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Interview with Frederic CHATEAU, Process Manager, and Juliette TRICOIRE, International Development Engineer, SONATS

Ultrasonic Shot Peening: A Reliable Innovative Process Meeting Automotive Industry Requirements

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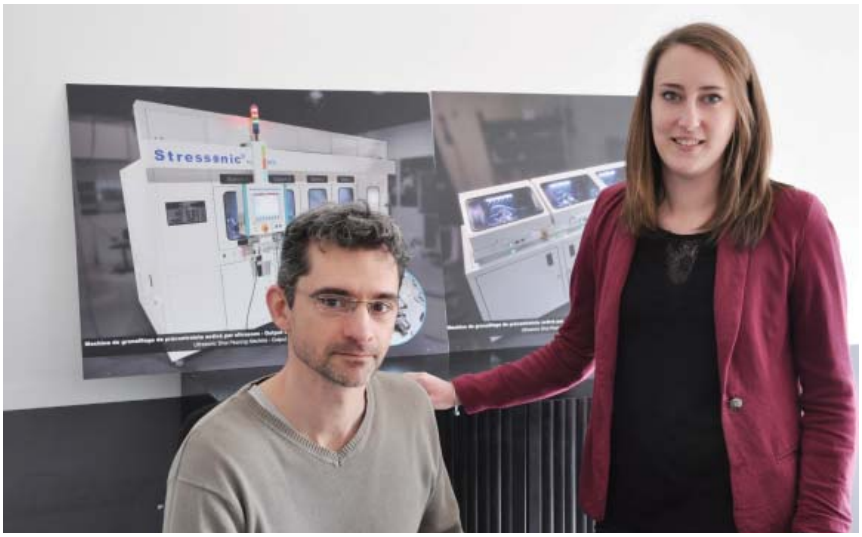
Ultrasonic Shot Peening: A Reliable Innovative Process Meeting Automotive Industry Requirements

Interview with Frederic CHATEAU and Juliette TRICOIRE, respectively Process Manager and International Development Engineer for the French innovative company SONATS, subsidiary of the Europe Technologies Group.



Frederic CHATEAU, Process Manager, and Juliette TRICOIRE, International Development Engineer, SONATS

(?) MFN: Thank you for taking the time to do this interview. Could you please quickly introduce SONATS to our readers and your positions in this company?

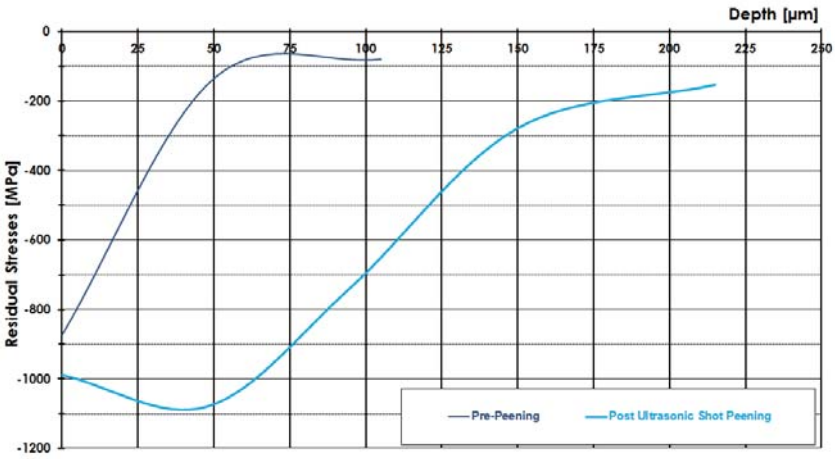
(!) J. T.: SONATS is a French innovative company with over 25 years of experience in material health analysis and metallic components fatigue performance optimization.
As a development of our patented technology STRESSONIC® (ultrasonically activated), we are offering cold working impact treatment solutions for enhancing fatigue and resistance to Stress Corrosion Cracking (SCC) by high quality processes: Ultrasonic Shot Peening of critical components, Ultrasonic Needle Peening (UNP/UIT), high frequency mechanical impact treatment (also called HFMI) of welded structures, and Ultrasonic Needle Straightening for quick and controlled sheet metal forming or straightening.
Our headquarters are located here in Nantes, West of France and we have a sister company in Birmingham, USA: Empowering Technologies Inc.
We address all industrial countries through a network of value-added representatives and technical partners. Worldwide technology awareness and identification of fatigue enhancement projects is actually the main part of my work at SONATS as an International Development Engineer. Then project development basically starts with the Process Engineering team. So I will let Frederic introduce to you what's next.

