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Surface Properties of Material after Shot Peening Treatment

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Abstract- Shot peening is a method widely used to improve mechanical properties of materials. The improvement in mechanical properties such as surface hardness, fatigue strength, tensile strength, damping etc. are due to the induction of compressive residual stress in the metal parts. The residual compressive stress induced by shot peening is the function of material and mechanical conditions. Its beneficial effects are mainly due to the residual stress field caused by the plastic deformation of the surface layer of material resulting from multiple impacts of the shot, although strain hardening and grain distortion caused by the multiple impacts of the shot also play a role in the modified mechanical behaviour of the peened components. Due to several advantages shot peening has been in the focus of research persons for the purpose of increasing the properties of the materials. In the present paper, a review study has been done on the shot peening effects on different materials. This review will help the researchers and readers to better understand the several benefits and applications of shot peening. The present review of shot peening process is focused on the latest development and pushes the readers towards the on-going research in this classic process. The authors have not come across any such type of review which focuses mainly on shot peening process.

Keywords: Shot Peening, Compressive Residual Stress, Peening Intensity, Almen Strip

INTRODUCTION

Shot-peening is a cold-working process used mainly to improve the fatigue life of metallic components . It is used to set up residual compressive stresses in the materials and these residual stresses remains in the material whether a load acting on the body or not. The residual compressive stress induced by shot peening is the function of material and mechanical conditions. Shot peening process is impacting a surface with shot (round metallic cast steel, glass, ceramic particles) with force sufficient to create plastic deformation. It operates by the mechanism of plasticity, each particle functions as a ball-peen hammer. The magnitude of the compressive stress induced and the depth of the induced layer depend considerably on the peening intensity. Peening intensity can be defined as a measure of the kinetic energy within a stream of peening media (shot).

LITERATURE SURVEY

Mehmood and Hammouda[1] carried out experimental study of the effect of shot peening parameters such as shot size, nozzle pressure, nozzle distance, impingement angle and exposure time on high strength aluminium alloy ASTM 2024 to determineAlmen intensity. He examined the effect of peening parameters on the Almen strip.

H.Y. Miao [2] experimentally studied the quantitative relationships between the saturation, surface coverage and roughness with respect to peening time based on aluminum Al2024 test strips. He found that compressive residual stresses have beneficial effect for the improvement of the fatigue life of the peened component.

Jiang X.P. [3] carried out the study of the effects of shot-peening and re-shot-peening on the profile of surface residual stress and the four-point bend fatigue behavior of Ti–6Al–4V (wt.%).

Aggarwal M.L. et al, [4] conducted the study to see the effects of shot peening on Nitrogen austenitic stainless steel and concluded that Shot peening of nitrogen austenitic stainless steel increases its hardness. The hardness can be controlled by adjusting the intensity of the shot peening.

METHODOLOGY

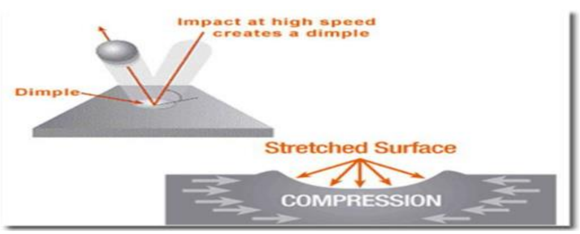

fig. 1.1 Shot peening process

Shot peening is a cold working process in which the surface of a part is bombarded with small spherical media called shot. Each piece of shot striking the metal acts as a tiny peening hammer, imparting a small indentation or dimple on the surface. In orderfor the dimple to be created, the surface layer of the metal must yield in tension. The non-yield layer will meet the dimple and resist the stretching deformation and thereby created residual compressive stress around the dimple. Overlapping dimple from multiple shot impact developed a uniform layer of compressive stress. The compressive layer squeezes the grain boundaries of the surface material together and significantly delays the initiation of fatigue cracking. As a result, the fatigue life of the part can be greatly increased.

