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Experimental Investigation of the Residual Stress and calculate Average Fatigue Life and Improved Resistance To Stress Corrosion Cracking on Aluminium Alloy 7075-T6 Plates by Using Various Shots through Shot Peening Process

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ABSTRACT: *Shot peening procedures developed over the ago in substantial improvements of fatigue properties and Fatigue life. The use of shot peening on aluminium 7075-T6 plates to improve fatigue properties and improve resistance to stress on the corrosion cracking with help of glass beads and various peening methods. When these components subsequently are loaded in tension or bending to a stress level in the range below the required for yield, the actual tensile stress at the surface is lower than that calculated on the basis of load and cross sectional area. Fatigue are major problem which normally start at or near the surface stressed in tension, thus processes that produce residual surface compressive stresses in components usually enhance the resistance to fatigue. The impact of glass shots which create resistance after the shot penning process carried out and also control the effects of failure on aluminium alloys*
Keywords: *fatigue properties, fatigue life, residual stresses, shot peening, aluminium alloys, aluminium*

I. INTRODUCTION

Benefits obtained due to cold working include work hardening and Peening having a larger shots which gives maximum compressive stress layer depends on the material surface which enhances ultimate strength and improved fatigue life. Both compressive stresses and cold worked effects are used in the application of shot peening in forming metal parts. The beneficial effects of shot peening are attributed primarily to the presence of residual compressive stresses at or near the surface. These compressive stresses can be very effective in prolonging fatigue life and in minimizing corrosion failures. Their effectiveness can be impaired considerably by (a) exposure to temperatures at which significant stress &relaxation can occur. (b) Fatigue cycling at R values minimum stress/maximum stress ratio approaching where the residual stress pattern tends to fade with increasing number of cycles, or (c) exposure to environments that chemically attack the surface, thereby changing the residual stress pattern in the surface of the materials.

II. SHOT PEENING EQUIPMENT

In commercial shot peening equipment, the shot is propelled by a high- pressure air stream in a nozzle or by a high speed rotating wheel. Factors that control the peening intensity are

1) Air pressure at the node or wheel speed
2) Distance of nozzle or wheel from the surfaces being peened
3) Angle between the shot path and the surface being peened
4) Rate of feed of shot to the nozzle or wheel
5) Type and size of shot or beads.
6) Time of exposure to the shot stream

Equipment of relatively small size may have one wheel or one nozzle, with some provision for moving the component in the shot stream or moving the nozzle to get uniform peening coverage of the component. Larger equipment may have multiple nozzle arrangements, with a mechanism for moving the components through the area subjected to the shot streams at a controlled speed to obtain the desired peening coverage. Shot peening with metallic shot is always performed in the dry condition, but for some glass bead peening of non-rusting materials the glass beads may be in a water slurry. The slurry is metered to a high pressure air nozzle which produces the blasting effects.

III. METHODS OF SHOT PEENING

Conventional (Mechanical) Shot Peening

Conventional shot peening is done by two methods. The First Method involves accelerating shot material with compressed air. Shot is introduced into a high velocity air stream that accelerates maximum of speeds up to 250 ft/s. The second method involves accelerating the shot with a wheel. The shot gets dropped onto the middle surface of the wheel and then it accelerates to the outer edge where it leaves on a tangential path.

Dual Peening

Dual peening further enhances the fatigue performance from a single shot peen operation by re-peening the same surface a second time which gives maximum coverage has been achieved and also its increasing the compressive stress at the outer surface of the compressive layer

Strain Peening

The Dual Peening increases compressive stress at the outer surface of the layer, whereas the strain peening increases the compressive stress over the entire compressive layer. This additional stress is created by preloading the part within its elastic limit prior to shot peening. When the peening media impacts the surface, layer which yields further in tension because of the preloading. This results in additional compressive stress when the metal's surface attempts to restore itself.

Laser-shot Peening

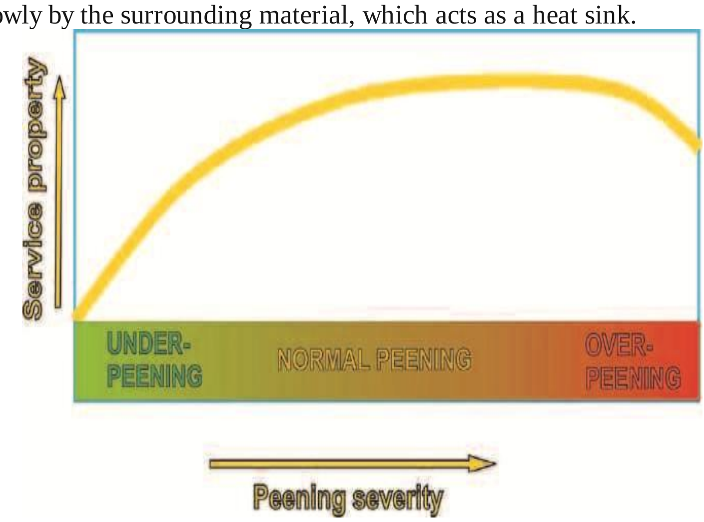
Laser shot peening, or laser shock peening (LSP), is the process of hardening or peening metal using a powerful laser. Laser peening can impart a layer of residual compressive stress on a surface that is four times deeper than that attainable from conventional shot peening treatments.

