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Shot Peening Process

T.V.Chavhan[1], A.H.Karwande[2]

[1]TE Student, Mechanical, SND COE & RC, Yeola , Maharashtra, India
[2]Asst.Prof. Mechanical, SND COE & RC, Yeola , Maharashtra, India

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Abstract- Controlled shot-peening is a process which is used largely in a manufacture of mechanical parts. It should not be confused with sand blasting used in cleaning or descaling parts. Shot-peening is in fact a true machining operation which helps increase fatigue and stress corrosion resistance by creating beneficial residual surface stresses. A technique consists of propelling at high speed small beads of steel, cast iron. Glass or cut wire against the part to be treated. The size of the beads can vary from 0.1 to 1.3 or even 2mm. A shot is blasted under conditions which must be totally controlled. A main advantage of this particular surface treatment is that it increases considerably a fatigue life of mechanical parts subjected to dynamic stresses. It has many uses in industry, particularly in the manufacture of parts as different as helical springs, rockers, welded joints, aircraft parts, transmission shafts, torsion bars, etc.

At an time when a optimum characteristics is being demanded of mechanical assemblies, shot-peening is the surface treatment method which is being increasingly chosen by engineers. However, shot-peening technology is yet to be fully perfected and a substantial changes produced in a treated material make it difficult at a present time to put a best conditions into practical use.

1. INTRODUCTION

This SHOT PEENING is the method of cold working in which compressive stresses is induced in a exposed surface layers of metallic parts by a impingement of the stream of shot, directed at a metal surface at high velocity under controlled conditions.It differs from blast cleaning in primary purpose and in the extent to which it is controlled to yield accurate and reproducible results. Although shot peening cleans a surface being peened, this function is incidental.The major purpose of shot peening is to increase fatigue strength. A process has other useful applications,such as relieving tensile stresses that contribute to stress-corrosion cracking,forming and straightening of metal parts, and testing a adhesion of silver plateon steel.

1.1WHAT IS SHOT PEENING?

Shot peening is the cold working process in which a surface of a part is bombarded with small spherical media called shot. Each piece of shot striking a metal acts as the tiny peening hammer, imparting the small indentation or dimple on a surface. In order for a dimple to be created, a surface layer of the metal must yield in tension (Figure 1). Below a surface, the compressed grains try to restore the surface to it original shape, producing the hemisphere of cold-worked metal highly stressed in compression (Figure 1).Overlapping Dimples develop the uniform layer of residual compressive stress

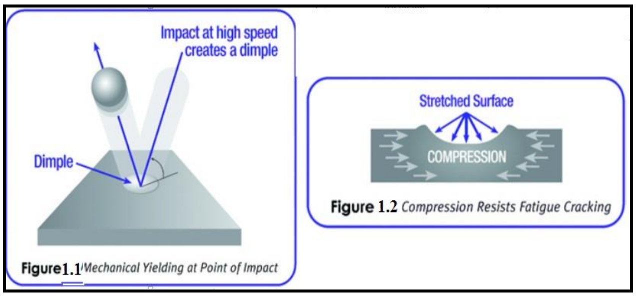

Figure1.1 Mechanical Yielding at Point of Impact
Figure 1.2 Compression Resists Fatigue Cracking

Fig.1. Peenig Action

1.2 WHY SHOT PEEN?

A atoms in a surface of a piece of manufactured metal will be under (mostly) tensile stresses left over from grinding, welds, heat treatments and other stressful production operation. Cracks promulgate easily in areas of tensile stress because a tensile stresses is already working to pull a atoms of the metal apart. By shot peening a material you introduce a layer of compressive stress by compacting a material. As a shot peening are performed, a atoms on a surface of a metal become crowded and try to restore a metal's original shape by pushing outward. A atoms deeper into a metal is pulled toward a surface by their bonds with a atoms in a compressive layer. These deeper atoms resist the outward pull creating internal tensile stress that keep the part in equilibrium with the compressive stress on a surface.

