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Effect of laser shock energy on surface hardness and tensile strength of 6061-T6 aluminum alloy

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Abstract:-*Improving the engineering material mechanical properties can be done through enhanced the compress remaining stresses on the surface of the material. Diversity of method such as process of water jet peening, ultrasonic's peening process, laser shot were residential in the last twenty years in this distinction. In this study the produce of laser shot investigated on 6061-T6 aluminum alloy with laser energy (300mJ) and (600mJ) with wave length (1064nm) Nd:YAG laser. By using Vickers micro hardness test on all specimens' surface show the effect of amount of laser energy on surface hardening on 6061-T6 aluminum alloy and tensile test to examine the amount of improve in tensile strength.*

The mechanical properties and micro-hardness of shot and un shot 6061-T6 aluminum alloy surfaces were compared and studies. This study shows that the laser shot notably advance the micro hardness led slight boost in roughness of the surface, but as laser energy enlarge more than 300 mJ the hardness will increase. Also the tensile strength improved by around 50% compared with untreated specimen.

1-Introduction

Aluminum alloys extensively have been used in industrial applications in aircraft and automotive industries for the reason that of their high specific strength and low density. Nevertheless, the mechanical properties of aluminum alloys surface, in exacting wear fight and resistance, are adequate for many engineering application requirements. Low hardness of aluminum alloys is a basic source of the broke wear and fatigue live character. Allotropic conversion not available in aluminum alloys as in other metals like cobalt, iron, or alloys of titanium, the risk of a martensitic conversion not exist and the hardening property using usual solid state aids are incredibly restricted [1].

Laser shot process measured as one of the majority brilliant metal surface improvement technique in conditions of its skill to persuade surface compressive surface hardness, remaining stresses, and modification of microstructure [2]. Zhung et al. report that improvement of turbine blades by laser shot in axial short sequence fatigue concert made of aluminum alloy [3]. The cause of laser peening process on advance of fatigue activities of alloys of titanium, hardness and elastic modulus of elasticity of nickel and nickel alloys -ferrous [4], [5]. A classic laser shot method utilizes a pulsed laser process given that pulse energy of 55 J at recurrence alacrity of 0.33 Hz and pulse girth of 8-30 ns. The rate and dependability of these laser systems have limited applicability of laser shot operation in viable sectors. The a variety of drawbacks in using lasers with pulse energy up to 55 J at upper replication rate have generated wide notice in laser with low control lasers with small spot range that can work at upper frequency. Systems like this are dependable and not expensive than to lofty have power over lasers [6].

From experimental studies the mechanical properties its recognized that are varied iron and aluminum support alloys be able to enhanced by laser fright shock action. When the surface of a metal induced to great pulsed laser energy is qualified; an elevated amount of stress wave is growth up. Mechanical properties development can be done in microstructure by wave propagate into material by alters it, which is the source of the practical improvement the surface proprieties. Facility to make stress waves in resources with short period bursts of laser energy has been known for some time but it has only been in latest years that these stress waves have been shown to provide a helpful in civilizing the fatigue property of an amount of metals and alloys [7].

Method of laser blast involves impinging the shell of object material with dumpy time laser pulses process. Object shell covered before with sacrificial film with black paint to enhance the absorbance of laser energy and to stay away from the effect of thermal achieve appears on shell of metals. Laser process with high blast directly vaporizes the thin film of black paint and the vapors always take up by laser energy process. Unbroken laser power inclusion for the vaporizes the black paint leads to ionization the atoms and finally and converts it to fast rising plasma state. Some piece of this energy movements through the object matter as shock wave. When the size of shock sign over the dynamic yield stress, development of other phases or elevated density range of dislocations will also product. This will give to the development of hardness and yield strength of laser process sample. After the course of shock wave the elastically harassed subsurface sheet tried to get well its original form but the stability of the material in the resilient and plastic region prevent this to arise and expand a compress left over tension at the shell [8, 9].

The control of laser shock presses dealing out on properties of LY12 CZ aluminum alloy was qualified by Shujuan et al. [12], they noticed that with the boost of the laser influence strength, fatigue strength and rigidity of the material enlarge.

The objective of this study is to explore and analysis the consequence of laser shot process on surface hardness of 6061-T6 aluminum alloy using laser energy Nd:YAG with different laser energy amount.

2. Experimental procedure

Test samples of 10 mm in diameter and 10 mm length are machined and prepared from bulk 6061-T6 aluminum alloy. In table (1) showing the full chemical composition for 6061-T6 aluminum alloy. The materials were cut successively cleaned in ethanol using an ultrasonic cleaner ready for the Laser shot process. Quick switch laser machine which working with elementary wave length of 1064 nm as used on the laser resource. By using the technique of full width half maximum of the laser source is 10ns and at the duplication speed was 10Hz. A dichotic reflect covered biconvex lens of central length 60mm was working for pulse deliverance (seven articulated arms). Spot size of the laser beam on the target was set to 1.5 mm with an overlap rate of 50% during laser shot.

The specimen was fixed on a special developed holder which can move in vertical (Y) axis and in horizontal axis (X) by controlled adjustment. The schematic experimental setup and laser shot profile are presented in Fig. 1. The specimen sample shoted by laser beam with (300mJ), (600mJ) energy after coating it by new black paint to enhance the absorbance of shoted laser energy and also to avoid the thermal cause on the surface, this used on flat specimen to micro hardness test.

