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Effect of garnet abrasive in water jet peening on AL 6063-T6 alloy

D.S.Balaji[1], T.Jeyapoovan[2]
[1]Department of Mechanical Engineering, Hindustan Institute of Technology and Science, India
balajimailer@gmail.com
[2] Department of Mechanical Engineering, Hindustan Institute of Technology and Science, India
jeyapoovan@hindustanuniv.ac.in

ABSTRACT

Water jet peening (WJP) is a modern surface strengthening process used for improving the surface integrity of the materials. In this study Al 6063-T6 alloy has been surface peened with pressurised water by varying input parameters such as Water pressure, Standoff distance and Traverse rate. The output parameters such as hardness and surface roughness were considered. An attempt is made to study the surface property by water jet peening with Garnet abrasive material. From the study it is found that there is an increase of hardness up to 20% is reports with the subsequent increase in the surface roughness of the material. A microstructural comparison was made to study the effect of peening and found that the abrasive water jet peening (AWJP) was performing better that the traditional water jet peening.
Key words : Water jet, Surface treatment, hardness

1. INTRODUCTION

Water jet has been widely used in various material removing actions such as cutting, milling and drilling of all grades of alloys.[5-7] Usually material removal action is carried out at a shorter stand-off distance of the nozzle with pressurised water. In this work an attempt has been made for peening action which shall be achieved by increasing the standoff distance and other related parameters. During the process pressurised water bubble, impact on the surface of the aluminium alloy which forms a plastic deformation on the surface of the alloy. The surface peening operation is usually carried out to improve the surface morphology of the material. Xingliang He et al [2020] reported a novel surface hardening technique that can increase the hardness of AL 6061-T6511 alloy up to 5 times the base alloy, by water jet cavitation loaded with yttrium oxide (Y_2O_3) Nano particles. The surface treatment was carried out for 600 sec which will embed the Y_2O_3 Nano particles in to aluminium alloy at room temperature. This embedment of nano particles is distributed over a distance of 2 microns from the surface. A dry sliding microscale friction test was conducted to analyse the friction behaviour of the material and found that the friction is reduced up to 50 % due to the cavitation peening on the surface. Using cavitation peening with embedded any type of materials like metals, polymers and composites can be treated to improve the mechanical behaviour of the alloy. [3]
Hayashi.M et al [2020] have studied the effect of residual stress on 304 stainless steel in plate and bar structures in water jet peening. In this study the water jet pressure of 60-70 Mpa was generated. This pressured liquid is transferred to the work piece through the nozzle with 2 mm diameter. Usually, the higher water jet pressure will create extreme impact on the targeted surface. The standoff length is taken as 100 mm with the water depth is 1.5 m with the scanning velocity of 0.4 m/s. Residual stress was compared to compare the peening performance which is measured using X-Ray diffraction method. The distribution of stress in surface of the alloy was compared with shot peening and found that water treatment is capable of producing better results than the shot peening process. Before treatment the residual stress varies from 400 to 520 Mpa and after water jet peening the residual stress increased up to −500 MPa at the surface of the work piece.[1]
N. Kamkar et al [2013] investigated the effect of water impingement erosion on Ti–6Al–4V alloy. Titanium based alloys are used in various situations like in exposed in rain, Steam and fogging effect. This research targets the usage of water jet erosion to enhance the life of the machine parts. The samples of Ti–6Al–4V rolled up to the advanced stage were subjected to water impingement erosion checks. Erosion characteristics were examined at different levels and their microstructure has been analysed. The input parameters considered in this research work are impact velocity of 350 m/s with 30,000 impingements. The microstructure reveals the damage features such as surface crack propagation and transgranular crack propagation. [2]

2. EXPERIMENTAL WORK

In the present work, water jet peening is carried out on Numerical Controlled machine tool of Hi-Cut 3503 make. Aluminum AL6063-T6 alloy was used as work piece material of dimension 120mm x 80mm x 12mm. In this study, Water Jet Pressure (Mpa), Stand of distance (mm) and Traverse Rate (mm/min) were considered as parameters and peening was carried out with Garnet (#80) as Abrasive. Experiments were designed using the experiments are conducted by

Box-Behnken Design (BBD) as shown in table1 and table 2. The nozzle has an orifice diameter of 0.2mm and focus tube diameter of 0.762mm

Table 1: Factors and Levels

Sl No	Factors	Units	-1	0	1
1	Water Pressure (A)	Mpa	150	160	170
2	Stand of Distance (B)	mm	80	90	100
3	Traverse Rate (C)	mm/min	1500	1750	2000

