Surface Modification of Red Brass Alloy by Using Laser Technique

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ABSTRACT:
Laser shock processing technique was performed on red brass alloy type C83300 specimens for the purpose of study its effect on the mechanical properties such as micro-hardness and surface roughness. LSP experimental setup system involved Q-switched Nd:YaG laser of wavelength of 1064nm and 10 ns laser pulse . Double distilled deionized water (DDDW) is used as the transparent confining layer. The effects of the LSP parameters as laser pulse energy, number of laser pulses and thickness of confinement layer on the surface micro-hardness, and surface roughness were investigated. The experimental results show that, the surface roughness and micro-hardness values increased when the laser parameters (mentioned above) have been increased and the maximum value of micro-hardness generated near the surface due to LSP. The optimum thickness of DDDW layer was 4mm. After this thickness (4mm) ,the results of microhardness and surface roughness are reduced due to the absorption of laser pulse energy by the confinement layer .
Keywords: Red brass alloy, laser technique, microhardness , surface roughness

INTRODUCTION:
The growth of the industrial needs of non-ferrous alloys are due to the request for these materials in many fields of technology [1]. We can take the copper compound as exampled for our task, Copper is "delicate, difficult to machine, and has practically boundless limit for cold work". One extraordinary element of the greater part of these composites is their erosion safe in a few atmospheres. The utilizations of Cu alloys include: adornments, coins, hardware, springs, shrubberies, surgical and dental instruments, radiators, etc.[2]. Laser is basically a coherent, convergent and monochromatic light emission radiation with wavelength extending from ultra-violet to infrared and it is recognized from other electromagnetic radiation for the most part regarding its coherent, spectral purity and capacity to engender in a straight line.[3]. High-power lasers can be used to modify metallic surfaces. One of the examples of the surface modification techniques is the laser shock processing. Laser shock processing (LSP) is an innovative surface treatment, with which mostly a Q-switched Nd:YAG laser with short pulses of several nanoseconds and with a power density, in the pulse peak, of as much as several tens of GW/cm^2 is used [4]. The

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solid surface hardening by laser treatment represents the structural transformations of the material; this can be established by irradiating the surface with a laser pulse [5]. Chin Wei Chang and Chun Pao Kuo [6] used new technique namely laser assisted machining (LAM) to improve the surface properties, where shows that LAM produce shows a better surface quality than conventional machining, . The cutting force is obviously significantly reduced and the case of cutting increased accordingly, resulting in evident improvement in surface roughness [7.]

. The possibility to generate shock waves by laser pulses was discovered in the early 60s [8]. Further investigations resulted in laser induced shock waves with increased impact, which were able to cause compressive stresses higher than the yield strength of metals. Laboratories in the USA and France then started with feasibility studies to apply laser shock processing for modification of material properties as an alternative to shot peening and deep rolling [9]. In many practical applications the surface roughness is an important parameter and in many cases modification of surface topography is necessary [10]. As advantage the laser shock processing allow to control the surface roughness of the material. Additionally, the roughness for LSP is significantly lower than for shot peening [11]. The principle recognized points of interest of the laser shock preparing system (LSP) comprise in its capacity of affecting of a moderately profound compressive lingering anxiety field into metallic materials bringing about enhanced mechanical conduct against exhaustion split start and development, mechanical wear properties and anxiety consumption with no recursion to some other helper mechanical treatment. From the metallurgical perspective, laser stun handling may have different noteworthy impacts on the microstructure of prepared materials. Close to pretty much known impacts like compressive lingering anxiety profiles and enhanced exhaustion resistance, some different consequences are needed for smaller scale [12].

Experimental Procedure:

2.1 Samples preparation:

The samples were manufactured from Red brass alloy. All samples were reshape into a rectangular shape with dimensions of 20×15×10 mm. Before the laser shock processing (LSP), the samples were Cleaned & polished by Grinder polisher device with SiC paper at various grades of roughness ranging from #200, to #1500 and then polishing by adding the emulsion " that Made from the powder of "Alumina" mixed with water on cloth placed in the device so as to get more Luster and shine s a mirror.

