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PEENING AND WET PEENING

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INTRODUCTION

The techniques of "cold hammering" metal objects to significantly improve their life and performance is as old as metal working itself. The swordsmith and the blacksmith continued to hammer the metal for some time after it was shaped and until the craftsman "felt" it was right. This hammering, or peening, is fully recognized today and is frequently written into the production requirement for high stress components. The surface compression induced by peening reduces the incidence and frequency of fatigue failure and so extends component life.

By the mid 1930s the value of shot peening was becoming widely appreciated and life extension of component parts could be accurately predicted. Based on materials then in use:

Leaf Springs	- Life increased by 600%.
Connecting Rods	- Life increased by over 1000%.
Coil Springs	- Life increased by 1370%.
Rocker Arms	- Life increased by over 1400%.

(Tilghman Wheelabrator 1936).

More recently material specifications have changed dramatically and peening is now frequently specified to greatly extend the safety margin in highly stressed aircraft components or to allow the use of lighter, less robust components in high performance engines. Many other applications exist and the list extends readily.

WHAT IS PEENING?

Peening is the technique which changes the characteristic of a metal surface to increase its fatigue strength. It is achieved by bombarding the surface with a high velocity stream of pre-selected round balls. This produces a permanent stretching of the surface causing a plastic flow of surface fibers. The crystalline grains are reoriented to a shallow depth which resists flow fracture since the slightly compressed layer is somewhat stronger than the material below this zone. Fibers beneath the top layer retain elasticity and the resulting equilibrium leaves the surface in compression and the low levels in tension.

The compressed layer extends 0.005 to 0.010 inch below the surface.

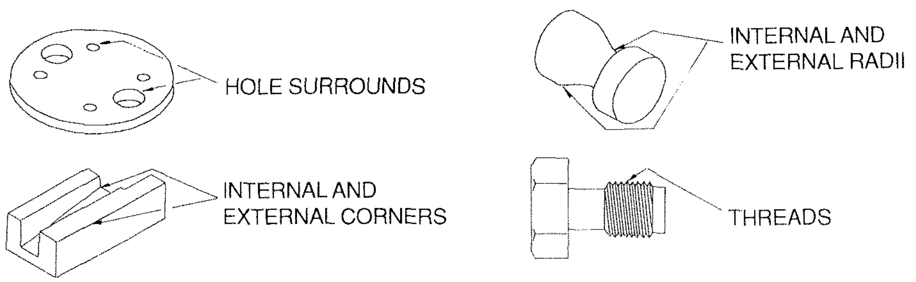
Since fatigue failures generally originate from tension stress and not from compression stress the effect is a considerably greater fatigue strength.

Peening also superimposes a random surface texture over the original surface which is usually directional (i.e., directional machining marks or polishing scratches, etc.). Surface cracks are less likely to propagate along a random texture.

USES OF PEENING

Any part subject to twisting or bending stress is likely to benefit from peening. The process is ideal when applied to irregular shapes where heat treatments may cause distortion. Peening is now frequently used as an alternative to polishing where directional scratches can propagate minute cracks. It is ideal for the treatment of fillets, grooves or unsupported edges or anywhere where sudden changes in form occur. (Such changes are commonly noted as fatigue fracture causes).

Examples:



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OVER-PEENING

Over-peening can weaken or damage a component either y so overstretching that its durability is exhausted (when surface splitting or cracking may become evident) or by erosion of surface material to unacceptable levels. Peening operations should always be controlled and monitored to a precise specification.

SPECIFICATION OF PEENING LEVELS

The degree of peening can be measured and is specified as ARC HEIGHT or DEFLECTION. (See also "Peening Techniques" below).

The process specified will take into account the shape, nature and duty of the component and will be used either to eliminate failure in existing designs, to allow components to be used more safely, to allow component performance increases or to permit size and weight reduction for new designs.

Measurement and test will establish the balloter, its material make-up, operating velocity and coverage.

