The Effect of Laser Treatment on The Erosion Resistance of a CU-NI Austempered Ductile Iron

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Abstract

The present work investigates the effect of laser surface hardening on the erosion resistance of alloyed austempered ductile iron (1.5% copper and 1.5% nickel) austenitized for different austenitising times.

Continuous wave of Co2 laser was used to heat by overlapping technique. The laser processing parameters used were; (1000) W, laser power, (1000) mm/min. Scanning speed and (40) L/min. Argon flow rate.

After laser treatments erosion tests were carried out on the untreated and laser treated samples surfaces. The erodent particles used were pressurized silica (+300 to 500) flow at speed of (50 m/sec). The erosion tests were performed at different angles (30°, 60° and 90°).

Erosion tests showed significant reduction in the erosion rate after laser treatment at all impinging angles. Erosion resistance is improved depending on the impingement angle, (weight losses in grams at 90° > weight losses in grams at 60° > weight losses in grams at 30°). Increasing the impingement angle increases the erosion rate for both untreated and laser treated samples. The erosion mechanism was studied by SEM observation of the fracture surface. In the untreated samples the erosion was mainly by severe plastic deformation, micro-ploughing and micro-cutting while in laser treated samples, it was by localized strain at the overlapped regions which leads to crack formation that eventually leads to fracture. This improvement in erosion resistance was attributed to the fine and homogenous structure, high hardness and the elimination of graphite nodules which were the source of notches.

Keywords: Lasertreatment, Erosion, ADI, Austempering, Hardness, Austenitising.

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1. INTRODUCTION

The properties of ductile cast iron are very much dependent on the microstructure and can therefore be significantly improved by heat treatment. One such treatment is austempering. The resulting iron is called austempered ductile iron (ADI) and its structure contains an austenite ferrite (ausferrite) in a high carbon austenite matrix. The application of austempering to ductile iron has generated a new family of irons with improved mechanical properties. This has in turn opened up the potential for a wider application of ductile iron and the possibility of weight reduction in some current applications. The structure in ADI is best referred to as ausferrite and consists of austenite and ferrite in a matrix of high carbon austenite rather than carbide as in austempered steel. This unique microstructure is responsible for the remarkable combination of mechanical properties attained by the material including high strength, ductility and wear resistance. [1-3]

Although ADI was developed during the early 1960's, it could lead to some extent still be considerable as a new material, this is because despite the many number of papers and researches [1-9] dedicated to ADI, many of them deal with the routine characterization of microstructure and mechanical properties with a view to optimizing processing. [2]. In many structural applications it is often required that the material be hardened at the surface while the interior of the material must remain soft or ductile. The higher hardness at the surface layer imparts excellent wear resistance while the soft inner core provides higher toughness and fracture resistance. In recent years there has been significant interest in use of laser in surface treating of materials.

The high intensity CO₂-laser has proved to be extremely successful in various industrial applications from the point of view of both technology and economy. A great number of successful applications of this technique have stimulated the development of research activities, which since 1970 have constantly been increasing. [10]

A very little work [10-13] has been done on the erosion resisting on the laser surface hardened ADI due to the long testing time required also the
lack of erosion experiments. A study carried out by K. Fadlullah and J. Abboud [11], has shown that laser surface of a nodular cast iron by laser surface melting and alloying with chromium reduced significantly the rate of erosion by at least a factor of 100 in comparison with untreated iron. Also, K. Shimizu et al [14] have studied the erosion of ductile irons of different structures and hardness. Their results showed that both FDI and PDI have the maximum erosion rate at 60º impact angle. The minimum erosion rate was for PDI (70), one third of FDI. Also they found that the erosion rate decreased with increase in the hardness and the amount of pearlite in the matrix.

In the present study, an attempt has been made to evaluate the scope of enhancing erosion resistance of an alloyed of austempered ductile iron (ADI) by laser surface treatment

2. Experimental work

The material from which the specimens were used is ductile iron of initially pearlitic matrix contain 1.5 Ni, 1.5 Cu, 2.26 Si, 3.35 C, 0.37 Mn, Cr 0.10, 0.2 Mg, Balance Fe. The alloys were heat treated to produce ADI at different austenitizing time the microstructure contains retarded austenite, ferrite and nodules of graphite, then alloys were laser treated. The dimensions of each specimen were 28x14x5 mm.

