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FACULTY OF ENGINEERING – SOHAG UNIVERSITY
Sohag Engineering Journal (SEJ) Vol. 3, No. 2, September 2023

An Experimental Investigation on Mechanical Behaviour of Laser Surface Treated AL6082/SIC/7.5% Metal Matrix Composites

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Abstract

Engineering fraternity is searching for new materials which possess higher strength and lower weight materials. In this connection Aluminium metal matrix Composites are the very constructive lightweight materials of universal engineering applications with enriched mechanical characteristics and are promising for Naval, aerospace and automobile applications. However, in various applications, mechanical properties such as hardness and tensile strength are prerequisite and are more relative to the closer surface regions. In other hand one of the surface treatments, Laser peening is an advanced surface treatment technique, to improve the surface morphology and hence the mechanical characteristics such as tensile strength and Hardness and is an added advantage for various applications. In the present work aluminium metal matrix composites are fabricated by reinforcing 7.5% SiC in Al6082 via stir casting method and surface of the AMMCs are laser peened using a 2.5 J flash lamp pumped Electro–Optically (E–O) Q-switched Nd:YAG laser system and Hardness and tensile behaviour are studied and Hardness and tensile strength are improved with increase of laser power density from 1J to 2.5J.

 DOI: 10.21608/SEJ.2023.229162.1043

Keywords: AMMC; laser peening; Tensile strength; hardness; laser power density.

1. INTRODUCTION

2. INTRODUCTION

Manufacturing community continuously Demands the advanced strength and lower dense material. This demand is fulfilled by the aluminium matrix compounds in which Aluminium is used as matrix element in the fabrication [1, 2]. Metal matrix composites (MMCs) are well designed combinations of two or further accoutrements in which, one is a Metal. These compounds can be fabricated using constituents which are readily available and simple ways [3]. The maturity of the experimenters boosting ceramic origins in aluminium and their blends to develop their compounds [4]. One of the substantially used boosters to produce Aluminium Metal Matrix compounds is Silicon Carbide (SiC) and quite a many fabrication styles are available for the fabrication of Al-SiC/ MMCs. Among the different styles, stir casting is simple, precious, and used for mass production. The maturity of published work on Aluminium- SiC compounds has concentrated on the accumulation of data on compound tensile strength. These studies have indicated the potentially constructive materials on strengthening as a result of SiC boosters [5]. Porosity increased with increase of wt. of SiCp in the matrix. Micro hardness increased with increase of SiCp underpinning and with reduction of flyspeck size in the AMCs [6].H.M. Mamunet.,al., studied the microstructures, Vickers hardness, tensile strength and wear characteristics of as cast SiC boosted aluminium (Al) matrix compounds by varying SiC content as 0, 5, 10 and 20 wt. which were prepared by stir casting style and stated that introducing SiC boosters in Al matrix increased hardness and tensile strength and 20 wt. SiC boosted AMC showed maximum hardness and tensile strength, also stated that compounding Al

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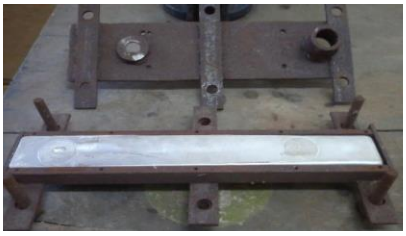
matrix with SiC boosters increased wear and tear resistance [7]. In other hand Mechanical factors subordinated to constant and variable loading frequently effects fatigue failure and it frequently initiates from the surfaces [8, 9]. Thus, adding the surface strength would effectively ameliorate the resistance against fatigue failure [10]. Surface enhancement methods, which are substantially made by modifying the surface of compounds, are extensively employed to ameliorate the parcels of factors including fatigue, stress erosion cracking, wear, and fretting. Among these face improvement technologies, laser peening is a currently developed process and is being extensively investigated. Due to its accurate positioning and precise operation, laser peening can be applied to numerous aircraft components alike blades and gears with good repetition and trustability, In the history, experimenters conducted innovative studies using LSP trials on metals and compounds that are prominently used in marine operations [11–14], aerospace [15 – 18], medical [19 – 21], and assiduity [22 – 24]. These studies validated the effect of several LSP parameters on mechanical structures and microstructure.