2. METHODS

2.1 CONVENTIONAL (MECHANICAL) SHOT PEENING

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

2.2 LASER-SHOT PEENING

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

2.3 DUAL PEENING

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

2.4 STRAIN PEENING

Where dual peening increases the compressive stress on a outer surface of the compressive layer, strain peening develops the greater amount of compressive stress throughout a entire compressive layer. This additional stress is generated by preloading a part within its elastic limit prior to shot peening. When a peening media impacts a surface, a surface layer is yielded further in tension because of a preloading. The additional yielding results in additional compressive stress when a metal's surface attempts to restore itself.

3. SHOT PINEENIG SPECIFICATION

3.1 PARAMETER SELECTION

A choice of shot peening parameters are dependent on the variety of conditions:

- knowledge of a application of a component
- component geometry
- manufacturing method
- mechanical properties of a base material
- strain sensitivity of a base material
- environment
- service conditions, loads and cycles

All the above must be considered when deciding on parameter selection and, equally important, maintained throughout a life of the product in the repeatable and consistent manner.

Following process controls is used and critical to maintaining process integrity:

- Media
- Intensity
- Coverage
- Equipment & Process Integrity

3.2 MEDIA: SHOT SHAPE AND SIZE

GLASS AND CERAMIC BEADS

Generally it are used for light peening applications. Glass bead sizes is usually specified by a letters AGB followed by the number that represents a mean diameter in microns divided by 10. Thus AGB-30 is on average 300 microns in diameter.

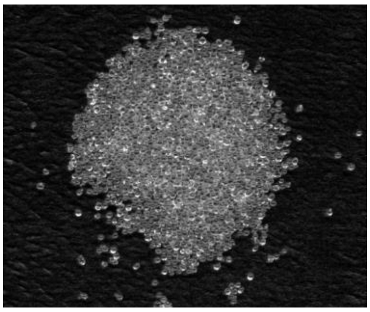

Fig.2.Glass and Ceramic Beads

CERAMIC SHOT

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

STEEL SHOT

It is a most common material used for shot peening. It can come in a variety of sizes and harnesses. Steel shot is classified by a size of the opening in a mesh that retains 80-85% of a shot. This value is given in ten thousandths of an inch. Thus for s-230 shot, the mesh that retains 85% has openings that is 0.0230" wide. Because of this, a average diameter of a shot is typically equal to one mesh size larger, *i.e.* s-230 shot has a mean diameter that are roughly 0.0280". Steel shot can have 4 different Rockwell C hardness classifications: S (40-51), M (47-56), L (54-61), H (= 60). M and L are a most common.

CUT WIRE SHOT

It is often preferred over steel shot due to a fact that it lasts longer, generates less dust, and has the greater uniformity in size. It is made by taking wire of a desired type and cutting it in lengths that is approximately equal to a 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 a wire used in thousandths of an inch. Thus CW-47 represents shot made from the wire that was 0.047" in diameter.

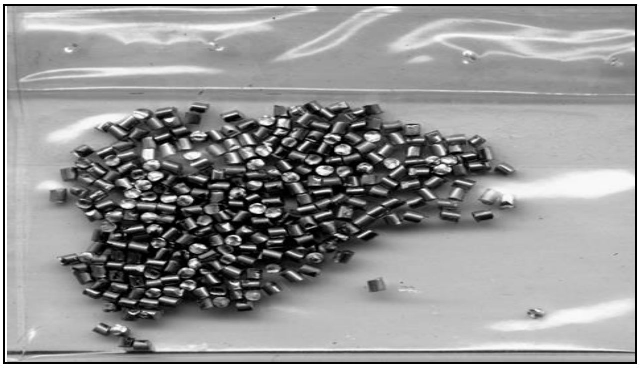

Fig.3. Cut Wire Shots

3.3 INTENSITY

Intensity control involves changing a media size and shot velocity to control an energy of a shot stream. Using larger media or increasing the velocity of a shot stream will increase the intensity of a shot peening process. To determine what intensity has been achieved, Almen strips is mounted to Almen blocks and a shot peening process is performed on the scrap part. The Almen strip is a strip of SAE 1070 spring steel that, when peened on one side, it will deform into an arc towards a peened side due to a induced compressive stresses from a shot peening process. By measuring the height of the arc, the intensity can be reliably calculated. This process is done before the actual peening process on production parts to verify the peening process is correct. The Almen strips also control how long a material is exposed to a shot peening process. The time to expose a material is determined from the saturation point on the saturation curve. The saturation curve is a plot of Almen strip arc height vs Time. A saturation point is defined as a point on the curve where doubling a exposure time produces no more than the 10% increase in arc height.A saturation curve plots Almen strip arc height vs. exposure time shown in fig.