IV. TYPES OF SHOTS USED

Shot for peening is usually chilled can iron, cart steel, pure nickel shots, high chrome nickel balls, cut wire, or glass beads etc.. In our paper we used glass beads as 0.018-inch diameter were used in peening, and chilled iron shot sizes. Basically Glass beads for peening are designated by nominal Screen size or diameter and also low cost for application. For special peening applications, malleable iron or non-ferrous shot of various composition like stainless steel and aluminum are used.

V. IMPACT OF SHOT PEENING EFFECTS

Each shot particle impacting a component's surface has a kinetic energy, 1⁄2mv2. Approximately half of this energy is transferred to the surface. Ninety percent of that transferred energy is converted into heat and 10% into the stored energy of cold work. It follows that we can think of the effect as that of a miniature thermal bomb. The plastic deformation creating a dimple occurs in a few millionths' of a second. Heat is generated around the dimple simultaneously being caused by the plastic deformation. This adiabatic heating is absorbed relatively slowly by the surrounding material, which acts as a heat sink.



The maximum temperature in the heated zone will be at the surface and will be affected by multiple impacts which impart additive heat inputs. It is suggested that the temperature rise very near to the peened surface will be sufficient to cause a significant degree of stress-relief.

VI. STRUCTURAL CHANGES

Most metallic engineering components have a relatively-ductile matrix embedded with a variety of hard, relatively-brittle, strengthening, phases. Plastic strain on peening is then concentrated in the matrix. Some 90% of the energy absorbed from impacting shot particles is converted into heat energy. The remaining 10% is largely used to produce a vast increase in the dislocation population. This increase is from about 10^6 to about 10^{10} (ten billion) dislocation lines per square millimeter. Such an increase and such numbers are difficult to visualize. On a scale of a square micrometer the increase is by a factor of 1 to 10,000. This scale is used where in (a) there is just one dislocation (represented as a single dot) whereas in (b) there are 10,000.

The dislocation distribution is extremely non-uniform. High-strain deformation has generated a sub-grain structure. This is a characteristic feature of heavily worked metals. Peening changes the structure for each crystal from one of relative perfection to one where we have a 'mashed up' structure - regions of intense dislocation content (sub-grain boundaries) surrounding regions of merely high dislocation content (sub-grains). When plastic strain has induced maximum hardening the sub-grain size has reached its minimum. The dislocation density in the sub- grain boundaries is then so high that they are semi-amorphous. Further plastic strain does not thereafter increase the dislocation content. We have a situation, because peening is an intermittent process, where impact generated heat is softening some regions and hardening is occurring in other regions. These mechanisms balance to give a maximum average hardness.

VII. SHOT PEENING FOR IMPROVED FATIGUE RESISTANCE

The most effective improvement in fatigue resistance by shot peening is achieved in components that are subjected to tension-tension loading in service.

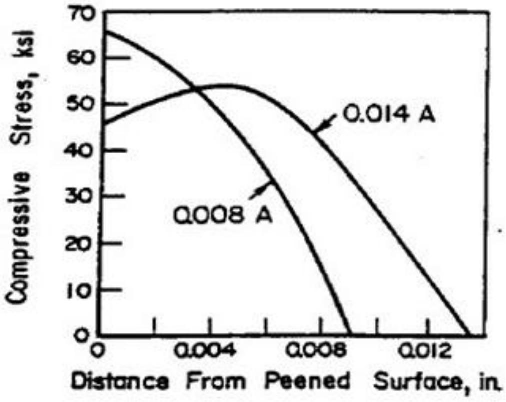
The improvement in fatigue resistance that peening provided made it feasible to use in application. Even though shot peening has effective in minimizing fatigue failures in many structural components, it is not necessary a cure for all structures that are subjected to fatigue failure. When such failure is observed in a components a complete review of the materials selection, processing specification, stress analysis, fracture appearance, metallographic structure, and components history should be considered in deciding what to do to the minimize the problem in future components of the same type.

If shot peening is recommended as a preventive measure to minimize further problems with fatigue failure, a testing program should be conducted to verify statistically the improvement in fatigue life that may be expected from the peening operation.

