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THE INFLUENCE OF LASER PEENING PULSE NUMBER ON HARDNESS, RESIDUAL STRESS AND ADHESIVE WEAR OF AISI 316l STAINLESS STEEL

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ABSTRACT

Improvement of Wear adhesive properties using laser peening treatment at varied number of pulse of Austenitic stainless 316L is studied. According to typical ASTM G99-05 number of wear inspection test are prepared in dimensions 20x10 mm then compiled into four groups. The surface test of three groups is exposed to a number of laser pulse 1, 2, 4 pulses respectively by laser peening without coating. Microstructure, residual stress, hardness, is tested. Wear test using pin on disc method are used on all groups of specimens at two parameters, diverse times 10 ,20,30 min with constant load 1kg , and divers load 1,1.5, 2 kg with constant time 10 min. from results it was concluded that decrease in hardness and rises in ductility shared to increases in wear properties for the original metal and leaser peening participated to rise in the wear resistance due to increase in hardness , compression residual stress and the heterogeneity of the evidence in the microstructure ,four pulse laser peening give the lowest wear rate comparing with one pulse which witness decreases in wear rate.

KEY WORD :- Austenitic stainless steel 316L, leaser peening, wear resistance, residual stress.

تأثير عدد نبضات القذف بالليزرعلى الصلادة والاجهادات المتخلفة والبلى الالتصاقي للفولاذ المقاوم للصدأ AISI 316l

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الخلاصة

تحسين خواص البلى الالتصاقي باستخدام عملية القذف باشعة الليزر بعدد ضربات مختلفة لفولاذ مقاوم للصدا اوستنايتي316L استنتج .ووفق المواصفة القياسية لاختبار البلى الالتصاقيG99-05 تم تصنيع عدد من عينات البلى الالتصاقي بابعاد 20x10 ملم وتم تقسيمها الى اربعة مجاميع اسطح ثلاثة مجاميع تم ضربها بنبضات ليزر بدون طلاء بعدد1,2,4 ضربة على التوالي . تم فحص البنية المجهرية ، الاجهادات المتبقية ،الصلادة .اجري اختبارالبلى الالتصاقي على كافة العينات بطريقة (pin on disc) عند زمن متغير(10 ,20,30) دقيقة وحمل ثابت 1كغم وحمل متغير1,1.5,2 كغم وزمن ثابت 10 دقيقة ومن النتائج وجد ان قلة الصلادة وزيادة المطيلية للمعدن الاساس اعطى زيادة في معدل البلى وعلى العكس ساهمت عملية القذف باليزر في تحسين خواص البلى بسبب زيادة الصلادة و الاجهادات الضغطية المتولدة والتجانس الملحوض في البنية المجهرية وان افضل نتيجة كانت عند عدد واحد ضربة مقارنة بعدد 4 ضربة التي شهدت زيادة في معدل البلى.