All the samples surfaces were ground with 600, 800, 1200 grit SiC papers to decrease the laser beam reflectivity and to make the surface topography. Before the laser surface processing, the specimens were cleaned with alcohol and dried to be ready for the analysis. The samples with different austenitizing time (15, 30, 60, 120, 180, and 360) min. were cut into two equal halves, one for the untreated and the other for laser surface treated examinations. Weight of untreated and laser surface treated samples were taken by a digital balance (0.0000).

The laser surface treatment was carried out by CO2 laser system available at Malta University. The machine operates in a continuous and a pulse, type of the machine is TRIA GON 9000, with maximum design power of 12000w, beam wave length of 10600 manometers and maximum current of 600A.
Test surface of 28x14 mm were scanned using a high precision mechanical step moving in line with a laser beam, the scanning was realized in a sequence of parallel lines at a fixed velocity and with 1 mm lateral shift. 1000 Laser power (watt), 1000 Scanning speed (mm/min.), 25 Focal distance (mm), 40 Argon flow rate (L/min.)

In the present investigation a sand blasting machine was used for erosive testing. Solid particles impingement were tested and manufactured according to the standard G76-83.

The erosion tests were pre-selected at 30°, 60° and 90° conducted at impact angles by changing the orientation of the sample with respect to the stream of the impinging particles, using angular silica sand erodent particles. Dried air was used for accelerating these particles. Each specimen was approximately eroded with exposure time of 2700 sec.

Figures(3.2) The ADI sample under laser machine head.

Abrasive particles (silica sand) used in the present investigation, were angular and spherical shaped, of size ranging between (300 to 600) µm,
3. Results and discussions

For the purpose of studying the possibility of increasing the wear resistance, specimens of austempered ductile iron ADI with different austenitizing conditions were laser surface treated (melting) and the erosion tests results will be discussed in this section.

The erosion tests were preselected at impingement angles of (90, 60 and 30) degrees conducted at impact angles by changing the orientation of the samples with respect to the stream of the impingement particles using angular and sphere silicon sand erodent particles. Dried air was used to accelerate these particles velocity (controlled by air pressure regulator). Each specimen was approximately eroded at an average air pressure of 10 bars with exposure time of 2700 seconds, the nozzle diameter was 2mm and the nozzle and sample surface was 10 mm.

At different austenitized times, the weight losses decrease rapidly by increasing the austenitizing time. As it can be seen in table (4.3) and figure (4.4a), the untreated samples weight losses was the highest at 15 minutes austenitized time sample (2.9927) grams and decreasing to (2.5728) grams of sample austenitized for 15 minutes to 2.0790 grams of sample austenitized for 6 hours, while for the laser treated samples the losses starts from (2.5506) grams of sample austenitized for 15 minutes and starts dropping to (1.1864) grams at austenitized time of 6 hours and at the same impingement angle.

At impingement angle of 60°, the untreated samples weight losses decreases rapidly, the values starts from (2.7355) grams of sample austenitized for 15 minutes to 2.0790 grams of sample austenitized for 6 hours, while for laser treated samples the weight losses decreases from (1.6911) grams of sample austenitized for 15 minutes to (1.5426) grams of sample austenitized for 6 hours.
Figure (4.4)a, Weight losses in grams at impingement angle of 90° for different austenitized time.

Figure (4.4)b, Weight losses in grams at impingement angle of 60° for different austenitized time.
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At $30^\circ$ impingement angle, the untreated samples weight losses decreases very rapidly starting from (1.8013) grams to (0.6220) grams, as the austenitizing time increases 15 minutes to 6 hours, while for laser treated samples weight losses decreases from (0.6916) grams of sample austenitized for 2 hours to (0.4995) grams of sample austenitized for 1 hour. These results are in agreement with work on other alloy carried out by J. R. Keough[2] shows that the laser hardening can improve significantly the surface properties such as wear and fatigue resistance.

4. CONCLUSIONS

The following conclusions were drown from this work;

The laser surface of ADI reduced significantly the rate of weight loss this could be attributed to the high hardness values. The effect of the impingement angle, weight losses decreases as the impingement angle decreases. This research has served to establish some data and throw light on the effect of laser treatment on ADI, so as to be able to exploit new applications and marketing for austempered ductile iron.

REFERENCES


