SHOT PEENING

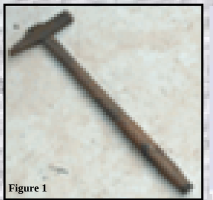
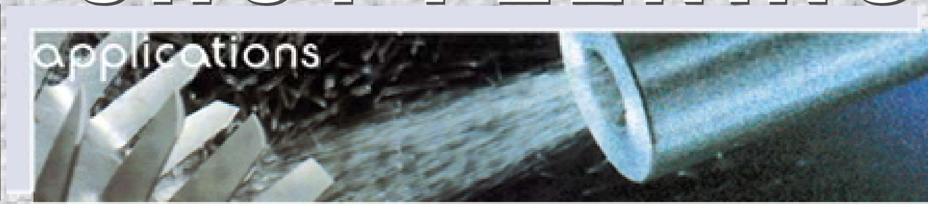


Figure 1



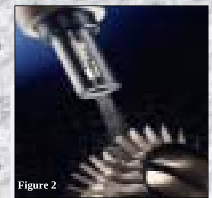


Figure 2

The word peen means to flatten with a small hammer. (Figure 1) This peening hammer was used by blacksmith William Shenk at the turn of the century.

(Figure 2) Modern State of the art, computer controlled machinery, can be held to you're desired standards.

The History of Shot Peening

Shot peening is not a new process. People have long known that pre-stressing or work-hardening metal could create harder and more durable metals. The process of was used in forging processes as early as the bronze age to strengthen armor, swords and tools. Gun barrels in the civil war were subject to peening to increase the hardness of Damascus steels, and the fillets of crankshafts in early European racecars were hand-peened with specially-made hammers by 1922. Of course, peening has evolved substantially in the late 20th and early 21st centuries, but the general idea remains the same. Shot peening the material with thousands of tiny balls of high-velocity shot works in much the same way as peening with a hammer did in medieval times.

Shot Media

- Steel spheres
- Cut steel wire
- Glass beads
- Ceramic beads

Why Shot Peen

The atoms in the surface of a piece of manufactured metal will be under (mostly) tensile stresses left over from grinding, welds, heat treatments and other stressful production processes. Cracks promulgate easily in areas of tensile stress because the tensile stresses are already working to pull the atoms of the metal apart. By shot peening the material you introduce a layer of compressive stress by compacting the material.

As the shot peening is performed, the atoms on the surface of the metal become crowded and try to restore the metal's original shape by pushing outward. The atoms deeper into the metal are pulled toward the surface by their bonds with the atoms in the compressive layer. These deeper atoms resist the outward pull creating internal tensile stress that keeps the part in equilibrium with the compressive stress on the surface.

Peenable Materials

- High Strength Steels
- Carburized Steels
- Cast Iron
- Aluminum Alloys
- Titanium
- Magnesium
- Powder Metallurgy

How It Works

Shot peening is a cold working process that imparts a small indentation on the surface of a part by impacting small spheres called shot onto the material surface. (Figure 3) This process creates the same effect that a peening hammer does by causing outer surface to yield in tension. The material directly beneath it is subjected to high compressive forces from the deformation and tries to restore the outer surface to its original shape. By overlapping the surface indentations, a uniform compressive layer is achieved at the surface of the material. 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.