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INTRODUCTION

Austenitic stainless steels are employed in production varied parts because of their marvelous corrosion confrontation and microstructure though these materials have insufficient wear counteraction and petite hardness. An effort is earlier made to elevate the surface hardness and wear counteraction of austenitic stainless steels by surface treatment such as leaser shot peening **[E. Haruman1,2006].** The adhesive wear happens as soon as two surfaces are touching comparatively one part move above the other, and this absolute motion is in one direction or a consecutive motion less than the influence of the load so that the compression on the contiguous swellings is great sufficient in making a load ductile distortion and sticking together. This sticking together will be at a great evaluation of efficiency and faculty in kin to the clean surfaces, and adhesion will happened among a numeral of these swellings whose extents will be larger and the area will be greater than before through motion . At the end there will be some kin wear in the thin soft tissue in the puny points of the conspicuous locales .This adhesion wear is measured straightway to the load realized and the sliding distance and deviously with the hardness of the metal. The adhesion wear is one of the most dominant wears, it shaped 15% of the manufacturing wear which occurs when the surfaces are gliding one over the other, so that the compression among the nearby swellings is adequate to fabricate several position embody sticking together and ductile. The technic of the shape of the adhesion wear could be give details as follows: **[E. Haruman1 et.al].** All surface though sleekly seems, it will be coarse in the microscopic scale and comprises a extend of tips and swales and when two faces encounter then this dealings happed at these swellings which are petite and comparatively sequestered; thus when implemented a load on these surfaces, at that time the position there will be a great compression and heat which will reason reaching the elastic limits of one surface or both surfaces and the distortion of the swellings in ductile avenue, so that, the actual touching spaces are augmented to a limit to backing the implemented load. The touching spaces areas are tending to be injured under the influence of the comparative actions among the two surfaces. The tiredness happens generally at one surface, for the reason that of the confrontation of the in among surface to crash breaking and tiredness because of the response of strain hardness through the sticking together of swellings. The detached material (because of the cut off swellings) will get the form of s little sheets which is generally transferred to the contradictory surface or it is found discretely among the two surfaces . **[E. Haruman1 et.al] [A.Triwiyanto et.al]** show that the adhesive wear can be improved by leaser shot peening which is explain a mechanical cold working practice where throbs crash the surface by extreme power strong dot and stimulate compressive remaining stresses established nearby, 4–5 times profounder and greater intensity with homogeneity across material surface hearten in refining the microstructure. The laser patch size and shape are important agent actors in the peening procedure. Circular shaped laser tracts are extensively adopted. In bonus greater compressive stresses are receivable for lesser patch s because of the reversal harmony of patch extent and power intensity. Various laser shocks and imbricate of tracts to defense great regions have shown important impact on the remaining stress profile. This is because of the actuality that the bigger figure of jolts the greater persuaded ductile distortion till a soakage point is attained .Additionally, overlapped areas appearance a relatively even allotment of compressive remaining stresses next LSP, greater laser jolts showed abysmal remaining stresses than in the state of on its own laser shock, abysmal stresses be able ascribed to the ductile distortion that generated more dislocation travels. The enduring stresses at the surface of the plat are smaller in the twin laser jolts, whereas it was bigger for on its own laser shock. This can be defined as the stress fullness point is got by on its own laser shock or the stresses have been relaxed due to rise in figure of

shocks .Moreover, the sucker film may have been ruined through multiple jolts**[Peyre et.al , 1996] [Sano et.al , 2006] [Mallesh et.al , 2006]**

Many researchers manipulation the subject like **[Abdullahi et.al , 2014]** manipulation the surface hardening using laser peen and its influence on the material surface concluding, penetration of the hardened layer ,amount of stresses produced and the role of its .the impact of laser to improve the qualities of the metal including the structure of microscopic and corrosion confrontation and the time of fatigue life and analogy the results with ultrasound which depend on the selection of shock conditions like velocity, wavelength, frequency, etc. . **[I.B Roman et.al , 2011]** shows that the surface treatment technologies have become important in industry to choice and avoid the need for costly materials demonstrated that laser shock processing (LSP) is now emerging as a viable surface treatment technique. This technique improves the mechanical qualities through persuading a compressive remaining stress. **[Askar Triwiyanto et.al]** studied the importance of chemical, thermal factors on the surface hardness of Austenitic stainless steel 316 L. Thermal ,chemical treatments of carbonate, nitrate and carbo-nitride at low temperatures of less than 450 ° C to get an oxidized film of extended Austenite phase without sedimentation of chromium carbide or nitride during carbonization or Nitrate and the formation of a lone stag of the extended stage, containing carbide chromium in the case of carbonization method and wanted in the case of nitriding and pointed out that the thickness of the layer is irregular as it reached 83 µ in by nitriding for a time of 8 hours while by carbonization and carbonate give Less depth for the same period and confirmed that the depth of the film can be greater than before when increasing the time for all thermal dealings and the resulted surface hardness amounted to 1600HV for the method of nitride and 1150 HV and 500HV for carbonizing which participated to improving wear resistance and corrosion compared to metal without treatment. **[E. Haruman1,2006]**studied the surface film resulting from liquid nitride of AISI- 316L austenitic stainless steel at low temperatures (400-500) C^{o} and its influence on the microstructure through the use of X-ray diffraction and the identification of phases as well as the study of electrochemical corrosion behavior at scan potential from (-1000 + 1000) mv relative to the open circuit voltage. The consequences revealed that the liquid nitrate generated a film containing the extended austenite at a temperature of less than 500^{o}C which participated to improving the corrosion behavior.

