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EFFECT OF SHOT PEENING TIME ON MECHANICAL PROPERTIES OF ALUMINUM ALLOYS AA2017-T4 AND AA6063-T5

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ABSTRACT:- The present work devote the effect of shot peening time on the mechanical properties for two aluminum alloys AA2017-T4 and AA6063-T5. The test carried out using standard tensile specimens under various shot peening times. The results showed that the increase in yield and tensile strength values. The maximum increasing at 15 minute for AA 2017-T4, and at 9 minute for AA 6063-T5. The maximum values of strain hardening factor (n) and strength factor (k) are recorded at 15 minute for AA 2017-T4 while recorded the maximum values of (n) at 24 minute and (k) at 9 minute for AA 6063-T5. The results showed that the percent elongation are increased to maximum value at 9 minute for AA 2017-T4 while the minimum value was at the same time for AA 6063-T5.
Keywords: Michanical, Aluminum alloys, AA2017-T4.

1. INTRODUCTION

It is well established that mechanical surface treatments, e.g. shot peening, deep rolling or laser shock peening are effective methods not only to enhance the fatigue resistance but also the wear and corrosion resistance of metallic materials(1). Shot peening is used on gear parts, cams and camshafts, clutch springs, coil springs, connecting rods, crankshafts, gearwheels, leaf and suspension springs, rock drills, and turbine blades. It is also used in foundries for sand removal, decoring, descaling, and surface finishing of castings such as engine blocks and heads. Its descaling action can be used in the manufacturing of steel products such as strip, plates, sheets, wire, and bar stock Shot peening is a conventional and widely applied method for introducing a layer of compressive surface residual stress. Shot peening can produce a large compressive stress magnitude at the surface (typically about 75%

of yield strength), and a moderate depth of compression (typically about 0.25 mm)(2,3)**.** Omar Hatamleh(4) , studies the effects of peening on mechanical properties in friction stir welded 2195 aluminum alloy joints, The results of an experimental study concerning the increase in mechanical properties from the laser peening was mainly attributed to the strain hardening which can be explained by the generation of dislocations under the effect of the plastic deformation from the high energy laser peening. Ali et al(5). measured the strain hardening as a function of depth from the surface on shot peened aluminium alloy friction stir welding (FSW) components. The results indicate an increase in hardness at the center of the weld, the thermo-mechanical affected zone (TMAZ), and the parent material. However the hardness depth did not exceed 0.4 mm from the surface. The strain hardening which can be explained by the generation of dislocations under the effect of the plastic deformation from peening, is likely to increase the flow resistance of the material to plastic deformation. Daniel Kottfer, Peter Mrva (6) studies the mechanical pretreatment of surface of aluminum alloy D16-T by shot peening. They concluded that the change in roughness of the shot peened surface is influenced by the size of the grain of the shot peening material, as size of diameter grows so does the roughness of the shot peened surface.

2. EXPERIMENTAL WORK

Two wrought aluminum alloys were chosen to conduct this research**.** The first alloy is AA 2017-T4 and the second alloy AA 6063-T5. The chemical compositions of the above alloys are tabulated in table (1) while the mechanical properties in table (2).

Tensile specimens manufacture according to the ASTM E8M(Figure 1)[9]. The specimens were grinding by emery papers ASTM grit 800,1000 and 1200.

Tensile tests were carried out by Gunt Universal testing machine type WP300. Tensile tests were done before and after shot peening at different times 3, 6, 9, 15 and 24 minute. Shot peened operation was carried out in a special device with a spherical steels ball with nominal diameter 0.5 mm, with average hardness of 52 HRC with the ball velocity of nearly 45 m/sec.

3. RESULTS AND DISCUSSION

The results of tensile tests for AA2017-T4 showed that the tensile strength (σ_u) and yield strength (σ_y) value increases up to 15 minutes and then reduction was observed in 24 minutes as compared with unpeened specimens. The increment of σ_u and σ_y about 7.9 % for σ_u and 13.8 % for σ_y. The elongation percentage increased up to 9 minutes and then decreased, (Figure2). The n is the strain-hardening exponent, and K is the strength coefficient. A log-log plot of true stress and true strain up to maximum load will result in a straight line.

The linear slope of this line is n, and K is the true stress at $\varepsilon = 1.0$. [10], (Figure 3). The strain hardening factor (n) was constant approximately (0.249) up to 9 minute and then increased up to 0.268 for 15 and 24 minutes. The strength factor (k) increased up to 15 minutes and then decreased for 24 minutes, (Figure 4). The improvement in the mechanical behaviour is derived from compressive residual stresses that are introduced into the near-surface of the components [11]. Surface integrity changes induced by shot peening mainly include work hardening due to the increase in the dislocation density, gives the surface layer higher ultimate, yield strength and hardness but lower ductility [12].