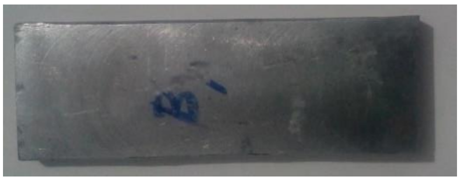
3. MATERIAL AND METHODS

The material selected to perform laser peening experiments for studying the mechanical behaviour of laser peened Aluminium Metal Matrix Composite is Al6082/SiC/7.5%. The composite is fabricated in the laboratory of SVU College of Engineering Tirupati, Andhra Pradesh by using 3kg volume, variable temperature, and variable speed Stir casting Furnace (Fig 1). For this, first the furnace is heated up to the temperature 800^{o}C then the alloy pieces are poured into the crucible, and it has been allowed to melt completely. At this stage the pre heated SiC particles are mixed slowly along with 1% of magnesium metal powder which gives wettability between alloy and reinforcement and then it is stirred for continuously for 5 minutes to get proper mixing of particle in base metal at this stage it is poured in a die (Fig 2). After the specimen (Fig. 3) got cooled and is then Pre machined (Fig. 4) and machined for tensile specimens as per ASTM Standards (Fig. 5) and Specimens (Fig. 6) for testing BHN.


(1)


(2)


(3)


(4)


(5)


(6)

Fig 1.Stir casting Furnace, 2. Mould 3.casting sample, 4. Pre machined sample, 5. Tensile Specimens, 6:Hardness Samples.

4. SURFACE TREATMENT

Laser Surface treatment (Laser Peening) motivates compressive residual stress in the surface sub caste by tremor Laser impact energy and plastic distortion occurs in the surface sub caste. Laser peening can convert deeper compressive residual stress arenas and good surface finish, and hence, it makes metallic accoutrements have better fatigue performance [25]. LSP may replace conventional styles for numerous operations similar as fatigue or stress erosion geste [26] LSP is an effective surface treatment fashion for perfecting the fatigue life of Al blends having colourful pre-existing notch configurations. Laser- shock processing redounded in the shock- convinced plastic distortion of the sword, which is substantiated by the adjourned face as well as the high viscosity of disruptions. Surface hardness increased by over to 80 after the LSP [27].

In the present investigation The surface of these specimens were treated with Laser peening using a 2.5 J flash lamp pumped Electro–Optically (E–O) Q-switched Nd:YAG laser system (Fig 7) under optimum parameters [28] by varying Laser power Density as 1 J; 2J and 2.5J and with the optimized experimental parameters as follows

1. Pulse duration 6–7 ns;
2. Repetition rate 2 Hz;
3. Spot diameter 1.5 mm,

After peening the samples were examined with Scanning Electron Microscope (SEM) and microstructures were presented in the Fig.8. Through these SEM images the average grain sizes are measured using image-J software (Table.1).

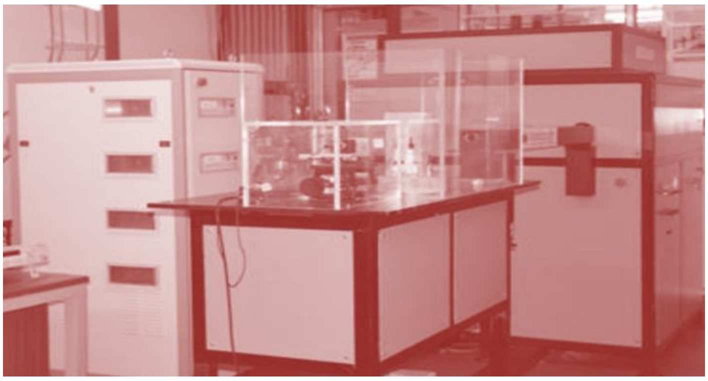
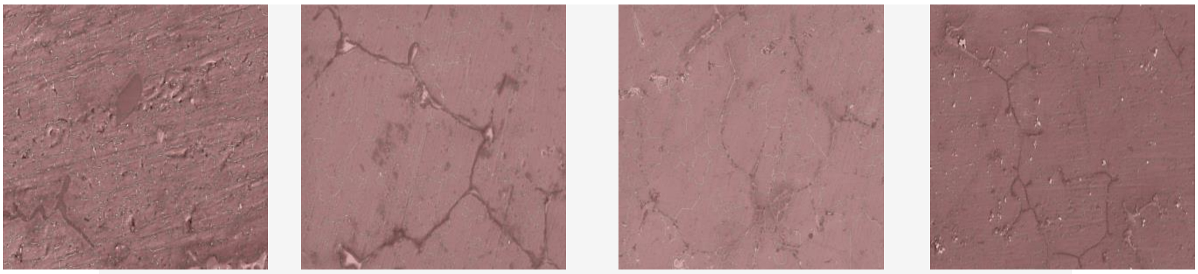


Fig. 7: 2.5 J/7 ns pulsed Nd:YAG laser with a spot diameter of 7.5mm.