Methods of shot peening treatment

Conventional shot peening process:

Conventional shot peening is done by two methods. Method one involves accelerating shot material with compressed air and another is accelerating the shot with wheel

1. Wheel method :

In the wheel method, shot is propelled by a bladed wheel that uses a combination of radial and tangential forces to impart the necessary peening velocity to the shot. The position on the wheel from which the spot is projected is controlled to concentrate the peening blast in the desired direction. Among the advantages of the wheel method of propulsion are easy control of shot velocity when equipped with a variable-speed drive, high production capacity, lower power consumption, and freedom from the moisture problem encountered with compressed air.

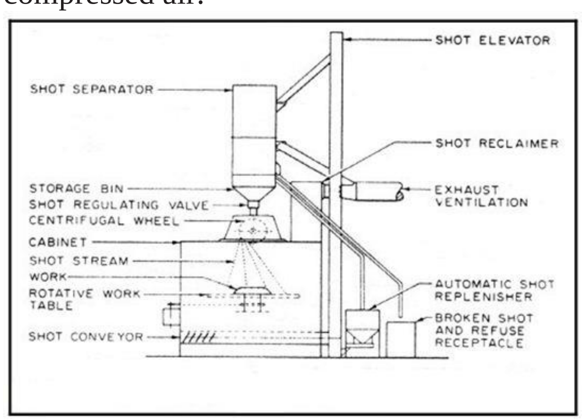

Fig.2 Accelerating the shot with wheel method

2 Compressed air method:

The air blast method introduces the shot, either by gravity or by direct pressure, into a stream of compressed air directed through a nozzle onto the work to be peened. Aside from being more economical for limited production quantities, the air blast method can develop higher intensities with small shot sizes, permits the peening of deep holes and cavities by using a long nozzle, consumes less shot in peening small areas on intricate parts, and has lower initial cost, especially when a source of compressed air is already available. In the late 1970s, another peening method was developed that uses gravitational force to propel the shot. Kinetic energy of the peening media is closely controlled by requiring the media to pass through a labyrinth before falling on the substrate from specified heights. Utilizing 1 to 2 mm (0.04 to 0.08 in.) hardened and polished steel balls as a peening media, surface finishes of less than 0.38 μm (15 μm.) are obtained while peening in the range of 0.23 to 0.38 mm (0.009 to 0.010 in.)Almen N shot peening intensities. Gravity peening has the drawback of requiring much more time for saturation, due to much lower impact velocities and greater shot.

Dual shot peening:

Dual peening further enhances the fatigue performance from a single shot peen operation by re-peening the same surface a second time with smaller shot and lower intensity. Large shot leaves small peaks and valleys in the material surface even after 100% coverage has been achieved. Peening the surface a second time drives the peaks into the valleys, further increasing the compressive stress at the surface.

Laser shot peening:

Laser-shot peening utilizes shock waves to induce residual compressive stress. The primary benefit of the process is a very deep compressive layer with minimalcold working. Layer depths up to 0.40" on carburized steel and 0.100" on aluminium alloys have been achieved. Mechanical peening methods can only produce 35% of these depths.

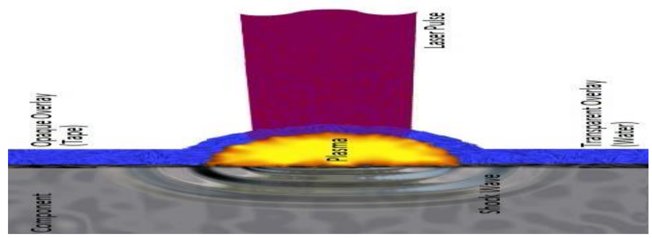

fig 4 Laser shot peening method

CASE STUDY

Experimental procedure:

The material used in this work was SAE 9245**s**teel. The chemical compositions of the steel are given in Table 1. Samples for fatigue tests were machined from bars of 10-mm diameter in the as-rolled condition. The dimension of the fatigue sample is given in Fig. The machined specimens of SAE 9245 were heated up to850 jC and held at that temperature for 20 min to transform microstructure completely to austenite. Austenitization was carried out in a flowing argonatmosphere.