The results for AA6063-T5 showed that there is an increase in the value of σ_u and σ_y up to 9 minutes shooting and then declining, and the increase percentage was recorded for both σ_u, σ_y, which is about 9 % and 8 % respectively. The elongation percentage decreased up to 9 minutes and then increased for 15-24 minutes (Figure 5). The strain hardening factor (n) was constant (0.123) for all shooting times except 24 minutes it increased to 0.155, but the (k) factor increased up to 9 minutes and then decreased (Figure 6). It can noted that the increase in σ_u and σ_y for AA2017-T4 is more than for AA6063-T5, while showed the opposite in elongation percentage, whereas is not exceed to 23% for AA2017 –T4 whilst the decrease to 15% for AA6063-T5. The increasing in (n) value is given clearly indicated the AA2017 tend to hardening more than the unpeend state. It was observed that the surface roughness of AA 6063-T5 was higher than AA2017-T4. Which gives an indication that the alloy with less strength have higher roughness than the alloys with higher strength (Figure 7).

The alloy 6063-T5 recorded the highest value of surface roughness at the time 24 minutes which is about 350 %, but the increasing of roughness for 2017-T4 was about 180 %, in comparison with the unpeened specimens. It is now clear that the performance of controlled shot peening, depends on the balance between its beneficial compressive residual stress, strain hardening and detrimental effects surface roughness[13]. AA 6063 gave an indication that the marks of peen are more deeply than the AA 2017,(Fig. 7).

4. CONCLUSIONS

1. σ_u and σ_y increase with increasing shot time up to (15) and (9) minuets for the AA 2017-T4 and AA 6063-T5 respectively, then decrease.
2. The elongation of AA 2017-T4 increases up to 9 minute then decrease while the elongation percentage for AA 6063-T5 decrease up to 9 minute and the increase.
3. The increment of n and k factor was limited.
4. The increasing of roughness (Ra) is more for AA 6063-T5 than for AA 2017-T4 , in metal, the roughness in low strength is more than the high strength, this because the deformation at surface is very high for low strength .

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Table (1): Chemical composition of the two alloys (wt%).

Materials \ Elements		%Si	%Fe	%Cu	%Mn	%Mg	%Zn	%Cr	%Al
AA 2017-T4	Nominal[7]	0.2-0.8	0.7 max	3.5-4.5	0.4-1.0	0.4-0.8	0.25	0.1	Rem.
	Actual	0.4	0.55	4.1	0.716	0.65	0.055	0.028	Rem.
AA 6063-T5	Nominal[7]	0.2-0.6	0.35	0.1	0.1	0.45-0.9	0.1	0.1	Rem.
	Actual	0.45	0.22	0.02	0.019	0.78	0.057	-	Rem.

Table (2): Mechanical properties of the alloys.

Materials \ Properties		σ_u (MPa)	σ_y (MPa)	El %	HB	K (MPa)	n
AA 2017-T4	Nominal [8]	425	275	20	105	-	-
	Experimental	455	290	21	115	1025	0.23
AA 6063-T5	Nominal [8]	185	145	12	60	-	-
	Experimental	200	160	15	65	329	0.123

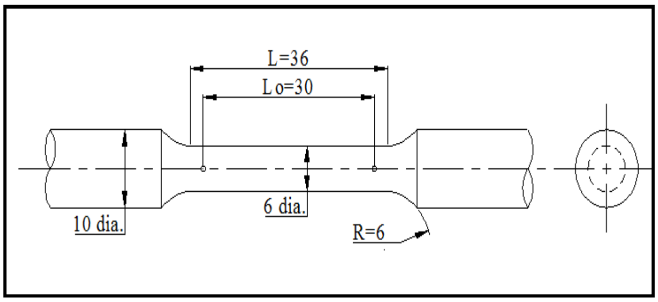

Fig (1): Specimen geometry and dimensions for tensile according to ASTM E8M (all dimensions in mm).

