

Ultrasonic Shot Peening: From Portable Systems to Robotic Production Lines

A robust process used by Automotive, Aerospace, Energy and Medical industries

THE STRESSONIC® Ultrasonic Shot Peening (USP) process is similar to conventional shot peening (CSP) in that it is a cold-working surface treatment. Both use media to impact the surface of a mechanical part, generating a compressive residual stress layer and improving material mechanical properties. Both enhance fatigue life and resistance to stress corrosion cracking.

USP differs from conventional shot peening methods by the way kinetic energy is provided to the shot. Instead of using a constant air flow, gravity or high-speed rotation of a turbine, USP uses the acceleration of a vibrating surface called a sonotrode. The frequency of vibration is within the ultrasonic wave range (20 kHz), which explains the name of the technique.

How It Works

A generator delivers a sinusoidal electric signal that excites a piezo-electric transducer to convert this electric energy into a mechanical displacement. Since the vibration delivered by the emitter is small, the vibration must be amplified by a series of boosters in order to transmit enough kinetic energy to the sonotrode which is directly in contact with the peening media.

Between the sonotrode and the precise area to be peened, a specific enclosure is designed. Thus, the media is hermetically contained in a controlled volume. Longitudinal vibrations of the sonotrode surface randomly disperse media into the treatment volume as molecules into a gas. This gas-like movement leads to a homogeneous treatment on all surfaces of the part being treated.

Surface Roughness / Peening Intensity Ratio Concerns

In critical applications where deep compressive stresses are required and surface roughness must be kept at a minimum, USP can be a viable alternative to conventional shot peening techniques.

Due to the treatment hermeticity, media quantity is reduced to several grams and USP can thus be performed using high-quality media—such as bearing-balls with high sphericity—that do not abrade component surface. Media with a larger diameter can be used to reach a high intensity, induce deep compressive stresses and lower surface roughness. (For example: $11.8\mu\text{in}/0.3\mu\text{m Ra}$ obtained on a TA6V part peened

with USP at 7-9A/F19A compared to $118\mu\text{in}/3.0\mu\text{m Ra}$ in CSP with same Almen intensity.)

Handheld Hermetic Peening for Downtime Reduction

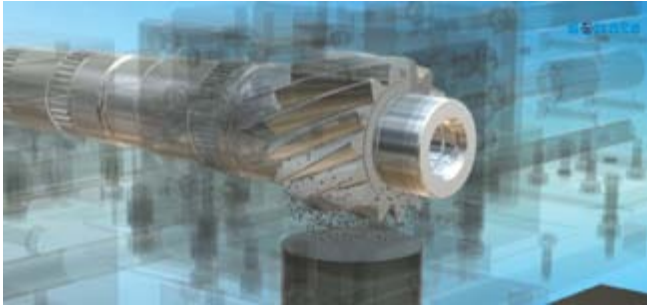
Reducing downtime—and its related costs—is a major issue for Aeroengine and Gas Turbine manufacturers and MRO industries when handling major repairs on assembled parts.

Portable USP systems by SONATS are the solution for these industries. On-site shot peening with USP eliminates the need to dismantle the component and eliminates the risk of media loss inside the component. Typical applications of this localized shot peening are:

- Fan disk blended areas, without engine extraction, leading to a 80% reduction of repair cycle time
- gas turbine fir tree peening with reduced dismantling and complete media containment throughout the peening operation
- in-situ peening of damaged helicopter blades that saved \$220,000 per blade (See Avion Solution, Inc. article in *The Shot Peener*, Winter issue, page 36)



StressVoyager® portable USP equipment on a storage trolley



Stresstonic® USP dynamic treatment of automotive output shafts

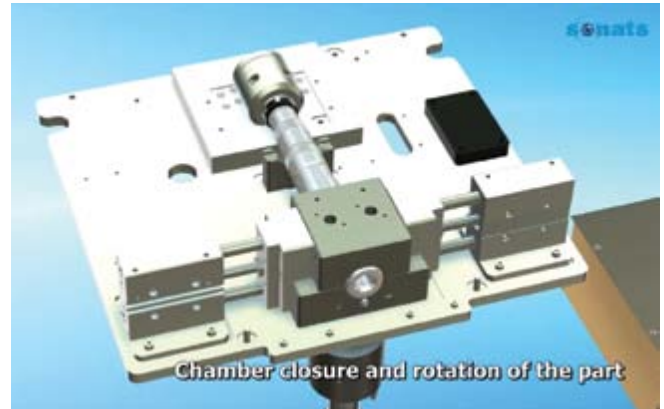
Automated Multi-Station Machines for Lean Manufacturing

Automotive gear manufacturers have to maintain high productivity while insuring an efficient and repeatable process to critical transmission parts. In this framework, major OEMs are utilizing USP automated machine integration in specific part production lines, thereby ensuring lean manufacturing preservation. Specifically in USP machines for gear peening, treatment is performed in dynamic mode to reach a pre-determined takt time. For example, a 40s takt time with a 4-station machine will produce 500,000 parts/year.

USP machines have the following automated functions: robotized handling directly from the previous process operation, media counting (in units or in grams), sonotrodes and media wear-out monitoring, operator warning when lifetime is reached, automated media loading/unloading for each independent workstation, global supervision and periodic quality report issuance. In lower production rate applications, semi-automated solutions are solicited with manual handling of the part through easily accessible windows.



Stresstonic® USP automated 4-station machine for automotive output shafts



Stresstonic® USP tooling plate for automotive output shafts

On multi-station production machines, the part tooling system includes a specific hermetic enclosure, part support and positioning tailstock (see photograph above).

The tooling systems are modular. They can be set up in any machine station, independently from part reference group.

Process requirements for transmission parts are specifically demanding. USP is preferred in critical applications, such as carburized gears and 20MoCr4 steel shafts, when high surface compressive stresses need to be homogeneously induced on the teeth flanks and teeth roots. USP is able to generate -1100MPa (145Ksi) surface compressive residual stresses while maintaining a low Ra value.

Robotized Cells

The highest automated solution for USP process is the complete handling of the process by 6-axis robots. For the treatment of aerospace blisks, for example, a recent USP implementation included the global handling of the part and robotized enclosure positioning to perform treatment on blades, disc central bore, and disc holes. The decision to use USP technology for the blisks was mainly motivated by its ability to generate very similar residual stress profiles on both intrado and extrado sides of the blades, insuring the aerodynamics of the part without distortion. ●

About SONATS

Founded in 1991, SONATS, Europe Technologies Group, is an innovative industrial company specializing in metal surface treatments using a patented ultrasonic process technology called Stresstonic®. The company headquarters are located in Nantes, France. SONATS provides equipment, services and competencies throughout the world through an international network.

EMPOWERING TECHNOLOGIES INC., SONATS American subsidiary, is located in Alabama and provides Northern America with local process support and equipment after-sales services.