Shot Peening Techniques for Springs

by Kumar Balan

A flat piece of leaf spring has, since the days of the black smith, received continued impacts of the hammer long after cooling down in temperature. Though the blacksmith didn't always realize the effects of his actions, it is now known that the life of this leaf spring is enhanced by upwards of 600% by such an action!

The same applies for Coil/Helical Springs and Torsion Bars, with different life enhancements. Various other automotive and aerospace parts such as Connecting Rods, Crank Shafts, Rocker Arms, Ring and Pinion Gears, Jet Engine Blades, Landing Gears, Transmission Shafts are regularly shot peened as part of their production processes.

So, what happens when a part is shot peened?

Mechanism and Effects of Shot Peening

When a part is pelted/bombarded with a stream of round metallic media (referred to as shot), each shot dents the surface of the part that it impacts.

Impingement of metallic media (shot or cut wire) causes plastic deformation on the part surface. This extends the superficial layer creating compressive stresses underneath and providing a balance to the applied working (tensile) stresses. This residual compressive stress delays the formation of fatigue cracks thereby increasing the useful life of a component.

Shot peening is a "cold working" process and is different from metal flow at high temperatures, even though there is a momentary increase in temperature of the surface being peened.

The layer of compressive stress commonly extends to depths varying from 0.005" to 0.030". Greater depths, if desired, are achieved by altering process parameters such as shot size, velocity of impingement, angle of impingement, exposure time etc.

The two commonly used parameters to gauge the effect of peening are intensity and coverage. Where coverage (100%, 200% or higher) is purely a visual check, intensity is measured by deflection of a representative strip of spring steel (commonly called the Almen Strip).

Intensity Measurements

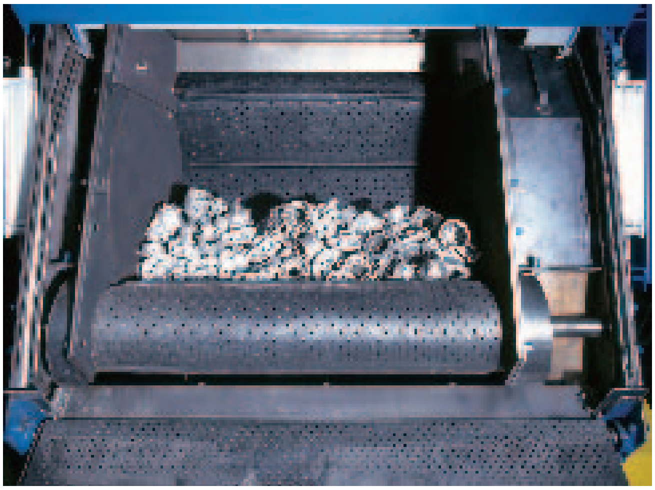
Part Verification Tools (PVT), are designed to hold test Almen strips in strategic locations on the actual or simulated part. Test strips in these locations simulate areas of the part where intensity requirements and therefore measurements are critical.

Intensity ranges could be anywhere from 0.010" to 0.015" on the 'A' scale, depending on the application. Coverage requirements could range from 100% to 200%. The above results are commonly achieved by processing the parts through a centrifugal wheel style blast machine.

Though pressure blast nozzle style systems have been used in the past, they do not render themselves effective when faced with high production rates as are seen in leaf spring and coil spring production lines. A centrifugal blast wheel on an average propels about 10 times the amount of blast media when compared to a blast nozzle, thereby covering larger areas and saturating them at a much faster rate.

Peening Machine Types

The type of peening machine is dictated by the part being peened and production rates.



Batch Style Peening

- Leaf Springs are processed inline on a continuous chain conveyor with multiple blast wheels targeting the part from the top and both sides
- Coil Springs are processed inline on a continuous chain conveyor with fingers that 'push' the spring through. Spinner rollers provided inside the blast chamber spin the coil spring when being blasted. Multiple blast wheels are used for peening
- Relatively smaller size springs, used for engine valves etc. are treated in bulk and peened in a Tumblast style machine
- Torsion bars are also peened in the inline configuration

Process Variables

Regardless of the peening technique or machine type used, achieving the intensity targets in a repeatable and consistent fashion is the primary goal of any operation. It is therefore important to understand the critical variables that alter the final results in a peening process. They are:

- Blast wheel type
- Wheel Horse Power
- Wheel speed
- Blast angle
  - Wheel positioning
  - Control Cage movement

Each of the above process variables influences the final result as follows:

The diameter of the blast wheel determines the tangential velocity of the blast media. In direct proportion, a 17.5" diameter wheel generates a greater shot velocity and therefore higher peening intensity than a 14" diameter wheel at the same speed.

Horse Power of the wheel simply determines the amount of media propelled, thereby affecting processing time.

Wheel size works in conjunction with the wheel speed (π x D x N) to achieve the desired velocity and thereby the intensity. Wheelblast peening machines can be equipped with variable frequency drives to vary the wheel speed and therefore the velocity.