Light peening using micron sized glass balls at relatively low pressures may be specified for light alloys, delicate components or for low levels of induced stress. Heavy peening using large steel balls at high velocity would be selected for steel castings, forgings and similar rugged subject.

Specifications usually arise from a combination of theory, previous experience and component testing.

PEENING TECHNIQUES

It has been stated that "peening, even carried out in an uncontrolled and indifferent manner, will probably have some good effect." However since the reliance of peening is often of great importance it is necessary to control its application to strict limits. The factors influencing good techniques are:

1) **Intensity of peening**
2) **Angle of impact**
3) **Standard of peening media**
4) **The achieved Arc Height or Deflection**
5) **Coverage of the component**

1) Peening Intensity

Literally the intensity of the blast which is the combined factors of velocity, hardness and the condition of the media or shot.

2) Angle of Impact

Usually the aim is to achieve an angle of 90 degrees. to the component surface. This is obviously not always possible due to component shape and the fact that the media is not usually ejected at a single angle. However peening is most effective at 90 degrees. and that ideal should be the aim.

3) Standard of Media

Specifications cover size, hardness and shape. Separation systems become all important in maintaining these standards and so will be required to eliminate dust, metal fragments, broken or miss-shapen shot and shot which falls below specified size range.

In dry systems separation relies mainly on providing an expansion chamber in which air velocity falls to a level at which full sized shot will fail to be recirculated while other matter including undersize broken material is carried into a collection hopper or bag. More sophisticated systems cater for roundness (by using spiral separators) and size (by the use of vibratory screening).

In wet systems glass bead conditioning uses similar techniques so that by slowing down the water flow the larger beads settle while dust and debris (including oil and grease on occasions) is "floated" off using weirs or positive filters. The detrimental effect of worn or even miss-shapen beads in a wet system is much less disadvantageous due to the "cushioning" effect of water. Excellent light peening without damage to fragile components can be undertaken using glass beads in a wet system.

4) Arc Height (Deflection)

A measuring system - now used internationally - was introduced by J.O. Almen and consists of the use of test strips produced to a very tight specification for thickness, flatness and hardness. Three types are used; "A" and "C" for varying degrees of shot peening, and "N" specifically introduced for lighter duty glass bead peening; both wet and dry.

The specifications are:

Type	Thickness	Flatness
N	0.031 +/- 0.001 inches.	+/- 0.001 inches.
A	0.054 +/- 0.001 inches.	+/- 0.001 inches.
C	0.094 +/- 0.001 inches.	+/- 0.001 inches.

S.A.E. 1070 cold rolled spring steel, 3 inches long x 0.75 inches wide, uniform hardness Rockwell C44-50.

During blasting the strips are retained on a metal block by four set screws. For large complicated components it may be necessary to fix a series of blocks to record arc heights on various planes, at different angles and on curved surfaces.

During production peening, strips should be processed at regular intervals, measured and retained for record purposes.

Deflection or intensity is expressed as the measured curvature as shown on the gauge, followed by the strip type "A", "C", or "N". For example 0.006 gauge reading on an "N" strip would be shown as 0.006N or 6N. 0.009 on an "A" strip as 0.009A or 9A.

The gauge used for measuring curvature consists of a clock gauge calibrated in 0.0001 inch increments. The spindle passes through the base onto which are mounted magnetic contacts to hold the Almen strip firmly in position. With an unused Almen strip held by the magnets the gauge clock is set at zero. After peening the strip is replaced so that the spindle registers the deflection from flatness (curvature) as a direct reading taken from the original zero. The concave face is used so as to eliminate variations caused by surface roughness.

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5) Coverage (Saturation)

This relates to the time of exposure of a component to a given blast stream. A number of test strips can be peened under a constant blast stream for different exposure times. Short initial exposure times show a relatively sharp increase in arc height and as exposure times extend, the increase in arc height reduces to become constant (saturation).

Checking Coverage

To ensure adequate coverage of a component its peening program should be specified and peening should then take place together with appropriate Almen strips. When the operation is complete the arc heights should be recorded AND THE PROGRAM REPEATED FOR DOUBLE THE EXPOSURE TIME. The arc heights achieved should, when compared to the originals, indicate a less than 20% increase. This being so then the original coverage is considered adequate and intensity is being achieved.

