Shot Peen Training

–

by Thomas N. Fritts

Index:

1. History of Peening

Metal peening has had a long history – the ball peen hammer was used to improve the quality of the gentlemen's sword. Manufacturing engineers and production managers generally are acquainted with some aspects of the shot peening process, but there is a scarcity of adequate literature and instructional material relating to present-day shot peening techniques, potential uses and economic advantages. This review of the state of the art, in the field, is presented on the premise that the spread of its application in production operations bears a direct relationship to the spread of the knowledge about what it can do and why.

John Almen, chief metallurgist at General Motors in 1938, discovered a method of measuring shot peening intensities and the depth of the compressive stress layers in shot peened parts.

The method developed by John Almen was named the "Almen Test" and is now the standard for shot peening procedures. Almen Test strips, intensity and measuring of the test strip will be discussed later in the session.

2. Description of Process

The shot peening process is carried out usually in a cabinet in order to confine the shot and facilitate its collection for re-use, as well as suppress dust.

The work to be peened is introduced into the shot stream usually by a mechanical means, which is so contrived as to expose the critical area to the shot according to a predetermined program.

The shot consists of hard particles that are classified as to size, usual sized range from 0.016 – 0.094" in diameter. Various kinds and types of shot are available.

Shot may be propelled by air, water or by a wheel, with velocities of the order of 200 feet per second.

The area covered by the shot stream is called the "*blast pattern*". In case of the pneumatic (air) type machine shot delivered from a nozzle and the shot pattern covers a circular area about 1.5 – 2.0" in diameter, depending on the nozzle size and the distance to the work.

Shot peening causes plastic flow in the surface of the object, stressing the material beyond its yield strength, which results in a residual compressive stress. The depth to which this compressive stress extends is dependent upon the properties of the material, the characteristics of the blast and the amount of shot striking the area being peened.

The properties of the blast are defined by:

- Velocity of the shot
- Size of the shot
- Type of shot
- Hardness of the shot
- Impingement angle

The amount of shot striking the area being peened is a function of:

- Quantity of shot flowing (shot flow rate)
- Shot pattern
- Manipulation of the work
- Time of exposure to the blast

The measurement of these factors will be discussed later.

3. Why do we perform Shot Peening?

Shot peening makes a dramatic improvement in the service life of highly stressed parts subject to cyclic loading. For instance, life increases of several hundred per cent are commonly achieved in such objects as springs, connecting rods, machine parts, aircraft components and other parts subject to vibration and reverse loading or shock loads.

But while the shot peening process offers a powerful tool to the design engineer, from a production standpoint, it also involves subtle factors, which must be applied with a considerable degree of fineness.

The shot peening of many critical parts that are subject to cyclic loading such as rotating components of jet engines are shot peened to increase service life and prevent premature fatigue failure of these highly stressed engine components.

These include disks, hubs, blade roots, as well as glass bead peening of blade airfoils.

Many of today's most important applications of shot peening are the accomplishment of three factors:

- Increased tensile strength
- Increased yield point
- Increased fatigue life when subjected to cyclic stresses or repeated stresses.
- Restored fatigue life by removing machining tensile stresses

4. How is Shot Peening accomplished?

If we were to strike a piece of metal (workpiece) with a ball peen hammer the metal directly under the ball of the hammer is indented.

There has been plastic flow of the metal, and the metal has been put in ***"compression"***.

The unaffected metal is restraining the surrounding metal, keeping it from flowing. However, the metal directly below the peened face has been placed in compression – the remaining metal is still in tension. Now, in order to cover a large surface, it would be impractical, and a long tedious process, to peen in this manner. The process of blasting or striking a surface in a uniform manner with a small metallic shot or glass beads is called ***"shot peening"***.

Using this process makes it easier to peen large or complex structures. This peening is performed by several methods, most generally by air pressure blast systems, automated to give the desired effects and control so as to meet the peening specifications with reference to:

- Shot type, size and hardness
- Intensity
- Coverage

Peening is generally applied to increase resistance to fatigue failure. Fatigue failures are quite easily recognized and almost without variation emanate from a focal point at the surface. These focal points are stress raisers, such as fillets, holes, keyways, seams, laps, tool marks, stamp marks, or variations in structure. When fatigue failures are encountered, the stress raisers should be removed or avoided totally, if possible.

5. When is Shot Peening necessary?

The need to perform shot peening has a wide range of application and uses. This depends on the service life of the critical nature of the workpiece.

In the past 40 years manufacturers have come to recognize the importance and advantages of shot peening.

The process, when applied, increases the service life of many highly stressed parts subject to cyclic loading. For instance, life increases several hundred per cent are commonly achieved in such parts as springs, connecting rods, machine parts, aircraft parts and many jet engine components, as well as other parts subject to vibration and reserve loading or shock loads.