Table 2: Box Bhenken Experimental Design

Exp	A	B	C	WJP		AWJP	
				HR	SR	HR	SR
1	-1	-1	0	116.5	3.285	129.3	3.385
2	1	-1	0	122.5	3.040	136.2	3.131
3	-1	1	0	109.6	3.597	120.0	3.705
4	1	1	0	116.5	3.182	129.0	3.279
5	-1	0	-1	113.6	3.188	126.0	3.284
6	1	0	-1	122.5	3.295	135.0	3.394
7	-1	0	1	119.8	3.203	131.5	3.300
8	1	0	1	122.4	3.217	133.0	3.314
9	0	-1	-1	120.5	3.301	135.2	3.400
10	0	1	-1	119.8	3.742	134.0	3.855
11	0	-1	1	124.7	3.942	141.3	4.061
12	0	1	1	113.4	3.072	127.0	3.165
13	0	0	0	108.4	3.043	118.5	3.135
14	0	0	0	108.6	3.075	119.1	3.168
15	0	0	0	108.0	3.056	117.5	3.148
16	0	0	0	108.3	3.054	119.2	3.146
17	0	0	0	108.7	3.075	119.0	3.168

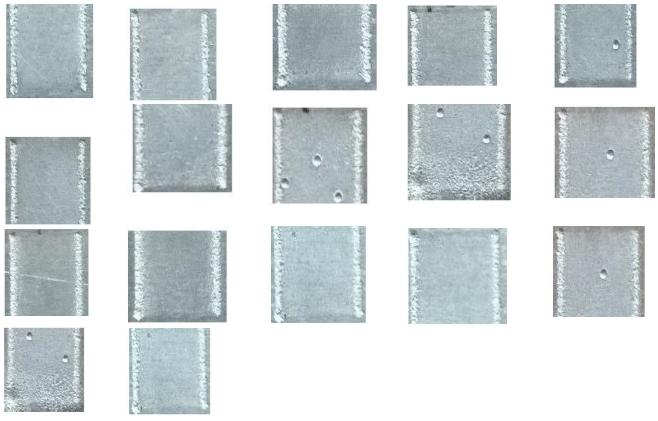

Figure 1: Water Jet peened samples

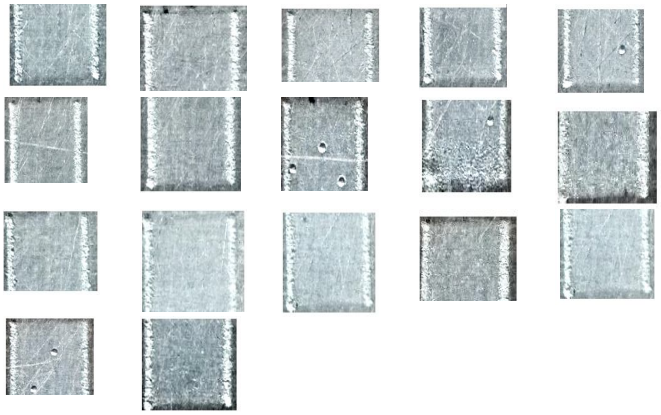

Figure 2: Abrasive Water Jet Peened samples

3. RESULTS AND DISCUSSIONS

a) Effect of Abrasives on Hardness and Surface roughness

The hardness of the sample was measured by using Vickers microhardness tester and found that there is an increase in hardness of up to 20 % was reported and the higher hardness is reported due to the combined effect of Water pressure (160 Mpa) , Standoff distance (80mm), and Traverse rate (2000 mm/min). The hardness value of 124.7 HV is reported for Water jet peening and for Abrasive water jet peening the hardness value is found to be 141.3 HV. The surface roughness of the samples were measured by using SURFCORDER SE 3500, from Kosaka Laboratories and found that there is an increase in surface roughness up to 22% due to the effect of water jet and abrasive water jet peening. Garnet (#80) is used as an abrasive material with a flow rate of 50 to 60 g/min for abrasive water jet peening. A comparison between the effect of abrasives on micro hardness and surface roughness was shown in the figure 3 & 4, an increase in hardness and surface roughness was observed during abrasive water jet peening. This is due to the presence of garnet increases the rate of the peening action, which is confirmed by testing the samples of same size, is treated with the same input parameters with water jet peening and abrasive water jet peening.

