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To cite this article: M. Abeens *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **574** 012018

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Comparative Analysis of Different Surface Modification Processes on AA 7075 T651

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Abstract. Modern industries turn into light weight high strength materials. Aluminum alloys are having such a great property, in which, AA 7075 T651 provides good strength than other alloys. Hence, hardness of aluminum alloys are poor there by improvement of surface hardness of aluminum alloy is necessitate. Shot peening, severe surface mechanical treatment (SSMT) and laser shock peening (LSP) are the surface property enhancement processes, which are used to improve the surface hardness of AA 7075 T651. This article deals with study the effect of shot peening, Severe surface modification process and laser shock peening on AA 7075 T 651. Among these two processes, LSP reveals better improvement in surface hardness. The Vickers micro hardness test is contacted on the specimens. 15%, 18% and 29% of harness improvements are obtain than unpeened specimen in shot peened specimen, SSMT specimen and Laser shock peened specimen respectively. The deformed layer thickness is 500 μm found in the laser shock peened specimen and 300 μm in the shot peened and SSMT treated specimens.

1.Introduction

The different surface modification processes are used to improve the surface quality of metallic materials [1-4]. On another hand, some particles like graphite, boron carbide etc., are reinforced in aluminum alloy for improving mechanical and surface properties [5, 6]. Typically, shot peening, severe surface mechanical treatment (SSMT), laser shock peening, ultrasonic shot peening (USSP) and etc. are utilized to improve the surface property of metals. During surface modification processes, permanent plastic deformation occurred on the surface of the material there by material gets hardened accordingly surface hardness of the material will be improved [7,8]. In this article has chosen to study the effects of shot peening, severe surface mechanical treatment (SSMT), and laser shock peening on AA 7075 T651.

In the shot peening process, high velocity balls are used to bombarded on the surface of the materials so the dimples are generated which reveals plastic zone and some elastic region. The recovered elastic region introduces residual stress on the surfaces [9]. Severe surface mechanical treatment (SSMT) is almost similar to the SSMT process but the high velocity is generated by the



use of rotation of the drum, which surrounded by the specimen there by the impact created distance, is varying [10]. LSP process generated the Shock pressure on the metallic material surface using laser source, there by plastic deformation induced on the surface [7]. Cho et al. studied the effect of shot peening process on aluminum alloy sung Zn balls which resulted, the enhancement in hardness after shot peening [10]. Thirumavalavan K et al. reported, the SSMT process enhanced the hardness of the AA 6061 with steel balls [11]. Abeens et al. investigated the effect of LSP on AA 7075 T651 and reported significant enhancement of hardness obtained after LSP [7].

Several studies are done to enhance the hardness of AA 7075 T651 by surface modification processes; hence, there is no comparative study between surface modification processes done on AA 7075 T651. That is the aim of this research work.

2. Materials and Methods

CI steel balls (40-45 HRC) are used for shot peening and SSMT process to create significant chances on AA 7075 T651.

2.1 Materials and Methods

AA 7075 t651 material possesses high mechanical property over the others as the material is processed through thermo-mechanical treatment, where it is subjected to a heat treatment of 745K for 30 mins duration, followed by water quenching. Stretching process is done for stress relief. As a result of which an elongation of 2.5% strain elongations and the aging for 6h at 394K has been done. Due to these superior qualities, AA 7075 t651 has been used for the current experimental work [6]. The material was purchased from PCM Metals from Bangalore with 8 mm thick square plate. The specimens are cut into cuboid shape with 10 mm x 10 mm x 8 mm dimensions for Hardness. The mechanical property and chemical composition of AA 7075 T651 are given Table 1 and Table 2 respectively. In shot peening process, 5 bars velocity compressive air is exerted via nozzle for bombarding balls on the surface of the material. SSMT process, the machine contains a shaft and drum. Shaft is having a specimen holder inside a drum. 100 balls are used to create impact on the surface of the material. A Q switched Nd-YAG laser with a wavelength 1064 nm, beam divergence of 0.8 mrad, beam quality factor (M2) of 2 and beam shape of top hat profile, whose diameter is 0.8 mm are used as peening parameters and 300 mJ energy is used as a laser pulse energy.

Table 1 Mechanical properties of AA 7075-T651

Property	Values
Tensile strength	540 (MPa)
Yield strength (0.2% offset)	499.87 (MPa)
Dynamic yield strength	541 (MPa)
Hugoniot Elastic Limit (HEL)	1.066 (GPa)
Elongation %	13%
Hardness (HV)	172.9 HV
Poisson's Ratio	0.33
Shear strength	330.94 (MPa)
Fatigue strength	158.58 (MPa)

Table 2 The chemical composition of AA 7075-T651

Elements	Composition
Silicon	0.03
Iron	0.14
Copper	1.3
Manganese	0.02
Magnesium	2.3
Titanium	0.05
Zinc	5.6
Chromium	0.9
Others	0.15
Aluminum	90.22

2.2 Hardness

Wilson Wolpert Vickers's micro hardness test is conducted on the AA7075 t651 at the cross sectional side from the peened surface to depth of 500 μm , in each depth five readings are taken and the average value is measured, using constant load of 1.96 N (200g) for 10 s dwell time.