The effect of laser peening pulse number on hardness, residual stress and adhesive wear of AISI 316LStainless Steel is actualize .

Experimental Procedure

The analysis of the used metal which are shown in(Table 1) were made by using ARL spectrometer in the specialized institution of engineering industries of ministry of Industry.

Manufacture of Specimens: Cylindrical specimens for the adhesion wear examinations are spawned in measurements 10x20mm according to ASTM specifications G99-05.

Grouping of Specimens:-

After completing the preparation of specimens, these specimens were classified and sorted into groups as shown in table 2.

Laser process

Three Grouping of Specimens as shown in table (2) are subjected to numbers of Laser pulsation processes by laser tattoo removal in department of laser engineering at the university of technology as shown in Figure(1). The prepared sample is fixed on the table of device then electromagnetic beam is applied to pulse the surface under these conditions

ʎ=1064 nm

Focal length=13mm

Pulse diameter =1mm

Time of pulse 20 second

After laser pulsing process is made many test are done such as microstructure, hardness, residual stresses, adhesive wear

Hardness investigation:

Vickers Hardness test is realized on all specimens in Table (2). The consequence which calculated with equation (1) are shown in Table (3)

$H_v = 1.854 * p/d^2$ (1)

Were (p): is the applied load in kg which is equaled 30kg for 30 sec.

(d.): average diameter in mm

Residual stresses:

Computerized Lab XRD-6000 shiatsu X-RAY diffraction meter in - Central laboratory - Baghdad in the Ministry of Housing and Construction was employed to measure the strain in the crystal lattice from the on-side and the quantity of the strain was implemented in brag law to account compressive residual stress in the leaser peening specimens . the obtained results from device was show the relation between 2 Theta (deg) which represented the strain Table (3) and Psi (deg .) represented the specimen location and its incline with the axis

Microstructure observation

Optical microscope was employed to observe the microstructure of specimens(A,B)as shown in table (2) .for this purpose specimens were. Equipped at steps contained grinding by emery papers having ranks from 220 - 320 - 400 - 800 -1000, 1200. And polishing method with a exceptional alumina polishing and granular size 0.5 µm and then chemical treatment of the surface using etching solution consists (49 $CuSO_4$ + 20ml HCl + 20ml distilled water). After that the samples washed with water and alcohol and dried in oven. The specimens are inspected by Nikon ME-600 optical microscope supplier with a NIKON camera, D XM-1200F as shown in Figure (2).

Adhesion Wear Experiments

Adhesion wear examination is complete using the weighing variance method on all the specimens in table(2) by the pin on disc device of wear examination.

The wear rate is computed from the subsequent equation:

$$W_r = \frac{\Delta W}{2\pi rnt} \quad (1)$$

Where 2πrnt is the sliding distance (cm) , $\Delta w = w1 - w2$ the weight of specimens before and after wear test and n= 940 rpm. The wear consequence is shown in Figures (3,4)