Chemical Composition:

The chemical composition of the Red brass was tested in the State Company for Inspection and Engineering Rehabilitation "SIER" by using SpectroMaxx device

LSP Setup:

The shock waves were induced by Q-switched Nd-YAG pulse ,repetition rate of 6Hz with wavelength of 1064nm, a pulse duration about 10ns at FWHM and the laser energy was varied from 100-400 mJ. De-ionized water was used to get the confinement layer in different Depths. Through the LSP impact, the laser beam was vertical to the sample surface during the practical work. and the DDDW layer was changed after each operation to maintain the purity of water, Control of water purity is important to avoid the water bubbles and the concentration of impurities which coming from the material ablation due to laser treatment. The distance between the laser source and the sample was 10 cm.

2.4. Micro-Hardness Measurements:

The micro-hardness was measured before and after Laser treatment for all case Vickers hardness method with "Digital Micro Vickers Hardness Tester ESEWEY" Model EW422-DAT.2012-UK production was used. The measurement was made With 4.9 N load and 15sec as a hold time. Three measurements were taken and averaged to one value also the measurement were of the various dimension of sample surface. Micro-hardness was measured at the impact center of Laser spot.

Results and Discussion:

Chemical Composition Results:

The elemental composition analysis results for copper alloy samples were tabulated in table 1 from these results can be concluded that the alloy type is a red brass alloy (C83300)

Table 1: The Chemical composition of Copper alloy samples.

Sample	Zn %	Pb %	Sn %	P %	Cr %	Fe %	Ni %	Si %	As %	Sb %	Bi %	Cu%
Alloys	**0.0212**	**0.001**	**0.002**	**0.001**	**0.005**	**0.030**	**0.002**	**0.003**	**0.0007**	**0.006**	**0.002**	**Bal**

Laser Pulse Energy Effect:

The effect of number of pulses on the micro-hardness of the Res brass alloy samples can be shown in Figure 1. From this figure can be noticed that the value average of micro hardness before the laser shock processing treatment for all sample were 54.22Hv increased to 106Hv after the LSP with laser pulse energy of 400 mJ. The effect of laser pulse energy on the hardness values show clear by increasing the hardness values from 87(Hv) at laser pulse energy of 100mj to 106(Hv) when laser pulse energy equal to 400 mj . The behavior of micro-hardness against laser pulse energy due to arise plastic deformations in the microstructure and to the increasing of LSP pulse energy leads to further refined grain .Therefore the micro-hardness values are increased .

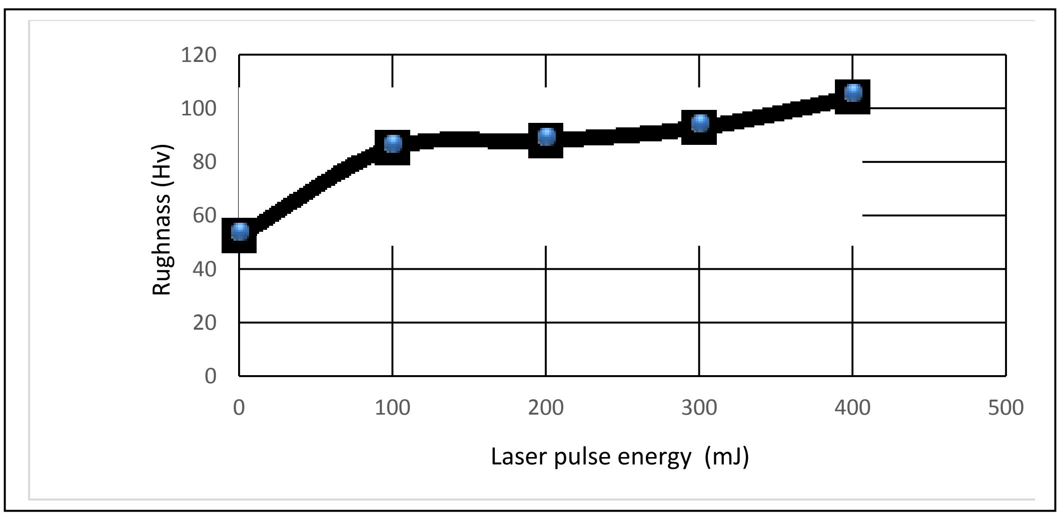

Figure.1 The micro-hardness (HV) as a function of laser pulse energy (mJ)

Number of Pulse Effect:

Figure 2 shows the relation between the microhardness and the number of laser pulses. One can be shown that the increasing of microhardness results from 106 (Hv) at 20 pulses to 125 (Hv) when number of pulses equal to 40, and the maximum value of microhardness was obtained at number of pulses of 60. These increases may be related to increasing of plastic deformation at the surface of samples.