3. Result and discussion

The surface of the material experiences the severe plastic deformation during surface modification processes thereby the strain hardening occurred in a peened specimens, which leads to enhancing the surface micro hardness [7]. In terms to estimate the surface hardness and the depth of hardening, the surface Vicker's micro hardness test is performed to the depth along the cross-sectional direction from the top surface of the unpeened and treated specimens. As depicted in Fig. 1 and Fig. 2 it is clear that the surface micro hardness of the LSP treated specimen is increased than other specimens

The average micro hardness of the unpeened specimen is 175 HV and little changes occur towards the depth due to its age hardening process. In the LSP treated specimens, the surface hardness value reaches 225 HV. The maximum hardness is 29 % higher than the unpeened specimen. Furthermore, the shot peened specimen reveals 202 and SSMT treated specimen exhibits 208 %. This is 11% and 8 % improvement to the LSP used specimen than shot peened and SSMT used specimen respectively.

The deformed layer thickness varies some hundred micrometers into the depth of the specimen with respect to surface modification processes. LSP treated specimen shows 500 μm deformation and other treatment treated specimens reveals upto 300 μm deformation.

During the strain hardening, the material gets strengthened. This strengthening occurs owing to dislocation movements where, the dislocation lines are created by the shockwaves, which start to move across the other dislocations. Therefore the material subjected to more deformation, and the number of dislocations start from the different directions at various slip planes. Finally, the dislocation density increases due to the increasing dislocation density thereby the material hardens [12, 13]. The impact of load variation also influences the dislocation movements. As the impact effect increases eventually the dislocation density also increased due to higher deformation.

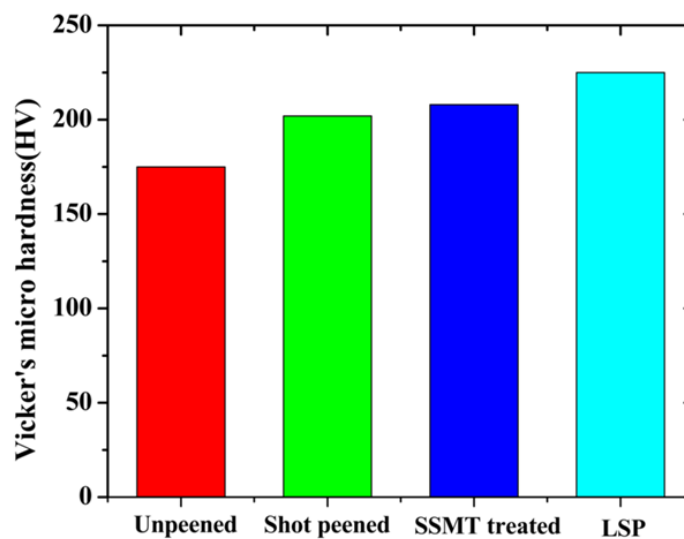


Fig. 1 Surface harness plot

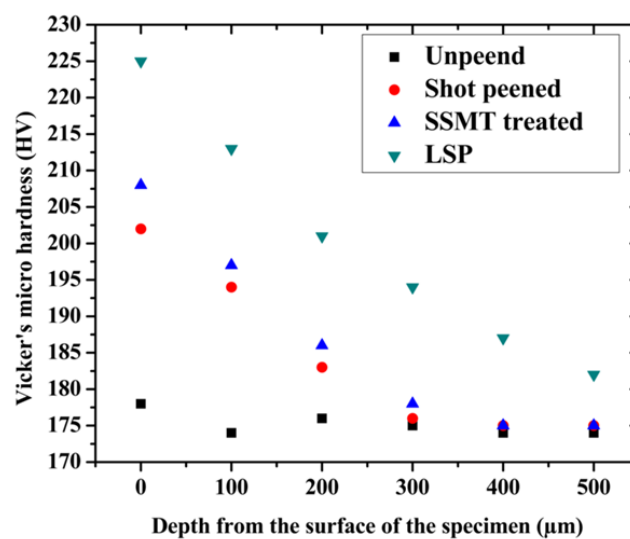


Fig. 2 Depth wise Vickers microhardness variation plot

The generated hardened layer presents some hundred micrometers depth in the LSP treated specimens. Due to, when the Shockwave propagates on the specimen the amplitude of the shock wave reduces, because it spreads to greater areas. Here the shock radius becomes higher than its initial value. When the radius reaches one-fifth higher than the initial value, the internal energy and density discontinues. This leads to the loss of the flow of the shockwave, so the hardness is

decreased by the increasing depth. During the impact load, the depth of deformation increases. Due to this, the magnitude level is greater and also the strain rate is higher.

4. Conclusion

This investigation is effect of varies surface modification processes on hardness property of AA 7075 T651

- The LSP treated specimen reveals higher hardness than all other specimens, which is 8 %, 11%, 29 % enhancement compare with shot peened, SSMT and unpeened specimen.
- 500 μm depth of deformation occurred in the LSP used specimen and 300 μm deformation revealed in the Shot peened and SSMT treated specimen.

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