RESULTS AND DISCUSSION

Figure (2A) observed the microstructure of parent metal of austenitic stainless steel 316L which evident large grain size from austenite $(\gamma)$and ferrite phases(α) which offered little hardness for the metal this microstructure is be in refining Figure(2B) by leaser peen process to improve some properties due to prompt compressive residual stresses which contribute in this improvement , Table(3) show greater laser shocks revealed great amount of remaining stresses in the case of on its own laser shock,. The remaining stresses at the face of the plat are lesser in the dual laser shocks, whereas it was. This can be defined as the stress fullness point is got by on its own laser shock or the stresses have been relaxed due to rise in figure of shocks .Moreover, the sucker film may have been ruined through multiple jolts **[Geoffrey K., 2014].**Figure (3) displays the correlation among wear rate and its influences factors (Time, Load,) when time, load, are increased wear rate increase .This is visible in samples group A, B,C ,D. in Fig(3)Since wear rate is depend on hardness at that time when hardness as shown in Table (3) reduced the wear rate will increase. In **Figure** (3B) which represents the correlation among time and wear rate demonstrations that example (A) offers the largest wear rate while sample (B)gives the fewer wear rate because of the efficiency of the persuaded compressive left over stresses using LSP. Research have revealed that this conduct rely on the LSP procedure mutable as figure of throb and the influence of its on wear conduct so the behaviors of wear properties of materials is patient up to advanced using leaser peen. Figure(3) sample (C ,D) wetness small increase in wear rate due to decreases in residual stress. **Figure** (4) demonstrations the influence of (load) factor and wear rate reasons an a rise in the ductile distortion in surface caps points among two gliding surfaces, the adhesive method of the two caps surfaces is founded on implemented load, if the load is little the touching base seems in higher minute and this is actual thin through slipping process that reasons a thin film from remove metals to effort as a defensive surface layer which limits the touching base among the two gliding surfaces and halts the direct metallic joining among the surfaces caps thus the desired force to cut the joining among the two surfaces caps is fewer than the force among the metal atoms itself and that will make a reduction in wear rate **[RemeltingWislei et.al , 2009], [**Paul S.,1996**]**On the other hand an growing in practical load will decay the film due to its brittleness and its shoots out the friction sliding surfaces for both the discs and sample through the slipping method which makes a strong metal touching base among them making the desired force to cut its touching base caps more than the force between the metal atoms it self .During the test, when the practical load on the pin is increased, the actual touching base area would increase towards the nominal area which improves the frictional force between two sliding surfaces.

CONCLUSIONS

1-Reductions of compressive remaining stress at a laser patch with the arising the figure of LSP.
2- LSP- influenced area can arrived to a highest with the increasing the figures of shock.
3-Influences of increasing Numerous LSP reason increasingly uneven surface residual stress allocation at a laser patch.
4-large wear rate is obtained in base metal at increasing time and load due to few hardens this can be contributed by leaser shot peen and the LSP at one pulse give the best result.

Table 1 the chemical analysis of 316 L.

Element %wt.	Fe	C	Si	Mn	Cr	Mo	Ni	Al	Co	Cu	s	Ti	V	W
Actual value	**0.65**	0.03	0.68	2	17	2.5	12	-	-	-	.03	.01	.02	0.001
standard value	-	0.03	0.75	2	16-18.5	2-3	10-14	-	-		0.1	-	-	-

Table 2 Grouping for samples

Emblems Of Specimens	conditions
A	as received
B	One laser pulsation
C	Two laser pulsation
D	Four laser pulsation

Table (3) Macro Hardness& Residual stresses results.

Emblems Of Specimens	Residual stresses MPa	Macro Hardness **Mpa**
A	-13	353.16
B	-342.628	873.09
C	-372.732	843.66
D	-897.452	774,99

Fig.(1) Method of leaser peen

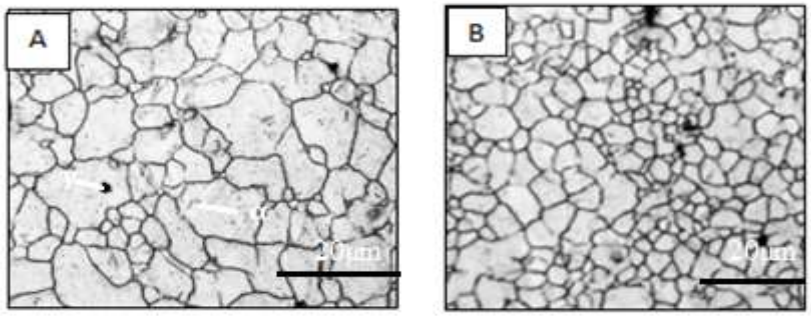

Fig.(2) Microstructure for 316L laser peened and un peened Sample40x .