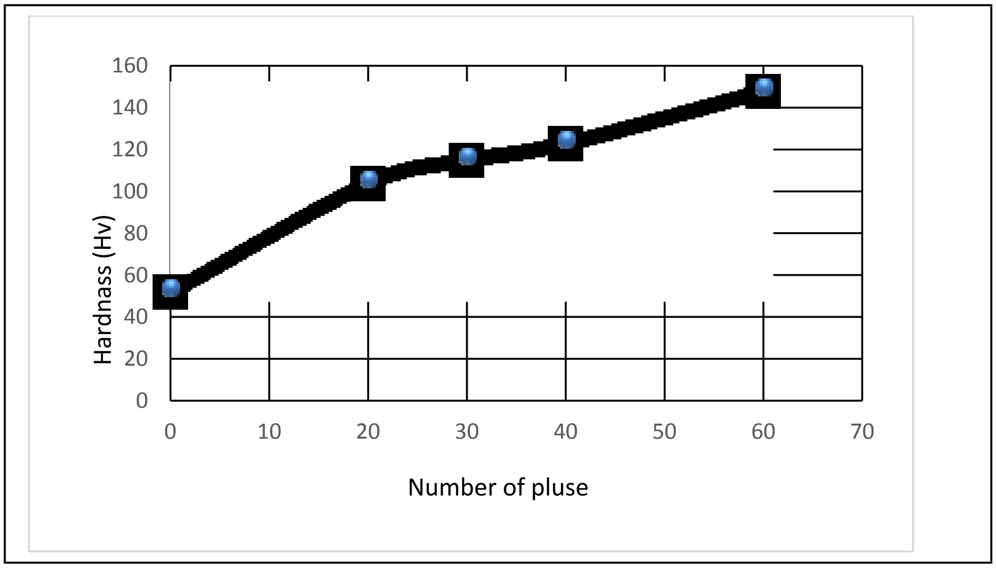

Figure 2 Micro-hardness versus with the number of laser pulses

Micro-Hardness Distribution:

The micro-hardness distribution of the samples were measured at different depth from sample surface to evaluate the penetration of laser inside sample. Figure 3 shows the same value of micro-hardness at the different depths. After LSP treatment the micro-hardness increased by 174% at the surface but when measured the micro-hardness under the surface this ration was gradually decreases .This behavior due to that the laser effect at least whenever we moved away from the sample surface as a result of absorption and attenuation of laser energy.

