Unviersty of Anbar

Anbar Journal Of Engineering Science©

journal homepage: http:// http://www.uoanbar.edu.iq/Evaluate/

Effect of Pulse Repetition Rate on Micro Hardness on the Surface and Cross Section of Gray Cast Iron by using ND-YAG Laser

A. Shahad[a], B. Abbas S. Alwan[b] and C . Kadhemm. A. Abed[c]

[a] *Mechanical Engineering Department , Alanbar university , Alanbar organization, Ramadi, 11190, Iraq (first author's affiliation)*
[b] *Metaiiuragy Engineering Department Baghdad university ,Baghdad organization , Baghdad, Iraq (second author's affiliation)*
[c] *Mechanical Engineering Department ,Alanbar university ,Alanbar organization, 11190,Ramadi, Iraq (third author's affiliation)*

PAPER INFO

Paper history:
Received … … …
Received in revised form … … …
Accepted … … …

Keywords:
ND-YAG Laser,
Pulse Repetition Rate,
Micro hardness.

ABSTRACT

This work, studied the effect of pulse repetition rate on the micro hardness for each of the surface and cross section by using pulsed ND-YAG laser with laser parameters (Energy = 4.12J).The distance off between the output nozzle and the minimum spot size on the surface of sample was (12mm),and pulse duration was (1.8ms).The results showed that the micro hardness increased after laser treatment ,but the micro hardness decreased with increase pulse repetition rate for both the surface and cross section of the pulses. The micro hardness increased as moving away from the molten zone towards the end of the pulses at the heat affected zone due to increase in cooling rate.

1. Introduction

Gray cast iron is used in many engineering applications such as, valves, tool beds and pistons because it has good mechanical properties, cast ability, excellent machinability and cheap priced [1]. Laser surface treatment is applied to enhance micro hardness as well as to Chanchiang the microstructures of gray cast iron [2].

Several researchers were interested in this problem Mohammed S.A. used pulsed ND : YAG laser with three laser's energy, which are (1J , 1.2J , 1.5J) with pulse duration (300µm) to study the effect of laser surface treatment on Aluminium alloys (2024 , 7075 , 390) . The results showed that an improvement in the micro hardness and wear test for AI-SI (390)[3]. Mahmoudi B., et.al was concerned with AISI martensitic stainless steel hardening by pulsed ND : YAG. They studied the effect of process parameters (laser pulse energy, duration time and travel speed) on the depth of laser treated area. The results showed that the hardness was up to (490 VHN) of AISI 420 with best laser parameter[4]. Behavikatti S.S, et.al studied the hardening of cast iron using low power fiber laser. The study adopted the laser surface hardening by using a fiber laser power (100w) in continuous wave and pulsed mode is used in conjunction with a beam integrator and study the effects of the process parameters viz, beam diameter beam power, travel speed and pulse time in the geometry, dimensions and hardness of heat effected zone. The results showed that the used of power fiber laser economical and also avoid cutting operations where the use of lasers to correct surface with a minimum of distortion [5].

2. Material and Methods

Sampling preparation starts from cutting the samples to the desired dimensions with a diameter of 10mm, and 5mm thickness for microstructure and micro hardness tests.

Calcium carbide paper was used to grind the sample, after that the samples were washed to remove oils from the surface before laser treatment by using alcohol. The chemical composition of the gray cast iron sample is given Tables (1) .

Table (1) chemical composition of Gray Cast Iron

Elements wt%	C	S	Si	P	Mn	Fe
Actual	3.45	0.12	2.24	0.26	0.76	Bal
Standard	3.3 -3.50	0.08 -0.13	2.20 -2.40	0.20 -0.50	0.50 -0.80	Bal

2.1 ND: YAG laser system

The specifications of pulsed ND: YAG laser are (1) the maximum power the of laser beam is (7.5 kw), (2) the pulse duration is (50ms), (3) wavelength (1064nm), (4) and the frequency is (1-100)Hz, as shown in Figure (2).