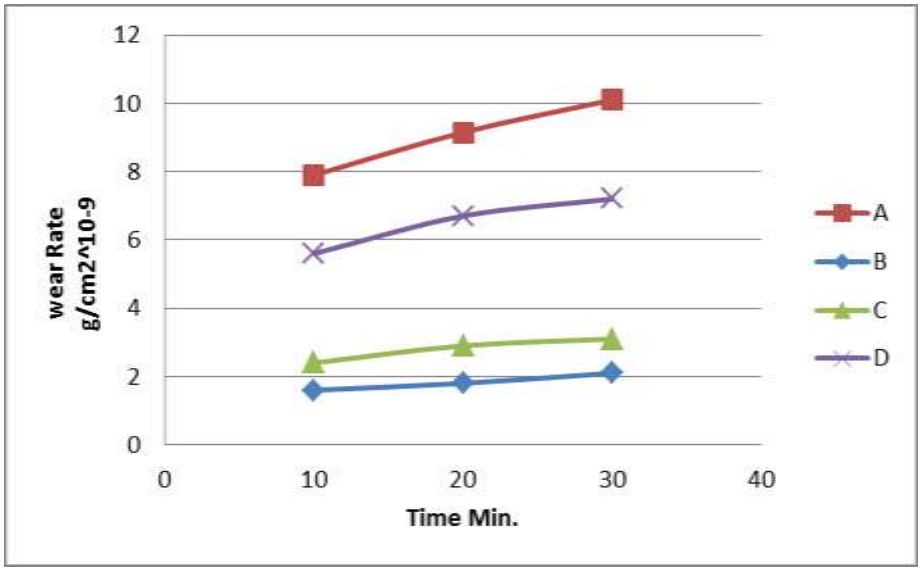

Fig.(3) Relationship between Time and wear rate

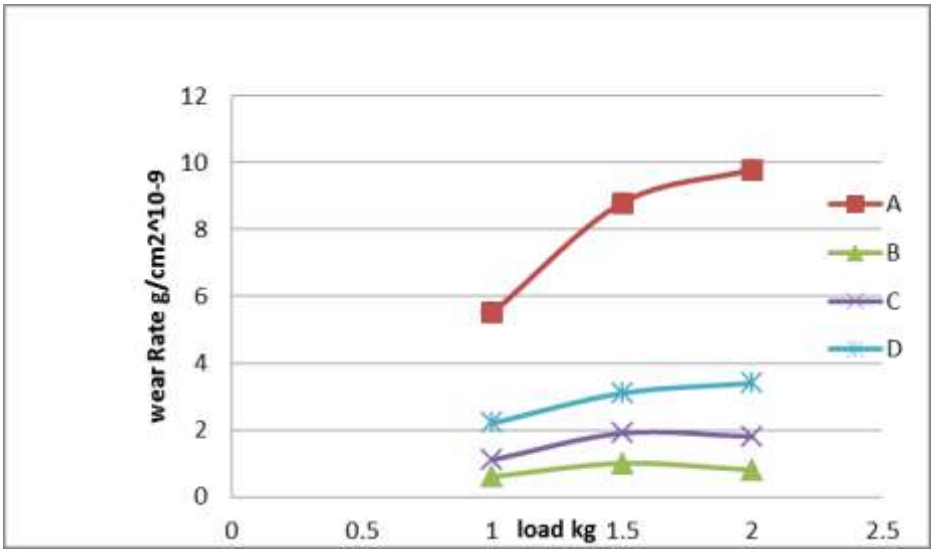

Fig.(4) Relationship between load and wear rate

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