Because of the residual stresses produced by shot peening, yield strength of peened tensile specimen usually are lower than those of corresponding unpeened specimens. This occurs because bulk of the material in a peened tensile specimen at greater than 0.015 inch and the combination of tensile stress in the bulk with residual compressive stress in material near the surface, results in a low elastic modulus and yielding at gross stresses that are lower than those for unpeened specimens. The effect of the surface compressive stress is retained until general yielding occurs across the test section as the results of the tensile load. Beyond this point, results of the tensile test are the same as those for an unpeened specimen. The ultimate tensile strength of peened and unpeened specimens of the same material are the same.

VIII. SHOT PEENING ON ALUMINIUM ALLOYS

Peening of aluminum alloys for improved fatigue resistance is usually limited to the high –strength alloys that are used most often in aerospace application. Weight must be kept to a minimum in these application and service stresses are relatively high. The residual stress pattern near the surfaces of these specimens is shown in figures 3 for the curved marked 0.008A. Compressive residual stresses occur from the surface to a depth of about 0.009 inch. Longer peening to an intensity of 0.014 produces compressive stresses to a greater depth, about 0.013 inch. Beyond this depth, the residual stresses are in tension to compensate for the residual stresses are in tension to compensate for the residual compressive stresses near the surface. To avoid distortion of peened components, and particularly for components of sheet metal, if the edges are not peened, the surface, the surface residual stresses there will be in tension. Fatigue cracks will then start at the edges, if the service stresses are uniform across the stressed are of the component.



The test sections of the specimens were hand polished in the longitudinal direction with 180- grit emery paper, shot peened and subjected to axial fatigue loading.

Glass shot of 0.01Binch diameter also were used in peening additional specimen to intensities equivalent to 0.0035 and 0.0040 inch on the aluminum strips. An Almen gage war used in measuring curvature of the aluminum strips. Residual stress measurements were made on aluminum strips representing each peening condition. The fatigue - specimens were subjected to axial tensile loading at R = 0.1. Tests were made at maximum stress levels of both 55,000 and 70.000 pi. Cycling rate was 1800 cycles per minute. Average fatigue data for quadruplicate specimens peened with glass shots are shown in Table.

Data in the table show comparisons between intensity value for peened aluminum strips and the standard Amen Type A values. The data also show that the compressive surface stress and the maximum compressive stress in the peened layer near the surface increase as the peening intensity increases within the limits of these experiments. Results of the short-cycle fatigue tests indicate that the preferred shot size is P23 for 7075-T6 aluminum alloy at an intensity of 0.0124A. However, other combination of shot size and intensity develop nearly the same results for the fatigue tests.

TABLE 1: RESIDUAL STRESSES DATA AND AVERAGE FATIGUE LIFE FOR AXIALLY STRESSED SPECIMENS OF7075-T6 ALUMINIUM ALLOY

Parameter	Calculated Intensity		Residual Stresses From Peening			Average Fatigue Life, When Maximum Stress Is	
Shot	Aluminium Strip Intensity	Almen A Strip Intensity	Surface Stress Ksi	Maximum Stress Ksi	Maximum Stress Depth,In.	55,000 Psi, 10^3 Cycles	70,000 Psi, 10^3 Cycles
Glass	0.0035	0.008	--	--	--	99	43
Glass	0.0040	0.010	--	--	--	107	16
Glass	0.0040	0.010	-44.5	-56.4	0.0115	143	39
P23	0.0035	0.0085	-48.4	-62.5	0.004	165	55
P23	0.005	0.012	-59.8	-73.0	0.004	185	64
P55	0.0035	0.009	-49.8	-59.3	0.0055	150	68
P55	0.0055	0.015	-52.5	-74.5	0.0080	171	48
P55	0.0070	0.019	-64.4	-81.0	0.0105	179	43
P93	0.0035	0.005	-36.5	-58.5	0.008	170	47
P93	0.0055	0.0085	-54.4	-62.8	0.010	175	44
P93	0.0070	0.009	-62.7	-82.9	0.0085	141	35

The data for glass bead peening in Table, indicate that equivalent peening intensity with glass beads does not develop the same fatigue life as does peening others like chilled iron shot (P23,P55,P93).The various diameter of shot sizes used in chilled which are p23as 0.023 diameter and p55 as 0.055 diameter and p93 as 0.093 diameter used.

IX. Peening For Improved Resistance To Stress Corrosion Cracking On Aluminium Alloy

Stress corrosion tests have been conducted on specimen of aluminium alloys to determine the effect of shot peening. Ring type specimens were used of 7075-T6 alloy for these tests. Iron contamination is removed from peened aluminium alloy components by immersion in a 25 percent solution of nitric acid for about 25 minutes.