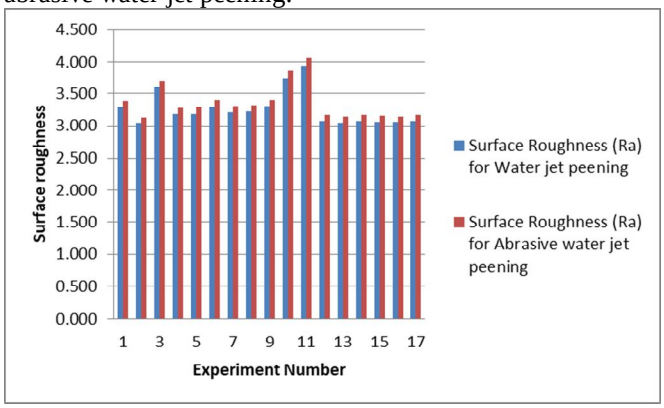

Figure 3: Comparison of Surface Roughness

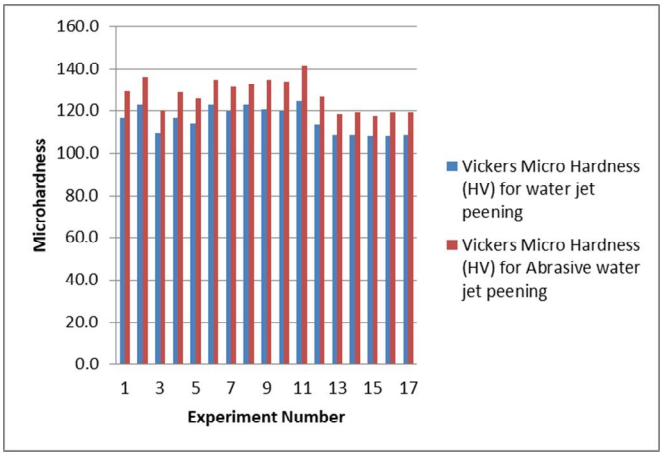

Figure 4: Comparison of Microhardness

b) Effect of Abrasives on Microstructures

The microstructures of the of the Water jet Peened and Abrasive Water jet peened samples has been shown in the figures below. In water jet peening process, few boundary dislocations are observed and the corresponding hardness values of the sample1 were found to be increased from 91.2 HV to 116.5 HV. The surface roughness's of the samples were also increased due to the mechanical deformation. In abrasive water jet peening the intensity of peening was more. For the same condition, the hardness value increased from 91.2 HV to 129.3 HV. A boundary dislocation was reported in the Abrasive water jet peening operation which is an evidence for plastic deformation. In water jet peening the surface erosion is minimum as it is shown in the figure 5 and the effect of abrasives such as boundary dislocation and abrasive deposition is reported in figures 6,7and 8 respectively.