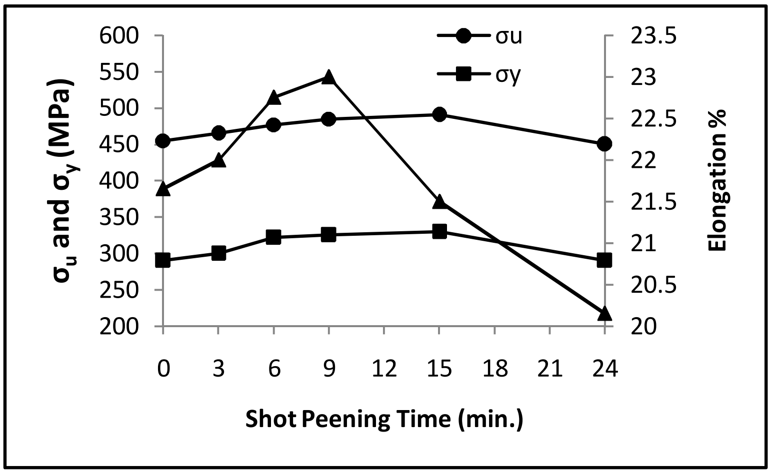

Fig. (2): Effect of shot peening times on the mechanical properties (σ_u, σ_y,) for AA 2017-T4.

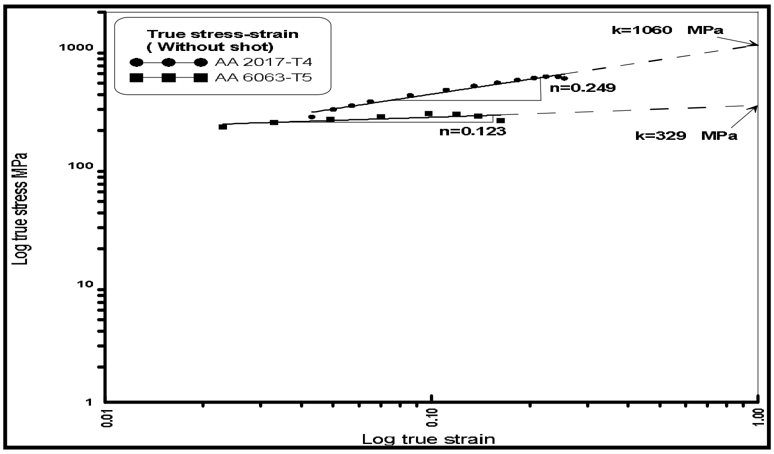

Fig. (3): Log-log plot of true stress-true strain curve of AA 2017-T4 and AA 6063-T5 (without shot).

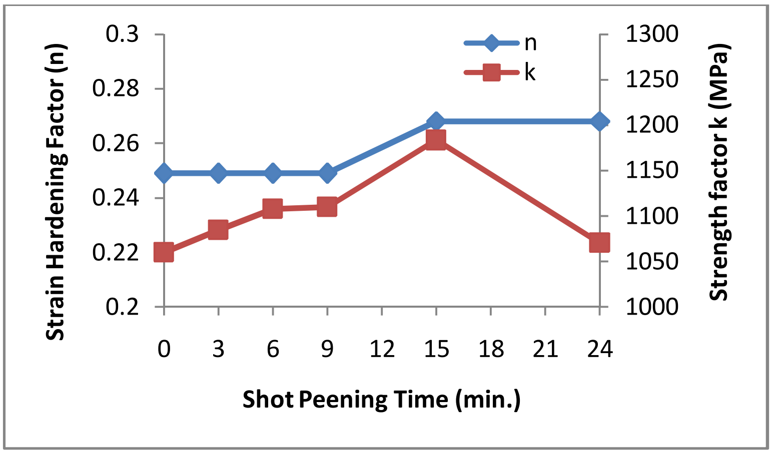

Fig.(4): Effect of shot peening times on strain hardening factor and strength factor for AA 2017-T4.

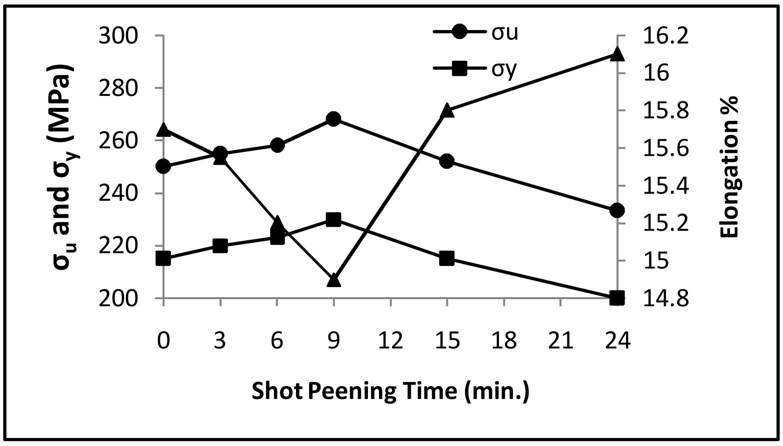

Fig.(5): Effect of shot peening times on the mechanical properties (σ_u, σ_y) for AA 6063-T5.