Figure 1. ND: YAG laser system

3. Result and discussion

3-1 The Relationship between the Pulse Repetition Rate and Micro Hardness

Pulse Repetition Rare (P.R.R) is one of the important factors affecting laser surface treatment. Particularly in this study the amount of heat increases ,the absorption of metal and temperature become high depending on the pulse duration due to the increase in pulse repetition rate. The relationship between different (P.R.R) (1-3) pulse/s and micro hardness are shown in figure (2). The micro hardness decreased when increasing in (P.R.R) this result correspond with [6] ,because (P.R.R) cause an increase in the temperature of the metal so that the metal kept the temperature and reduced the time that allows the heat to leak out of the metal and did not reach the temperature of metal to the temperature of the room. This means that the heat accumulated in the metal led to a low cooling rate. This is main reason for the decrease in the values of micro hardness, as shown in figures (3), (4) and (5).

The micro hardness in cross section of the sample treated by laser with different value of (P.R.R) also decreased with increase in (P.R.R) which is higher than the values of surface micro hardness because the cooling rate on the surface less than the cooling rate inside the metal (cross section) this led to increase the micro hardness metal from the inside the most of the surface in case (P.R.R1) the micro hardness in cross section equals (723 HV), (P.R.R2) the micro hardness in cross section equals (620 HV), and (P.R.R3) the micro hardness in cros section equals (553HV) as shown in figures (6),(7) and (8) Fig.(2) The relationship between the micro hardness and P.R.R Fig.(4) The variation values of micro hardness with P.R.R2 for the distance off (10mm) .

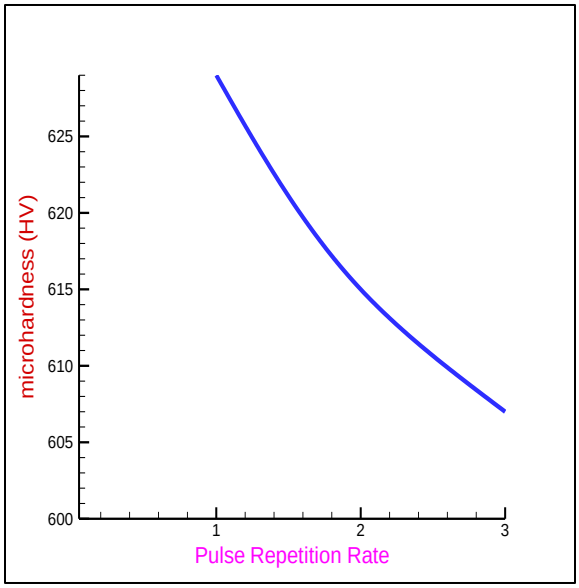

Figure 2. The relationship between the micro hardness and P.R.R

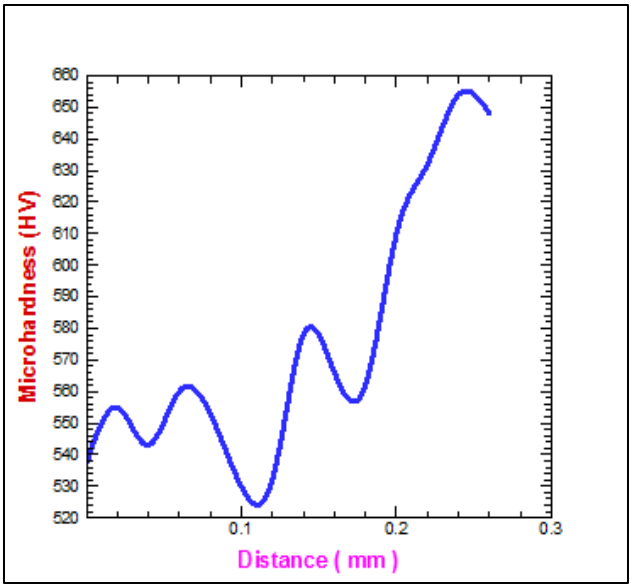

Figure 3. The variation values of micro hardness with P.R.R1 for the distance off (10mm) .

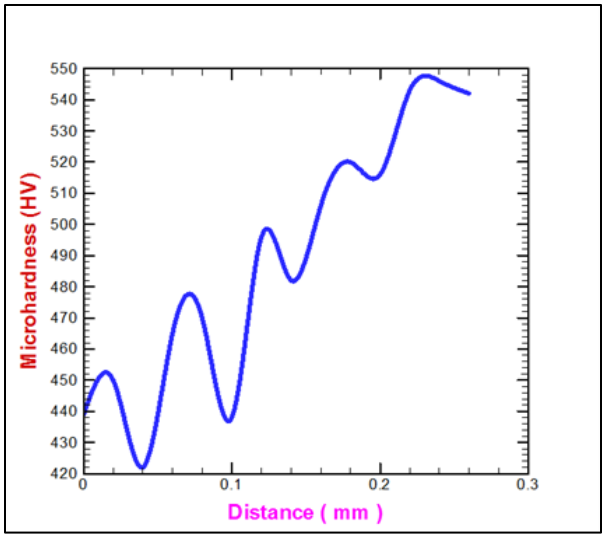

Figure 4. The variation values of micro hardness with P.R.R2 for the distance off (10mm) .