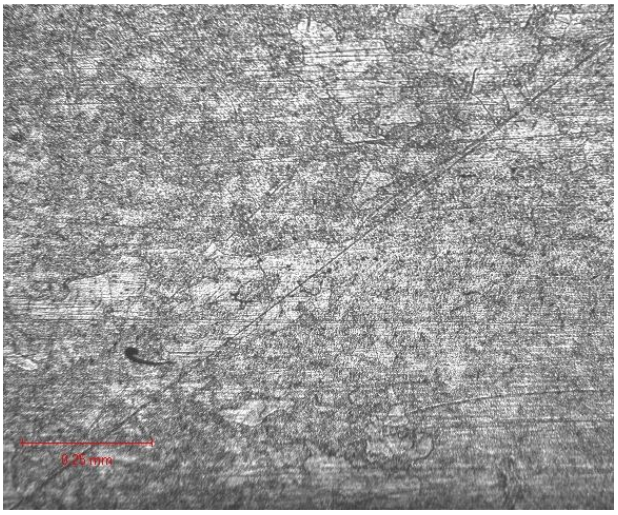

Figure 5: Microstructure of Water jet peening

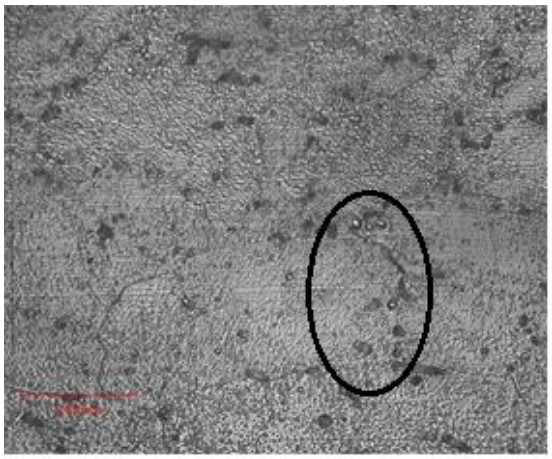

Figure 6: Microstructure of Abrasive water jet peening

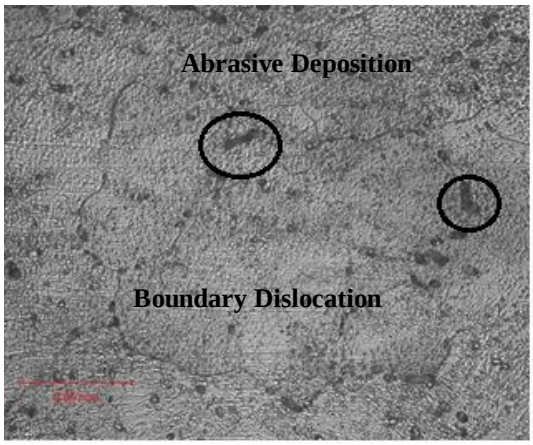

Figure 7: Microstructure of Abrasive water jet peening

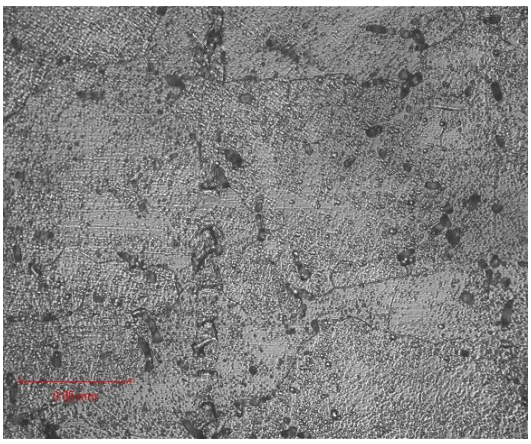

Figure 8: Microstructure of Abrasive water jet peening

The above figures 5,6,7 and 8 shows the effect of water jet peened samples by varying the water jet pressure, Standoff distance and Traverse rate as shown in the table 1. From the microstructure it is observed that the material is prone to a

minimum plastic deformation and the corresponding hardness value shows the effect of water jet on the alloy.

4. CONCLUSION

In this research work a comparative study between Water jet peening and Abrasive water jet peening on Al 6063-T6 alloy were made. The following conclusions were drawn from the comparative study. The abrasive water jet peening process was performed better when compared to water jet peening process in terms of hardness. An improvement in hardness up to 20% was reported due to the combined effect of process parameters such as Water jet Pressure, Standoff distance and Traverse rate. The abrasive flow rate increases the intensity of peening with mild erosion. The surface roughness of the abrasive water jet peened sample was increased due to the combined effect of process parameters. The microstructure evidence also confirms the boundary dislocation and plastic deformation. There were no visible cracks reported in microstructure after peening treatments. The abrasive water jet peening process performs better in terms of hardness and surface roughness.

REFERENCES

1. Hayashi, M., Okido, S.and Suzuki.H (2020). Residual Stress Distribution in Water Jet Peened Type 304 Stainless Steel, *Quantum Beam Science*, 4, 18
2. Kamkar, N., Bridier, F., Bocher, P., and Jedrzejowski, P. (2013). Water droplet erosion mechanisms in rolled Ti–6Al–4V, *Wear* 301, 442–448.
3. He, X., Song, M., Du, Y., Shi, Y., Johnson, B. A., Ehmann, K. F., Wang, Q. J. (2020). Surface hardening of metals at room temperature by nanoparticle- laden cavitating waterjets. *Journal of Materials Processing Tech.*, 275, 1-6.
4. Hutli, E., Nedeljkovic, M., and Bonyár, A. (2018) Controlled modification of the surface morphology and roughness of stainless steel 316 by a high speed submerged cavitating water jet. *Applied Surface Science*, 458 ,293–304.
5. Ijiri, M., Shimonishi, D., Tani, S., Okada, N., Yamamoto, M., Nakagawa, D. and Yoshimura, T. (2019). Improvement of corrosion resistance of magnesium alloy by high- temperature high-pressure cavitation treatment. International *Journal of Lightweight Materials and Manufacture*, 2(3), 255–260.
6. Latchoumi, T. P., Balamurugan, K., Dinesh, K., and Ezhilarasi, T. P. (2019). Particle Swarm Optimization approach for waterjet cavitation peening. *Measurement*,141,.184–189.
7. Luan, W., Jiang, C., Ji, V., Chen, Y., and Wang, H. (2008). Investigation for warm peening of TiB_2/Al composite using X-ray diffraction, *Materials Science and Engineering*, 497, 374–377.
8. Oka, Y. I., Mihara, S., and Miyata, H. (2007). Effective parameters for erosion caused by water droplet impingement and applications to surface treatment technology, *Wear*, 263, 386– 394.
9. Dwi, A., Surakarta, U. M., & The, C. (2020). of Emerging Trends Analysis of Mechanical and Metallographic Properties on The Joining Between Aluminum and Brass by Using The Brazing Method, *International Journal of Emerging Trends in Engineering Research 8*(2), 440–446. https://doi.org/10.30534/ijeter/2020/31822020
10. Ryzhenkov, A.V. . Dasaev, M.R. Grigoryev,S.V Kurshakov A.V (2020) The Influence of Structured Relief on Wetting Properties of Zinc Plated Steel Surface, *International Journal of Emerging Trends in Engineering Research*, 8(1), 164-169 https://doi.org/10.30534/ijeter/2020/22812020