(a) (b) (c) (d)

Fig 8. SEM Images: a) Un peened AMMC b) AMMC Peened with 1J c) AMMC Peened with 2J d) AMMC Peened with 2.5J.

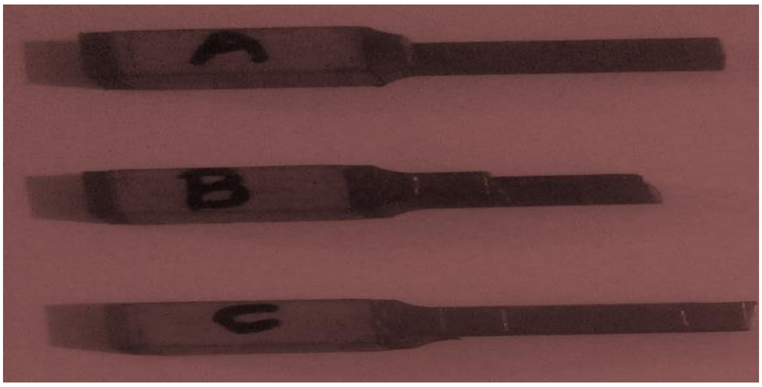


Fig 9. LP/Tensile Tested Specimens.

Fig 10.. LP/BHN Tested Specimens.

TABLE 1. SEM IMAGES WITH AVERAGE GRAIN SIZE

Sl No	fig	LP Power	Average Grain Size
1	fig. 10 (a)	Un Peened	9.99 microns
2	fig. 10 (b)	LP/1J	9.68 microns
3	fig. 10 (c)	LP/2J	2.93 microns
4	fig. 10 (d)	LP/2.5J	2.92 microns

TABLE 2. TENSILE STRENGTH AND BHN VALUES

Material	LP Power	Tensile Strength	BHN
Al 6082	Un Peened	96	58.4
Al6082/sic/7.5%	Un Peened	155	72.4
Al6082/sic/7.5%	LP/1J	166	83.17
Al6082/sic/7.5%	LP/2J	177	85.8
Al6082/sic/7.5%	LP/2.5J	181	86.73

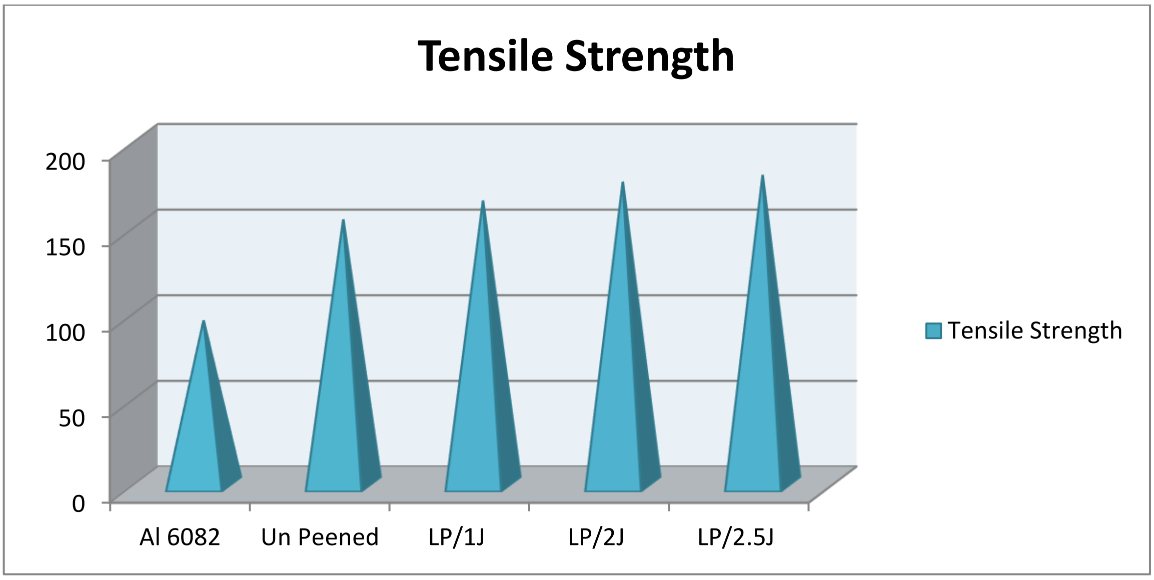


Fig 11. Tensile Strength.