Table no. 1 :Chemical compositions of material

Material	Chemical compositions (wt %)			
	C	Si	Mn	P
SAE 9245	0.40	1.50	0.50	0.050
	0.49	1.80	0.80	Maximum

fatigue strength occurs at a shot peening intensity in the range 20–25 A.

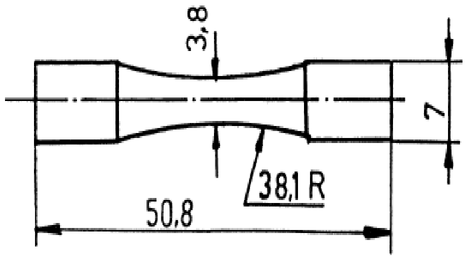

fig 5 dimension of fatigue sample

To see the effect of peening intensity on the fatigue strength, fatigue specimens were peened at various air pressures and peening times corresponding to 10, 15,20, 25 and 30 A. More detail of peening intensity and Almen test strips has been given elsewhere. The peening parameters used in this study are given in table .The procedure for measuring peening intensity is as follows. An unpeened Almen strip is fastened to a steel block and exposed to a stream of shot for a given period of time and air pressure. After removal from the steel block, the peened surface of the strip curves in a convex manner. The height of this curvature gives the shot peening intensity. The intensity designation should include both the arc height and the type of Al men strip used, e.g. 10 A intensity shows that arc height is 0.010 in. and the strip used is A. Fatigue tests were carried out in a Wohler type rotating bending fatigue testing machine at a frequency of 1400 cycles/min. S–N curves were established for unpeened and peened conditions. Fatigue limit was taken as that stress value at which the sample endured at least 3.106 cycles. Three tests were carried out at each stress level and the results reported are an average of the three tests.

Table no. 2Shot peening parameters

Materia	Shot size (mm)	Air pressure (psi) Air pressure (psi)	Peening time (sec)	Peening intensity (Almen A)
SAE9245	S230 (0.58 mm)	30	30	10
		30	30	15
		45	30	20
		60	45	25
		60	60	30

Experimental procedure and discussion:
Results of the rotating bending fatigue S–N curves for SAE 9245 steel are shown in Fig. S–N curves were determined for samples shot peened using size S 230 shot at the intensity of 25 A and 100% coverage. Fatigue results of un peened specimens were also included as a base line to compare with the shot peened data. The arrows in the figure represent the samples that did not break during the tests. It can be easily seen from this figure that shot peening improved fatigue life by 30%, compared with unpeened specimens. The effectiveness of shot peening depends in large measure on various factors including work piece material, shot material, shot size, shot hardness, type of peening machine, time of peening and peening intensity. Except peeningm intensity ,other factors have been extensively investigatedand optimized for various materials. In the present study, the effect of peening intensity on the fatigue strength has been observed. To determine optimum peening intensity, fatigue specimens were shot peened at various air

pressures and peening times corresponding to 10, 15, 20, 25 and 30 A .The results are shown in Fig.. Fatigue strength increased from approximately 370 MPa forunpeened specimens to a maximum of approximately 480 Mpafor the specimens peened to 25 A. As can be seen from Fig. the maximum fatigue strength occurs at a shot peening intensity in the range 20–25 A.