(!) F. C.: Thanks. As the Process Manager of SONATS, I work with specialized technicians, engineers and doctors to provide a first analysis of the customer application needs. Based on the requirements (residual stress profile, roughness, hardness, production flow) we define different sets of Ultrasonic Shot Peening parameters and work closely with the Material Characterization Laboratory located here in SONATS to validate the best solution. After this, my department is also involved in the process industrialization, either through on-site service, or subcontracting service in our workshop or through the development of standardized or customized production machines. The process team support is provided up to the final installation in customer workshop.

(?) MFN: Our readers may not know what Ultrasonic Shot Peening is; how would you explain the main difference between this process and the most usual Air or Wheel Blasting techniques?

(!) J. T.: 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 processes 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

> **« USP differs from conventional shot-peening processes by the way kinetic energy is provided to the shot. (...) USP uses the acceleration of a vibrating surface called a sonotrode. »**
>
> **Juliette TRICOIRE, International Development Engineer, SONATS**



Example of Residual Stress profile on Automotive Gear transmission (Steel alloy)

wave range (20 kHz), which explains the name of the technique.

(?) MFN: Could you describe how it works?

(!) F. C.: 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.

(?) MFN: This process being different from Conventional Shot Peening, what are the key parameters of Ultrasonic Shot Peening (USP)?

(!) J. T.: You are right, the first key parameter of the process is the vibration amplitude; its value is set up during the qualification step of the project. In the machines, a closed-loop system is ensuring that the amplitude won't vary in order to provide a repeatable process. Then, to reach the whole Almen intensity range, and optimize the surface roughness of the treated area, media quality is a critical factor we master in the process: we define and control the material, density, hardness, diameter and sphericity of the shots we use for each batch.

(!) F. C.: On the back of what Juliette just mentioned about media quality, we are frequently consulted for critical applications where deep compressive stresses need to be induced, while surface roughness has to be kept very low. With USP, due to the treatment hermeticity, media quantity is reduced to several grams and USP can thus be performed using high quality media (bearing balls type, high sphericity) which do not abrade component surface.
Greater diameter media can be used to reach a high intensity, to induce deep compressive stresses and lower surface roughness (e.g. 11.8µin/0.3µm Ra obtained on a TA6V part peened with USP at 7-9A/F19A vs 118µin/3.0µm Ra in CSP with same Almen intensity).

(?) MFN: This precise shot peening technology seems to be more dedicated to small volumes as in the Aerospace industries. Can we imagine high-volume production for the automotive industry for example?

(!) J. T.: It's true that Ultrasonic Shot Peening was first developed to address aerospace applications, yet we have been working for more than 10 years with Automotive OEMs, starting with Formula 1 parts in the 2000's.

(!) F. C.: Starting from five years ago we've focused our experience on high volume production where our equipment can process up to 500,000 parts per year. Today, one machine in two we design and build is to be incorporated into automotive production lines. We are now developing machines to be delivered in the next coming years that can comply with plant production rate of 2 million parts per year.

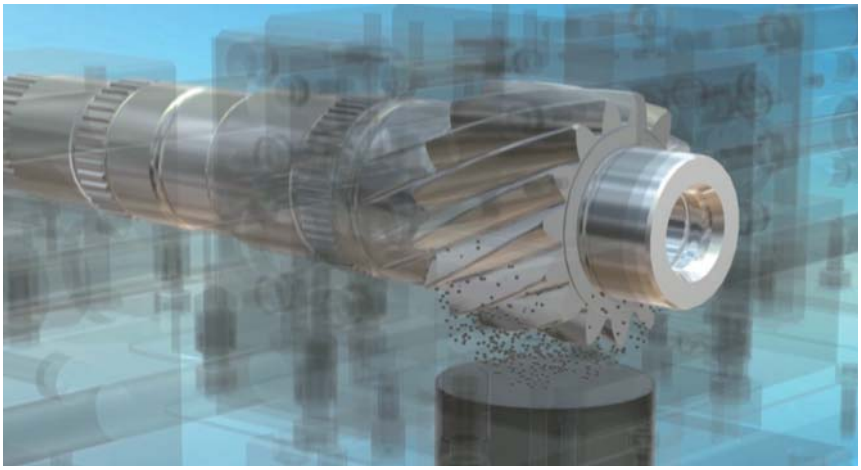
(?) MFN: What are the challenges for you to develop your USP solution for the automotive market further?