Continued in page 16

SHOT PEENING TECHNIQUES FOR SPRINGS
Continued from page 14

Blast wheels are always mounted in a permanent and rigid location in the blast cabinet. However, blast pattern alterations, if required, are achievable by altering the control cage settings. The control cage location determines the exact point of blast media discharge from the blast wheel.

Other process variables affecting peening results include:
- Media flow rate
- Size of media
- Consistency of size

Media flow rate is controlled using a commercially available flow control valve (MagnaValve – manufactured by Electronics Inc. – is a widely used valve in the industry). MagnaValves are provided at the feed side of the blast wheel, usually at the outlet of the media storage hopper.

Vibratory Classifier classifies the peening media into oversize, right and undersize/fines. A combination of two sieves ensures that consistent size of peening media is available for every cycle.

Size of peening media plays an important role in determining coverage and peening cycle time. As a rule, (a) smaller size of shot allows higher stress on immediate surfaces, and (b) larger sized shot provides stress in material depths.

Leaf Spring Peening

Leaf Springs are individually processed in an inline style peening machine with the concave geometry of the spring exposed to the blast wheel. A typical Leaf Spring Peening Machine consists of a single blast wheel from the top and one blast wheel on either side to process the sides of the spring simultaneously.

Line speeds in excess of 10 feet per minute are achieved in an inline Leaf Spring Peening Machine. Where higher line speeds are desired, the blast machine is equipped with greater number of blast wheels with higher HPs.

Under working conditions, leaf springs are repeatedly subjected to unidirectional bending stresses and are therefore sometimes stress peened. During ‘Stress Peening’, the spring is loaded or ‘statically stressed’ in the same direction as the working stress anticipated during service of this spring. On completion of peening, the static stress is released. It has been proven that ‘stress peening’ further enhances the working life of a leaf spring over the conventional peening process.

Leaf Springs are peened with metallic peening media in a centrifugal wheel blast machine.

Coil Spring Peening

Coil Springs, due to their helical geometry, present a slightly challenging situation than simply blasting flat surfaces as in case of leaf springs. Further, it is important to assess the effect peening has had in the cross-section of a coil in order to fully understand its resistance to fatigue cracking.

Individual springs are transported by means of an inline conveyor into the blast zone. The blast zone is equipped with a set of parallel rollers that rotate the spring when peening. Rotation of the spring in the blast zone facilitates the blast stream to pass between the coils in order to hit the inside surface of the wire where the highest stress is located under service loading.

For Coil Spring production lines with high production volumes, peening machines that peen two springs simultaneously have also been developed.

Developments are underway to determine whether supplementary blast nozzles can be used to target specific areas of the wire geometry in order to address locations of high work stress concentrations.

Peening Torsion Bars

Torsion bars are peened in the inline orientation by conveying individual bars on a skew roll conveyor.

A single wheel with a variable frequency drive (to alter wheel speed and thereby the velocity) is used to peen the bar as it spins and moves along its length.

Valve Springs

Smaller springs (typically used in engine valves etc) are processed in batches in a Tumblast style machine. Verification of peening intensity is carried out by tumbling an Almen block with an Almen strip along with the batch of parts being processed.

Advancements in Spring Peening Equipment

The requirement of consistency and repeatability of peening results cannot be stressed enough. Process checks are built into the equipment with features/components such as the vibratory classifiers for maintenance of consistent media size, variable speed drive for blast wheels to maintain shot velocity, and speed control for work conveyors to alter exposure time.

In situations where such process parameters have to be monitored and displayed, ‘real-time’ peening equipment controls have evolved to sophistication.

TouchScreen or PC based operator interface units have now replaced multitude of push buttons and indicator lights. Control systems not only display various process parameters in real-time, but also permit the operator to create ‘recipes/techniques’ containing relevant process parameters.

Such recipes identified by their unique part number can be stored and retrieved for use at a later date.

In order to assist maintenance personnel with troubleshooting the machine during times of breakdown, control systems now provide a map of all inputs and outputs in the machine along with their individual status. This helps isolate the location of the problem and thereby leading to faster correction.

Modern controls systems also recognize the need for security and permit up to four levels of the same. Systems Administrator, Engineer, Maintenance personnel and finally the Operator all have different accesses to the machine controls.

In summary

Spring peening has evolved over the years into a monitored and controlled operation. Modern day spring peening equipment suppliers recognize the need for repeatability, consistency and quality of operation and design equipment to offer such exacting features as found in other precision production equipment.

Evolution of this technology has not been restricted to the mechanical aspects of equipment alone. Trials are underway to study the effects of supplementary blast techniques to enhance the effectiveness of the peening operation. Also gaining prominence is the sophistication of controls systems to monitor, display and report on the entire peening operation thereby providing trailing evidence about various operating parameters.

Kumar Balan is a Product Engineer with Wheelabrator Group Equipment/Process Design & Specification Conformance.