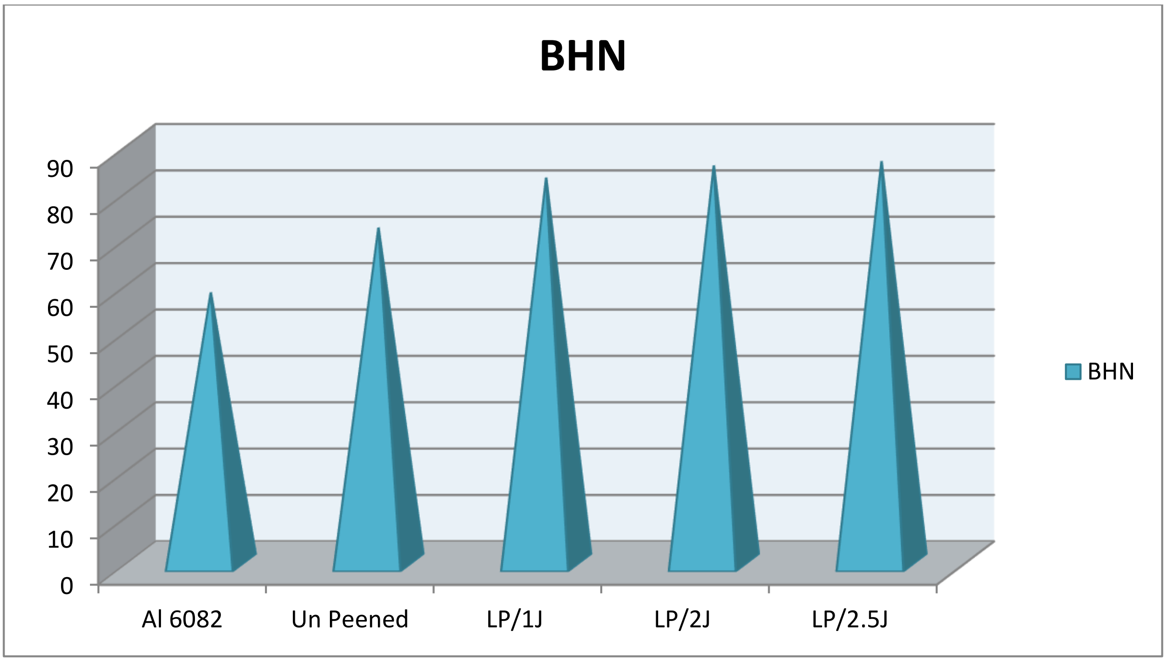


Fig 12. BHN Values.

5. RESULTS AND DISCUSSIONS

After Laser Peening on Tensile And Hardness Samples these specimens were tested for Tensile Strength and Brinell Hardness Number (Figs. 9 &10).and test results are tabulated in Table 2 and shown in Figs.11&12.

When observed the Table 1 and Figs. 11&12, the Tensile Strength is increased 61% when compared the pure Al 6082 Alloy and 7.5% SiC Reinforced Al 6082. Further it is improved 7% for Laser Peening with 1J power Density, 14% for 2J Laser Power Density, and 16 % for 2.5 J Laser Power Density, the BHN is increased 23% when compared the pure Al 6082 Alloy and 7.5% SiC Reinforced Al 6082. Further it is improved 14.87% for Laser Peening with 1J power Density, 18.5% for 2J Laser Power Density, and 19.79 % for 2.5 J Laser Power Density.

From SEM images (Fig.8) it is evident that, when grain size decreases the tensile strength and hardness increases as the grain size decreases with increase of laser power density in the present study.

6. CONCLUSION

4. surface treatment was given successfully to the Al6082/SiC/7.5% AMMC by using Laser Shock peening.
5. It is observed that the Tensile Strength and BHN are increased with increase of Laser Power Density.
6. It is concluded that the properties are increasing to aluminium Metal Matrix Composite when laser power density of laser peening is increased.
7. Also, it is concluded that maximum of 16% of Tensile Strength is increased for 2.5J Power density and Maximum of 19.79% of BHN is increased with 2.5J Power Density.

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