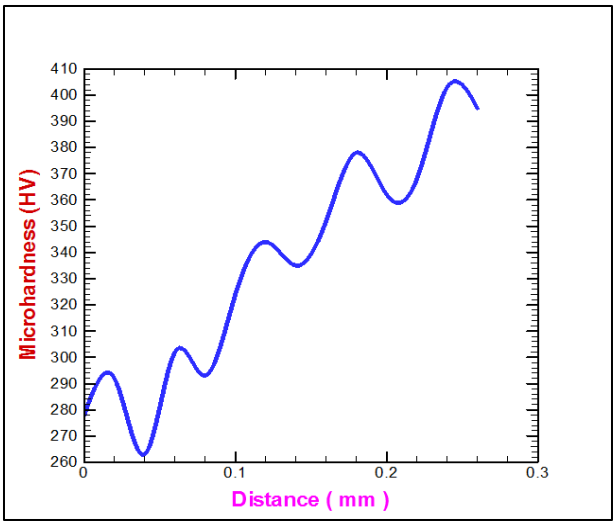

Figure 5. The variation values of micro hardness with P.R.R3 for the distance off (10mm) .

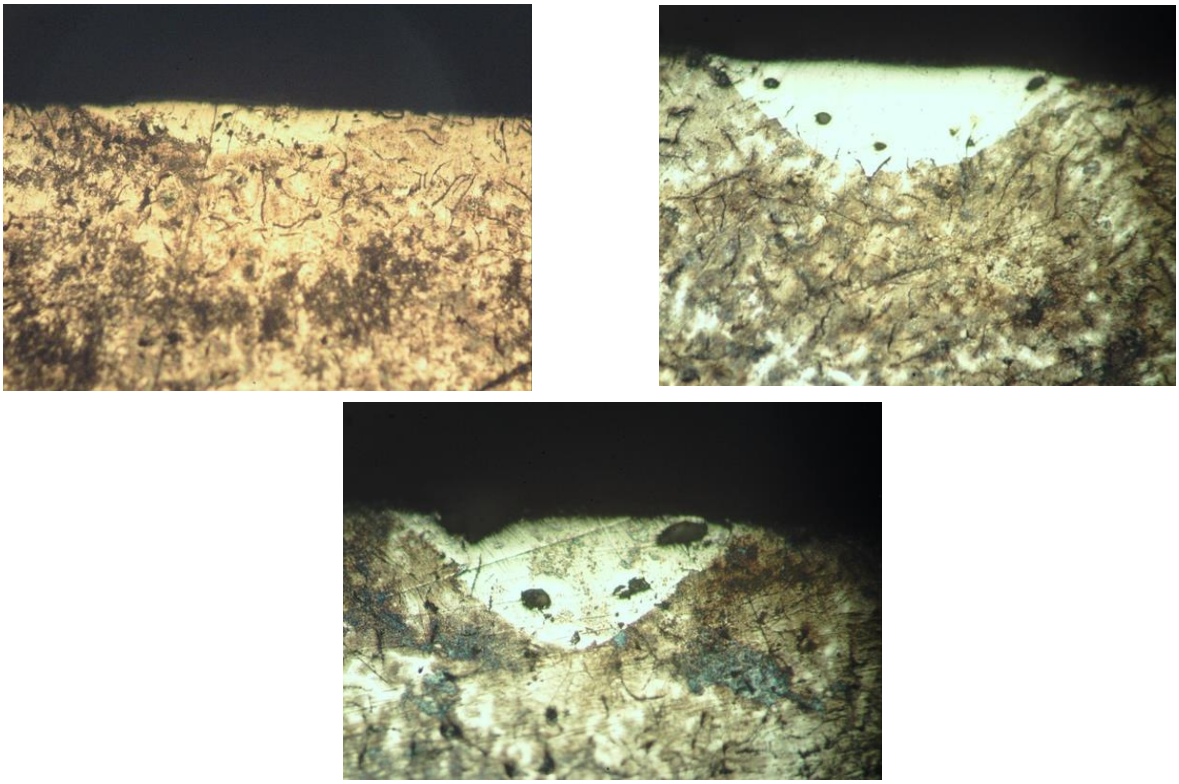

Figure 6. Cross section of sample with different (P.R.R), (A) (P.R.R1) ,(B) (P.R.R2) and (C) (P.R.R3)