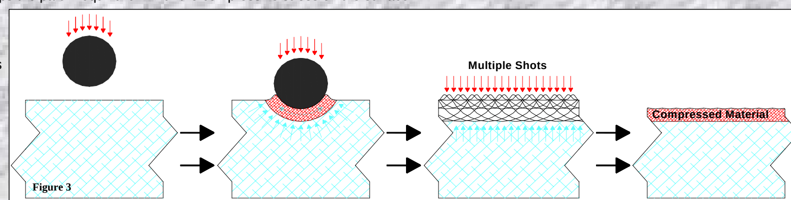


Figure 3

Shot Peening Benefits

- Enhances fatigue strength (Figure 4)
- Improves ultimate strength (Figure 5)
- Prevents cracking due to wear
- Prevents hydrogen embrittlement
- Prevents corrosion
- Prevents galling
- Prevents fretting
- Can increase gear life more than 500%
- Can increase drive pinion life up to 400%
- Can increase spring life 400% to 1200%
- Can increase crankshaft life 100% to 1000% (Figure 6)
- Can permit the use of very hard steels by reducing brittleness
- Possible to increase the fatigue strength of damaged parts extending the wear
- Increases lubricity by creating small pores in which lubricants can accumulate
- Substitution of lighter materials can be possible without sacrificing strength and durability
- Leaves a uniformly textured, finished surface ready for immediate use or paint and coatings
- Can be used to curve metal or straighten shafts without creating tensile stress in a Peen forming process
- Shot Peening can be used in a number of specialized processes such as flow treatment of pipes used to transport polymer pellets used in oil and gas industries. Polymer pellets will slide against the inside of a smooth pipeline, melt and form streamers or angel hair. These long polymer fibers will contaminate the pellet flow and clog up the transfer system. When the inside of the pipeline is roughened by shot peening, the polymer pellets bounce or roll instead of sliding along the inside of the pipe. The pellets contact with the side of the pipe is shortened, and formation of angel hair is prevented.
- Optimal fatigue properties for machined steel components are obtained at approximately 700 MPa, any higher and the materials lose fatigue strength due to increased notch sensitivity and brittleness. When compressive stresses from shot peening are added fatigue strength increases proportionately to increased strength.

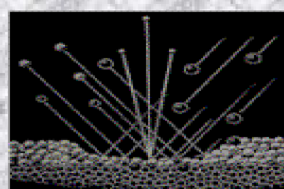


Figure 4

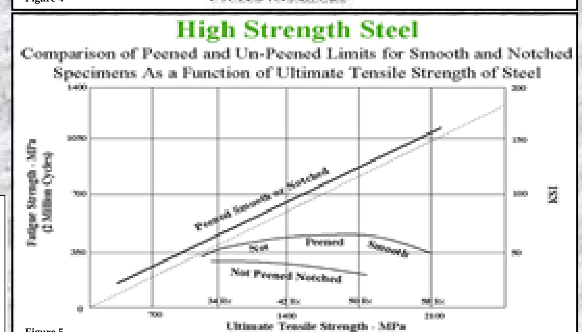


Figure 5


Figure 6

(Figure 6) Crankshaft fatigue life is increased by shot peening the radii on the shafts journals.

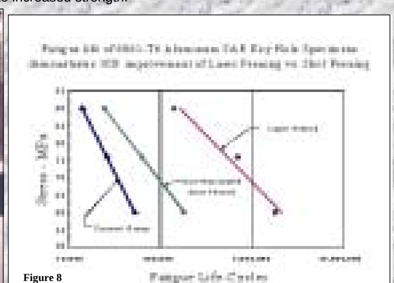


Figure 8

(Figure 8) Graph showing increased fatigue life due to Laser-shot peening.

Controlling the Process

Media

Media control involves using high quality shot that is mostly round and of uniform size and shape. The diameter of the shot should be the same through out the media. If the shot diameter is not uniform, each individual shot will have a significantly different mass. This exposes the material surface to varying impact energies that create non uniformities. These non uniform layers will create inconsistent fatigue results.

Intensity

Intensity control involves changing the media size and shot velocity to control the energy of the shot stream. Using larger media or increasing the velocity of the shot stream will increase the intensity of the shot peening process. To determine what intensity has been achieved, Almen strips are mounted to Almen blocks and the shot peening process is performed on a scrap part. An Almen strip is a strip of SAE 1070 spring steel that, when peened on one side, it will deform into an arc towards the peened side due to the induced compressive stresses from the 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 the material is exposed to the shot peening process. The time to expose a material is determined from the saturation point on a saturation curve. The saturation curve is a plot of Almen strip arc height vs Time. The saturation point is defined as the point on the curve where doubling the exposure time produces no more than a 10% increase in arc height.

Coverage

Coverage is the 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.

Methods of Shot Peening

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 the shot to speeds of up to 250 ft/s. The second method involves accelerating the shot with a wheel. The shot gets dropped onto the middle of the wheel and 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 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.

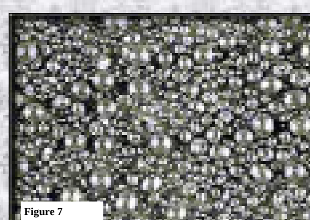


Figure 7

(Figure 7) This picture shows high quality spherical steel shot of various sizes that should be used in all shot peening processes

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 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. **Figure 4** shows the increase in fatigue life that laser-shot peening can create.

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

References:

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2. http://www.superiorshotpeening.com/shot_peening.htm
3. http://www.shotpeener.com

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