GOOD PEENING PRACTICE

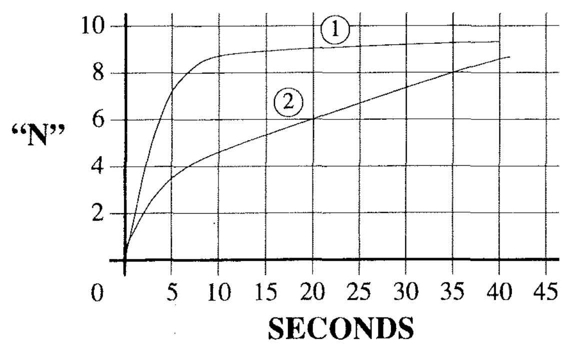
The action of peening is rapid and when correctly applied will ensure that arc height is reached very quickly. It should always *be the aim to achieve this situation by avoiding the use of shot* or beads of too small a diameter, setting pressures too low and operating with excessive gun to work distances.

Continued increase of arc height usually indicates faulty set-up.

The aim should be to gain a relatively low increase in arc height after the "flattening off".

The condition of peening media is a vital factor in good peening practice. Careful check of surface finish can play a part in monitoring media since worn or broken spheres tend to produce a duller, matte finish than would be produced by good spheres. Protection of the surface and particularly of threads, sharp edges and shoulders is greatly enhanced in wet systems where harsh impact of bead to component is cushioned by water.

GRAPH TO ILLUSTRATE THE DIFFERENTIALS BETWEEN OPTIMUM & INEFFICIENT PEENING SET-UPS



① **OPTIMUM PEENING SET-UP**

② **POOR SET-UP (Beads too small, Pressure too low, Distance or Angle incorrect)**

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PEENING PROCESSES AND EQUIPMENT

Metallic shot (steel balls) constitute the most widely used peening media when high intensity "A" and "C" readings are sought. Centrifugal wheel throwing and air operated machines are available each with separation, grading and dust control.

Over-peening is a danger and care must also be taken to ensure that contamination (scale, oxides, fragments of shot, etc.) is not embedded in the component surface. Use of steel shot on non-ferrous metals can result in cross-contamination. It is now possible to achieve "A" and "C" strip levels in wet blast machines using ceramic or stainless steel balls.

Dry air blast systems use non-metallic beads for medium operations and the sophisticated range of equipment available includes monitoring devices for media control, separation of broken beads and a wide range of dust control units. Dust can be a problem and the component must be dry and free of oil or grease before blasting.

To provide an environmentally improved system completely free of dust, a highly controllable process and one in which even the most delicate aerofoil or similar surfaces can be treated safely, wet blast equipment has been extensively developed. Although the wet process is ideal for use with aluminum or light alloys it may be used with ceramic or stainless steel beads to produce "A " and "C" levels of intensity.

No prior degreasing or cleaning of the component is necessary and a very smooth finish can be maintained. Finishes are significantly better than those achieved in dry processes for the same intensity and can often eliminate the need for subsequent finishing operations.

Pumps are now able to feed a series of blast nozzles with a consistent and high concentration of blast media to water. Fine control is possible and a wide variety of peening levels can be obtained from equipment adjustment and without the need to constantly change media size or type.

Centrifugal separation is used to remove waste material and broken beads. The cut-off point of cyclones can be adjustable to reduce the unwanted material to less than 10% of the entire charge. Automatic replacement by measured addition of new beads is also available.

For very critical work it is possible to monitor the solids to water ratio of the flow from pump to guns and to use the signal so received to activate automatic glass bead top up.

Wet blast machines, like their dry and shot blast counterparts, may be used in manual, semi or fully automatic forms to suit application and work rate. The current range of Vapormatt peening equipment includes fully programmable CNC machines with 3 axis gun movement and worktable positioning to an accuracy of +/-0.5%.