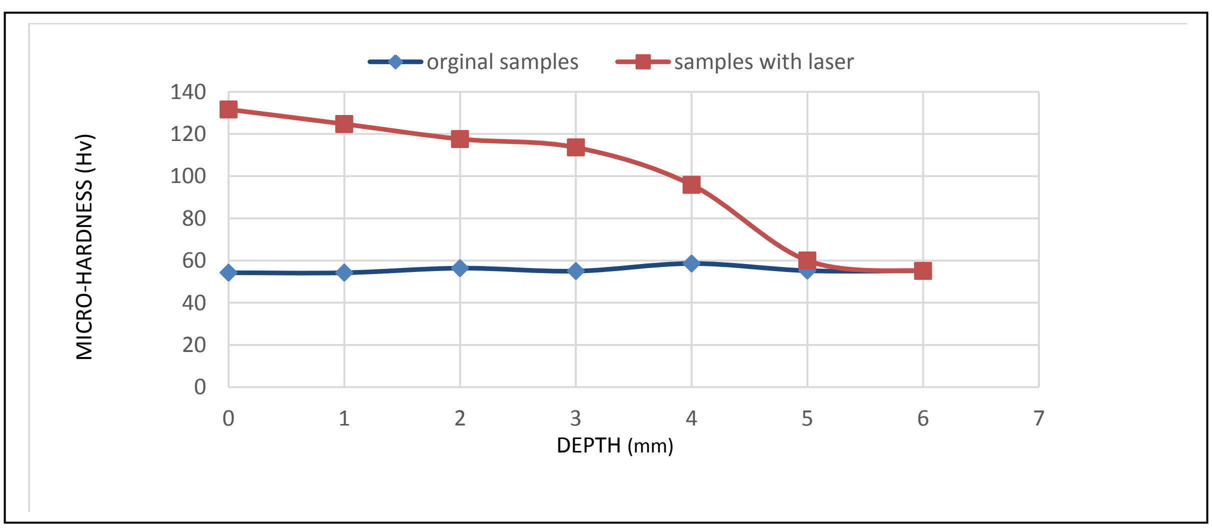

Figure 3 Micro-hardness distribution of the specimen cross section before and after LSP.

Confinement Layer Effect:

The experiment of this section was carried out at the fixed conditions such as laser energy of 400mj, laser wavelength of 1064 nm and number of laser pulses 60 pulses. Figure 4 shows the relation between the micro-hardness and the depth of confinement layer(depth of DDDW).At the beginning the micro-hardness rate increase with the increase of the water thickness until the maximum values of 189(Hv) that's at the DDDW depth of 4 mm, because of the pressure of confine- ning plasma produced by laser pulse on the surface increase with DDDW depth, but at the water thickness greater than the 4 mm the micro-hardness values decrease gradually. That behavior is happen due to that the water layer absorbs much laser energy and water absorption reduces the intensity of laser.

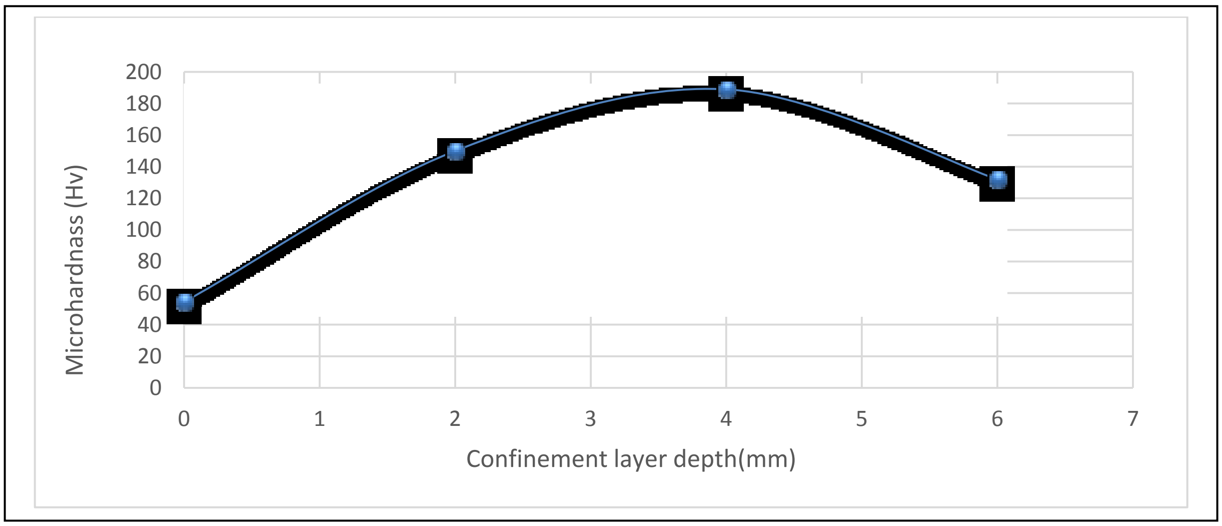

Figure 4 Micro-hardness as a function of confinement layer depth (mm)

CONCLUSIONS:

1-The micro hardness increased by 143% when the laser energy increased from 0 (without laser treatment) to 400mj.

2-The micro hardness increased by 41% when the number of laser pulses increased from 20 to ٦٠ pulse.

3-The micro-Hardness increased by 47% when the confinement layer depth increase from 2mm to 4mm and. This value decreases with the increase the confinement layer above 4 mm.

4- The results of micro hardness distribution show that the values are less whenever we moved away from the sample surface because the laser energy at least because of its impact absorbed by the sample surface.

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