After rinsed, the peened surface are checked by means of a potassium ferrocyanide solution to insure the iron contamination has been removed.

Peening had a greater affect in retarding or preventing fracture of specimens in less severe environments. Examination of failed specimens indicated that attack of the peened surface occurs by pitting.as soon as the peened layer is penetrated, intergranular attack can occur, causing cracks and final failure.

Peening can be effective in reducing initiation of stress corrosion cracking only (1) if all exposed surfaces subjected to tensile stresses are peened and (2) the peened surface layer remains intact so the corroding media do not come in contact with the layers that are under tensile stresses. Various processing alternatives were considered to overcome the problem of stress corrosion cracking in aircraft structural forgings of 7075-T6 components. Localized areas of residual tensile stress in the machined components are a major contributor to the tendency for stress corrosion cracking of these components. Residual tensile stresses occur as a result of removal by machining of the surface layers which may have been in compression after heat treating. Distortion may result if the stresses are of sufficient magnitude. Straightening after machining increases the localized residual tensile stresses.

In addition, machining of the forgings may expose areas of short-transverse end grain, which are more susceptible to stress corrosion cracking than the other surface areas in a machined forging. Changing the design to avoid end grain exposure on machining is one alternative. But the cited references indicate that shot peening of these surfaces and all other surfaces of the machined forgings also will improve the stress corrosion resistance.

Experience gained with high-strength aluminum alloy forgings has indicated that shot peening without first establishing the most desirable peening conditions and without the required controls will not necessarily lead to improved stress-corrosion resistance. When peening aluminum forgings, use of the largest shot size and greater intensity that will not produce distortion is usually recommended. Table 2.explains the Typical shot sizes and intensities are as follows

Sections	Intensity	Shot Sizes
Sections 0.150 Inch And Over	0.010A - 0.014 A	0.025,0.028
Sections Under 0.150 Inch	0.006A - 0.0010A	0.017,0.019
Holes	0.003A - 0.005A	0.011,0.013

Surface roughness tolerances also should be considered when selecting shot sizes. The cited reference also indicates that all aluminum alloy components peened with metallic shot should be cleaned after peening by immersion in a nitric acid solution or by additional peening with glass beads. After cleaning, the forgings should be coated with a special oil supplied for this purpose until they are further protected by anodizing and painting.

X. PEENING FOR IMPROVED RESISTANCE TO STRESS CORROSION CRACKING IN 7075 –T6 ALUMINIUM ALLOYS

Table 3. Results Of Stress Corrosion Tests On Specimens Of 7075-T6 Aluminium Alloy With Glass Beads

Peening Methods	Peening Variables		Hours To Failures
	Intensity	Shot Or Beads Sizes	
Glass Beads Peening	0.003 To 0.005a	0.013	195.1 223.2 224.3
	0.006 TO 0.008 N	0.002 To 0.004	197.8 245.2 275.3
Shot Peening	0.003 TO 0.005A	110	139.8 180.7 192.8
	0.003 TO 0.005A Plus Glass Beads Cleaning	110	274.5 649.5 129.4
Control Penning	As Drilled And Reamed		219.4 219.4

Stress corrosion cracking trend to start at faster holes certain aluminium alloy components, since the holes usually represent stress raisers. Furthermore, the corroding medium tends to be retained around the fasteners. The stress corrosion can be reduced by shot peening in the holes but it is not always convenient to do this, for example, when the holes must be drilled and reamed during aircraft assembly.

A special tools was created and it moved axially through the hole, the hole, the steel balls are forced against the holes surface by a revolving hammer. To evaluate this effect, the specimens were peened on all surface with 280 shot too an intensity of 0.010 to 0.012A.they were then loaded in a testing fixture to a stress of 38,000psi (65%of yield strength) and subjected of yield strength1 and subjected to alternate immersion in a 3.5 percent solution of sodium chloride (10 minutes in and 50 minutes out of the solution per cycle). Results of these stress corrosion tests are presented in the table. Examination of control specimens (as drilled and reamed) indicated that the reaming process also developed residual compressive stresses in the holes. This account for the fact that the control specimens survived longer than some of the peened specimens. However results of this tests indicate equivalent effect of shot peening or glass bead peening reduce the stress corrosion cracking.

XI. CONCLUSION

Each shot materials is recommended for specific applications, the shots must be created a maximum stress to the materials which increase maximum of fatigue life to the material by using shot peening process. Glass beads peening also increase the endurance limit up to 30 percentage. Peening had a greater effect in retarding or preventing fracture of specimens in severe environments also peening had the benefits of protecting the materials from various efforts and also improved resistance to stress corrosion cracking

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