laser treatment) to 360mj and the effect of laser energy was clear on the surface roughness that the surface roughness increased from 0.106 μm to 1.129 μm for 7277Al.

2)The micro-hardness of 7277Al samples are increased by 80% when the number pulses of

laser increased from 25 to 100 pulse and the surface roughness rate of 7277Al samples were increased by 69% when the number pulses of laser increased from 25 to 100 pulse.

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