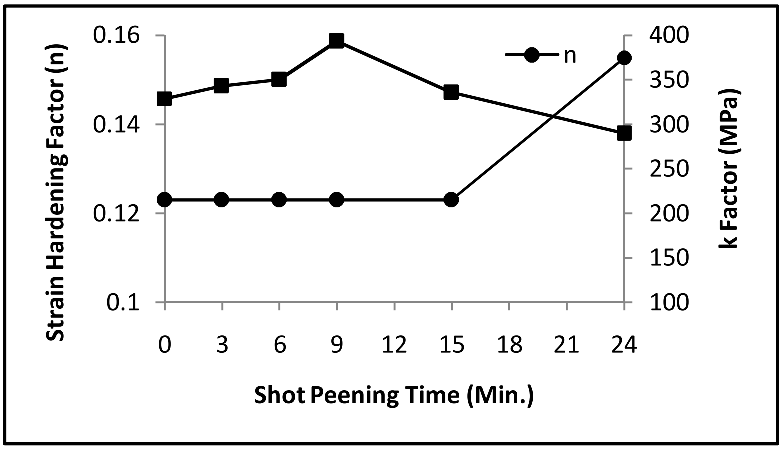

Fig.(6): Effect of shot peening times on strain hardening factor and strength factor for AA 6063-T5.

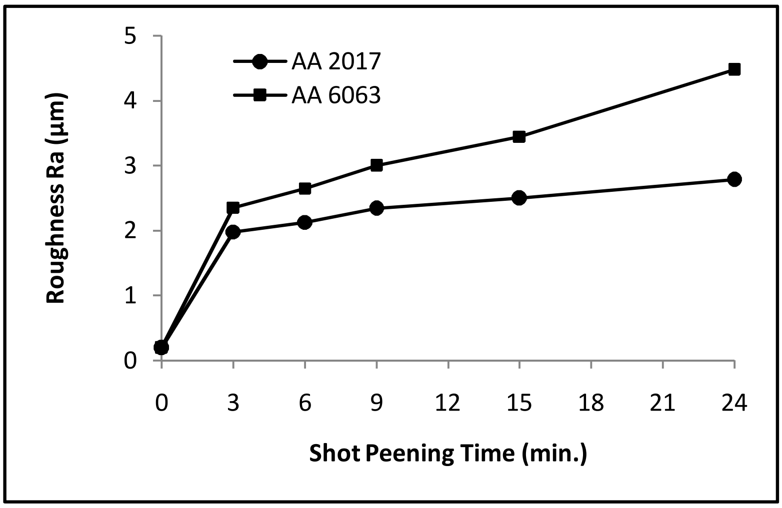

Fig.(7): Effect of shot peening times on the surface roughness Ra (µm).

تأثير زمن القصف بالكرات على الخواص الميكانيكية لسبائك الألمنيوم (AA2017-T4 & AA6063-T5)

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الخلاصة:

اشتمل البحث على بيان تأثير القصف بالكرات الفولاذية على الخواص الميكانيكية لنوعين من سبائك الألمنيوم (AA2017-T4) و (AA6063-T5). اجري الفحص على عينات شد قياسية تحت تأثير أزمان قصف مختلفة. أكدت النتائج زيادة في قيم مقاومة الخضوع ومقاومة الشد لتسجل أعلى زيادة عند زمن (١٥) دقيقة لسبيكة (AA2017-T4) و(٩) دقيقة لسبيكة (AA6063-T5)سُجلت أيضا أعلى قيم لمعامل الاصلاد الانفعالي (n) و معامل المتانة (k) عند زمن (١٥) دقيقة لسبيكة (AA2017-T4)بينما سُجلت أعلى قيمة (n) عند زمن (٢٤) دقيقة وقيمة (k) عند زمن (٩) دقيقة لسبيكة (AA6063-T5). أوضحت النتائج أيضا إن نسبة الاستطالة تزداد لتبلغ أعلى قيمة لها عند زمن (٩) دقيقة لسبيكة (AA2017-T4) بينما سجلت أدنى نسبة استطالة لسبيكة (AA6063-T5) عند ذات الزمن.