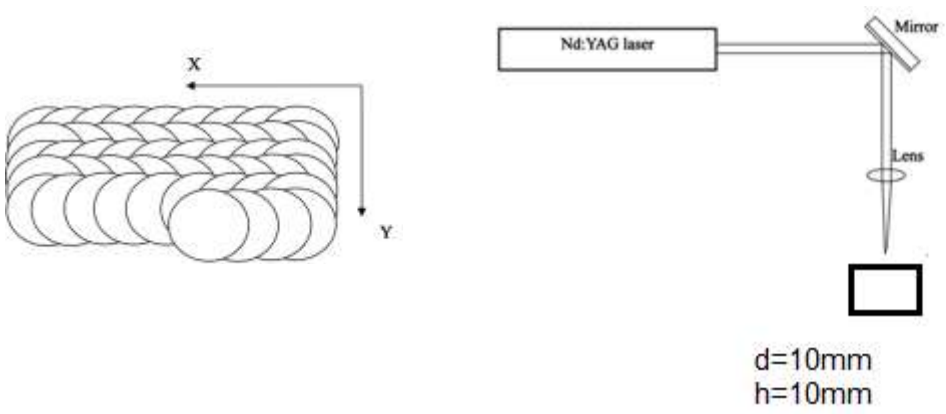

Fig. 1 Representation of laser shot.

Table (1) Chemical composition of (6061- T6). [11]

Elements w%	Fe	Mg	Zn	Si	Mn	Cr	Cu	Al
Measured value	**0.38**	**1.0**	**0.19**	**0.61**	**0.11**	**0.22**	**0.32**	**Balance**
Slandered value	**Max 0.75**	**0.8-1.25**	**Max 0.25**	**0.4-0.8**	**Max 0.15**	**0.04-0.35**	**0.15-0.4**	**Balance**

2.1 Micro Hardness mechanical test was applied on all specimens in both cases by means of Vickers micro-hardness tester. By using load of 50g and 10s holding time all measurements were made. The results are shown in Table (2).

2.2 Tensile test specimens were prepared according to ASTME 8M-04 standard for tensile property, whose dimension is shown in Fig. 2. Using Testometric tensile machine with axial load (N) and cross head speed 20 (mm/min). The obtained results are shown in Table (3). The tests were carried out for laser shot treated and untreated samples and they were repeated three times for each test condition.

The samples had a gauge length of 30 mm on measuring with the extensometer; the 6 mm width net segment was subjected to laser treat.

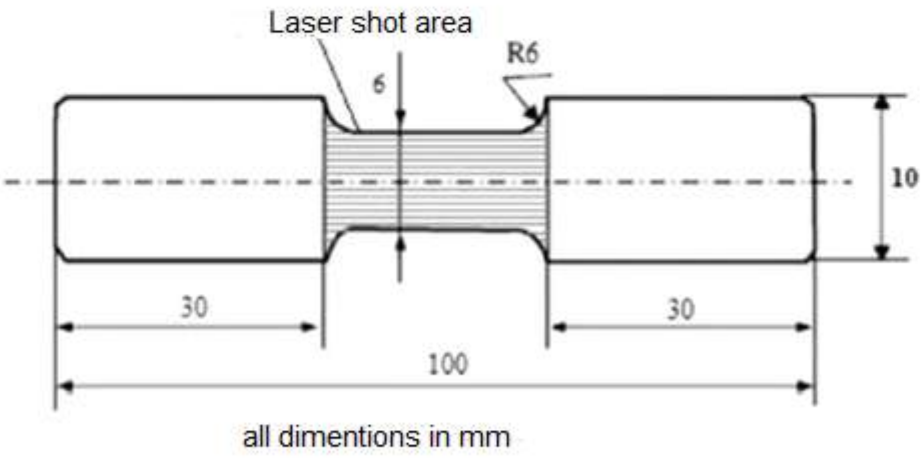

Fig. 2. Dimentions of tensile specimen

3. Results and discussion

Vickers micro-hardness and is normally associated with limited yield stresses which present the in sequence on micro-strain and also limited effort on surface hardening.

The highest micro-hardness value is 122 HV on the surface. It is observed that the micro-hardness value increase due to increase laser shot energy on the target surface. The surface micro-hardness enlarged by 22% after increase amount of laser shot.

Stress-strain curve of untreated 6061-T6 aluminum alloy and treated alloy under laser shock (300mJ) and treated alloy under laser shock (600mJ) are shown in Table (3). Experimental results showed that laser shock processing can improve the elongation value from around 3.1% for untreated specimen to 5.6% for treated one. The tensile strength of untreated 6061-T6 alloy was about 215MPa, and the tensile strength of 300mj, 600mj energy shocked specimen around 320MPa and 324MPa respectively. It's shown it's increased about 50 %. It was considered that the enlarge in tensile strength comes from the increase in the hardness and the disruption density in laser traumatized area.

Table (2) Micro hardness test results.

cases	Hardness (kg/mm^2)
As received (A)	**100**
Laser 300 mJ (B)	**112**
Laser 600 mJ (C)	**122**

Table (3) Tensile test results.

cases	Tensile strength (MPa)
As received (A)	**215**
Laser 300 mJ (B)	**320**
Laser 600 mJ (C)	**324**

4. Conclusion

Summary in this work, the laser shot was efficiently performed on 6061-T6 aluminum alloy by using Quick switched laser of energy pulsed amount 300 mJ and 600 mJ. Roughness of surface and morphology of the face was felled and found that there are no micro or nano cracks on the outer shell of surface, but surface roughness showed a raise. No close to metal surface solidification experiential in micro structure investigation, laser shot is plenty to inform major surface tough Aluminum alloy 6061-T6 as shown in table (2) but, also this advance in hardness is limited as laser shot enlarged. Laser shock processing caused a boost in the tensile strength by a energetic interface among diffusing solute atom and the movable disarticulation. The strength of the material improves due to hardening which resulted from an increase in the dislocation stupidity after the laser shock handing out.

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