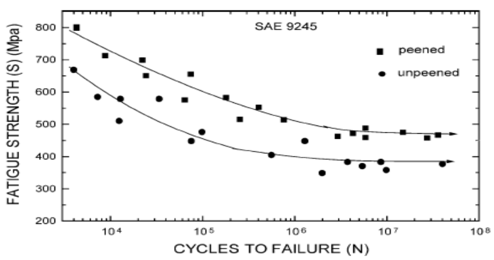

fig. 4.2 S-N curve for shot peened and unpeenedspecimen

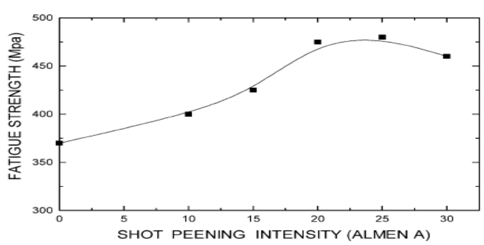

fig 4.3 effect of peening intensity on fatigue strength

SHOT PEENING SPECIFICATION

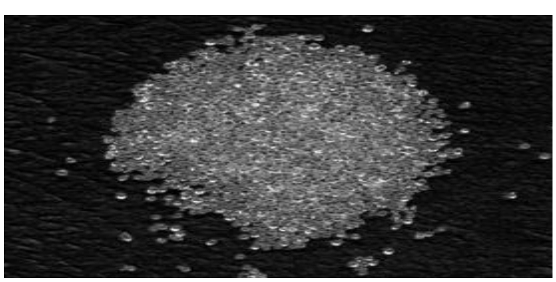

Fig. 5.1 Glass and ceramic beads

ceramic shot may be used instead of glass bead due to the fact that it is harder, allowing for significantly greater reuse. Ceramic bead is frequently classified by the minimum diameter in microns, thus AZB-150 indicates that the smallest size bead is 150 microns in diameter. The size range allowed extends up to the next largest size classification.

Cut wire shot is often preferred over steel shot due to the fact that it lasts longer, generates less dust, and has a greater uniformity in size. It is made by taking wire of the desired type and cutting it in lengths that are approximately equal to the wire diameter. Cut wire shot can be bought as-is (with sharp edges), conditioned (rounded edges), and special conditioned (nearly spherical). It is also possible to get cut wire shot made from different metals such as zinc or copper. Cut wire shot is designated by the diameter of the wire used in thousandths of an inch. Thus CW-47 represents shot made from a wire that was 0.047" in diameter

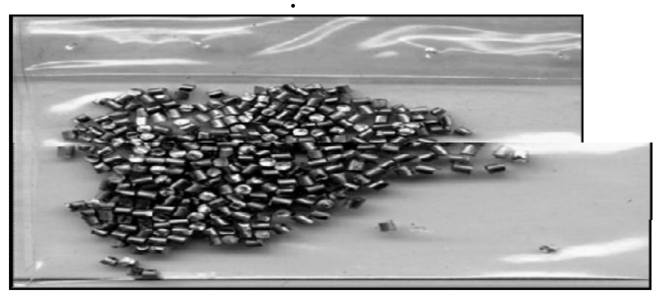

fig.5.2 cut wire shot

ADVANTAGES

1) Enhances fatigue strength
2) Improves ultimate strength
3) Prevents cracking due to wear
4) Prevents hydrogen embrittlement
5) Prevents corrosion
6) Prevents galling
7) Prevents fretting
8) Can increase gear life, pinion life, spring life and crankshaft life

9) Can permit the use of very hard steels by reducing brittleness
10) Possible to increase the fatigue strength of damaged parts extending the wear
11) Increases lubricity by creating small pores in which lubricants can accumulate
12) Substitution of lighter materials can be possible without sacrificing strength and durability

CONCLUSION

In modern manufacturing technology lots of surface treatments are used. There are various methods available for reliving stresses but shotpeening is much effective than any other process .Many industries adopting shot peening techniques for increasing the fatigue life of components. The shot peening treatment is apply after the machining like grinding, welding, etc. it will increases the properties like fatigue strength, ultimate strength, prevent corrosion, etc. and thus life of component increases.

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