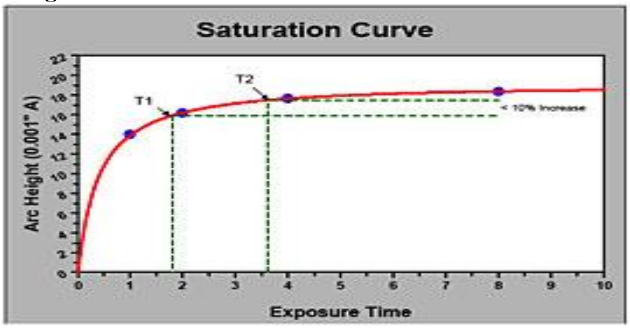

Fig. 4 Saturation Curve

3.4 COVERAGE

Coverage is a measure of original surface area that has been obliterated by shot dimples. Coverage is crucial to high quality shot peening and should never be less than 100%. A surface that does not have 100% coverage is likely to develop fatigue cracks in the un-peened surface areas.

4. PROCESS CONTROL PARAMETER

Major variables in a shot peening process is shot size and hardness, shot velocity, surface coverage, angle of impingement, a resulting peening intensity, and shot breakdown. The quality and effectiveness of shot peening depend on a control of each of these interdependent variables.

4.1 SIZE OF SHOT

When other factors, such as shot velocity and exposure time, are constant, an increase in shot size results in an increase in peening intensity and depth of the compressed layer, plus a decrease in coverage. Selecting the minimum shot size capable of producing the required intensity is preferable to take advantage of a more rapid rate of coverage obtained with smaller shot. The selection of a particular shot size may be dictated by a shape of a part to be peened. In shot peening of a fir-tree serrations of steel compressor blades, complete coverage can be obtained only if a radius of a shot does not exceed the radius of a serrations. The same principle applies to a selection of shot size for peening a root radius of threads. When peening fillets, a diameter of the shot used should not exceed one halfthe radiusof the fillet.

4.2 HARDNESS OF SHOT

Variations in a hardness of shot do not affect peening intensity, provided a shot is harder than a work piece. If a shot is softer than the work piece,a decrease in intensity occurs.

4.3 VELOCITY OF SHOT

Peening intensity increases with shot velocity; however, when velocity is increased, shot must be inspected for breakdown more frequently for purging the system of broken shot.

4.4 ANGLE OF IMPINGEMENT

By definition, the angle of impingement is the angle,90° or less,between the surface of the work piece and the direction of the blast. As this angle is decreased from 90°, peening intensity is reduced. Peening intensity varies directly as the sine of a angle of impingement. When the low impingement angle is unavoidable, increases in shot size and velocity may be required to attain the desired intensity.

4.5 BREAK DOWN OF SHOT

To maintain a required intensity and to provide consistent peening results, the production peening unit must be equipped with the separator that continuously removes broken or undersized shot from a system. The rate of removal should approximate a rate of wear and breakdown. The percentage of full-size and rounded shot in a system should never fall below 85%. Higher percentages is preferred. Sharp-edged broken media can scratch the part, generating the stress raiser; therefore, rounded shot, like minuscule peening hammers, is mandatory. Integral shot conditioners on peening machines consist of screens of air wash systems, neither of which can fully discriminate whether shot is broken because these devices is designed to handle only a specific weight of the shot. The only practical method of maintaining 85% good shot in a machine is to remove a entire shot load and reclassify it in the separate machine that distinguishes both size and shape.

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