Laser surface treatment has improved the micro hardness and changed the microstructure of gray cast iron and transformed it to marten site phase in the molten zone. Heat affected zone consists of nodular graphite as shown in figure (7).

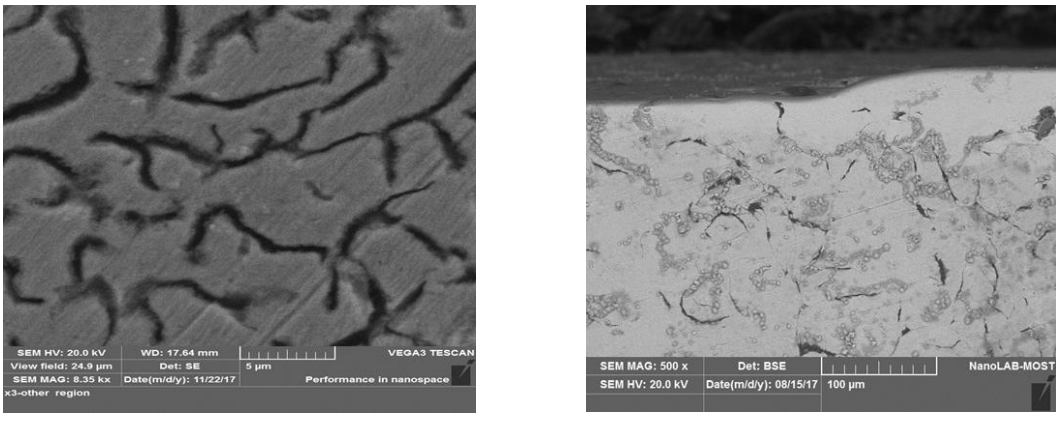

Figure 7. Microstructure of gray cast iron before and after laser treatment , (a) after treatment and (b) after treatment

4. Conclusions

These study arrives at the following conclusions :

1- The use of pulse repetition rate increased metal temperature which led to decreasing micro hardness of the surface and the cross section of the metal. Thus this method was not efficient in improving micro hardness.

2- Micro hardness increased when moving away from the center of the spot because the cooling rate increased, and this in turn led to an increase in hardness .

3- Micro hardness increased twice as much after laser treatment because de-creasing in the distance off. The values of micro hardness of cross section was greater than the micro hardness of the surface because the cooling rate in cross section was higher than the cooling rate of the surface.

4- These study obtained a homogeneous micro structure of gray cast iron after laser treatment.

References

[1] Karamisa M.B.,Yildizli K. Materials Science and Engineering A,527, PP. 5225-5229 ,2010

[2] Lampman S., Introduction to surface hardening of steels ,ASM Hand book ,Vol.4, Heat treating ,ASM International , Materials Park, OH,PP.295-267 ,1997.

[3] Mohammed , S.A., "Study the effect of laser surface Treatment on Aluminum Alloyes", M.Sc. The sis, University of Technology, Baghdad ,2004

[4] Mahmoudi B., "Laser surface hardening of AISI 420 stainless steel treated by pulsed ND:YAG laser" , Journal of Materials and Design, Vol.31, P.P: 2553-2560, 2010 .

[5] Mohammad Ansari, Mahmoud Heydar zadeh, sohi, Reza soltani and Mohammad Javad Torkmany., "Effect of pulsed Nd:YAG laser remelting on chromium surface alloyed AA6061-T6 aluminum", International Journal advance manufacturing Technology , 2015 .

[6] Abbas S. Alwan " Effect of quenching media on the mechanical properties and abrasive wear resistance of 34Cr4 steel blade with soil texture used in agricultural equipment's soitexture used in agricultural equipment's ". Eng. &Tech. Journal, Vol.32, part(A), No.9, 2014. Pp2205- 2215.