The key factor to recognize is that shot peening is normally beneficial when the objective is to obtain long service life under conditions of severe dynamic loading and continued stress reversals.

Jet engine parts are a prime example of these conditions.

6. ***Shot Peening machines and equipment.***

Shot peening machines may be classified into three major categories, depending on the medium that propels the shot. These are:

- Air blast machines
- Centrifugal blast machines
- Vapor blast machines

A typical peening machine is made up of the following major parts:

- Shot propelling device – for accelerating the shot to the desired velocity. Also for returning the shot to the separator after passing through the projecting device.
- Separator – for removing broken and undersize shot.
- Shot adding device – for replacing broken and undersize shot.
- Work conveyor – for handling the work so as to subject it to a definite controlled cycle under the blast.
- Cabinet – for confining the shot within the machine.
- Dust collector – for removing the dust resulting from the blast.

Air Blast Machines: May be subdivided into three kinds, depending on the method of introducing the shot into the air stream.

1) Suction-induction machines: In this type of machine, compressed air is allowed to expand through a nozzle which is provided with a port or auxiliary tube through which the shot enters the nozzle. The shot is drawn into the air stream by entrainment and is then accelerated by the air that is traveling at relatively high velocity. This is the simplest machine and is used to peen small parts or small quantities, or when the required intensity of peening is low. It is used for laboratory work and for other applications when the shot size is changed frequently.

2) Gravity-Induction Machines: In this type of machine, the nozzle is identical to that of the suction –induction type, but the shot is introduced to the nozzle by means of gravity. This results in better control of velocity and flow rate.

These machines have a slightly higher blast efficiency than that of the suction-induction type. They are used where a relatively fixed nozzle position is satisfactory and where the vacuum is not sufficient to lift shot from the lower storage bin. The gravity induction type machines have minimum air requirements.

3) Direct Pressure Machines: With this type of machine, the shot is stored in a pressure vessel that is maintained at the same pressure as the air blast. The shot is fed by gravity into a mixing chamber in the pressure vessel, where it is caught in the air blast and discharged through a nozzle.

This is the most elaborate type of air blast and has more flexibility, since greater nozzle movements are possible. It is used for peening small areas, such as fillets, at the higher intensities.

Nozzles: In all three types of air blast machines, the shot is discharged through a nozzle that is expendable, due to the abrasive action of the shot. The life is dependent upon the composition of the nozzle and of the material flowing through it. "Long Life" nozzles have the added advantage of providing a uniform shot stream because of the nearly constant orifice size.

It is important in air machines to provide a good pressure regulator and water trap in the compressed air line because any condensation which is admitted to the shot supply tends to "freeze" the shot into a solid mass.

7. ***Holding fixtures – Tooling***

Nozzle Support Holders – universal type for ease and accuracy of location.

Almen Test Strip Blocks – to support the Almen test strip for intensity measurements.

Masking – by means of rubber, neoprene, masking tape, or plastisol coated fixtures to protect areas that do not require or allow peening.

Work Holding Fixtures – to support, position and move the work piece so as to expose all areas of the part to be peened, such as turntables, lance mechanisms both vertical and horizontal movement.

8. ***Materials – Peening Media***

Steel Shot = nearly spherical particles obtained by the disintegration of a molten stream of metal by water, air or some other method. Grit is angular particles manufactured by crushing hard shot and this product is used only in abrasive blast cleaning applications, not shot peening.

Glass beads =nearly spherical particles made from molten glass, used when ferrous contamination may be a problem.

Cut Wire = pieces of wrought steel (either carbon or stainless) wire that are cut to lengths equal to its diameter and then pre-rounded to make essentially round shot. Cut wire shot does not fracture during use but will erode to smaller sizes. Unconditioned cut wire shot is used in abrasive blast cleaning but never in shot peening because of its sharp edges.

9. Production Control and Quality Control

SAE J442 - Almen Test Strip, Holder, Almen Gage
SAE J443 - Use of Almen Strip for Intensity Measurement
SAE HS-84 Handbook on Shot Peening

10. Specifications and Requirements

The various engine manufacturers have similar specifications, references and requirements, however most of them reference the following:

- SAE AMS 2430 Shot Peening
- SAE AMS 2431 Peening Media
- SAE AMS 2432 Computer Monitored Shot Peening
- SAE AMS-Mil-S-13165C
- SAE J442
- SAE J443

Pratt & Whitney Standard Practice Manual
70-52-00, -01, -02, -03, -11, -12

CFMI Standard Practice Manual
70-41-00, -01, -12

IAE Standard Practice Manual
70-38-04, -01, -02, -03, -13