(!) F. C.: From a process point of view, the requirements for transmission parts are really demanding. USP has proven that it is efficient and reliable for such critical applications. We manage to induce homogeneous high surface compressive stresses on teeth flanks and teeth roots (e.g .-1100 MPa / -145 Ksi).

(!) J. T.: Today, we can quickly provide standard interchangeable stations that enable the customer to gradually equip the production machine to comply with ramp-up periods and optimize their ROI.

« Currently, one machine in two we design and build is to be incorporated into automotive production lines. We are now developing machines to be delivered in the next coming years that can go up to 2 million parts per year. »

Frédéric CHATEAU, Process Manager, SONATS



Stressonic® Ultrasonic Shot Peening output shafts dynamic treatment
Nota: 3D Animation is available on SONATS YouTube channel ETsonats

We have been providing machines with different level of automation. For low-production rate applications or pre-series before ramp-up, semi-automatized solutions are solicited, with manual handling of the part, through man's-height access windows. Highly automatized machines include functions like media counting (in units or grams), media wear-out individual alarm and replacement, global supervision and periodical quality report issuance.

(?) MFN: Are you able to provide robotized systems?

(!) F. C.: To comply with the most demanding production rates, we provide fully robotized cells with handling of the parts directly from the previous process operations. Especially in gear-peening USP machines, we implement the shot-peening process in dynamic mode. In the latest delivered machines, we reach for example, a 40s takt time with a 4-station machine for a global volume of 500'000 treated parts per year.

(!) J. T.: For parts handling, loading/unloading from the machine and baskets management – complying with lean manufacturing requirements, and reducing pre- and post- peening operations – we are partnering with automation specialists like GEBE2, a subsidiary of our Europe Technologies Group.

(?) MFN: What are the key advantages of your production machines?

(!) J. T.: Well, for all kind of parts, the main advantage to integrate USP is that the machine, which has a small footprint (e.g. 4-station machine for output shafts USP: 2.40mx4mx2.5m), can be directly embedded in the global production line, even in white rooms. It precludes the customer from encountering either subcontracting costs or time wastage – mainly avoiding shipping operations or from internal flows from a workshop to another to bring the parts to a conventional shot peening machine.

(!) F. C.: As we first explained, treatment is performed in a hermetic chamber; we don't need to carry out realize masking operations. Also, shots used are perfectly spherical ball-bearing media that do not abrade the surface so you do not need to decontaminate or clean the part after ultrasonic shot-peening operations. This often reduces the global cycle time.

(!) J. T.: We have been working on optimizing the energy consumption (electricity and compressed air); it is actually really low: 400V, 5kW, 60m3/h. And to further answer your question, concerning financial advantages, the global ROI of the USP integration in production line is consequent. It of course varies from one application to another, but average treatment cost per part including machine amortization, wear-out parts and consumables is less than 1€/part over 5 years.

(?) MFN: You are mainly talking about gears and transmission parts; do you have any experience on other automotive parts?

(!) J. T.: We did develop machines and qualify the process on parts other than pinions, transmissions shafts or gears. We deal with different materials such as various steel alloys –treated and untreated, aluminum, and Inconel alloys for parts like crankshafts, camshafts, connecting rods, head cylinders, injectors, turbo wheels, compressor wheels, and stab bars…

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

(!) F. C.: We actually not only improve fatigue life of components but also welded structural parts, with another process called Ultrasonic Needle Peening – UNP (also called UIT – Ultrasonic Impact Treatment).

(?) MFN: In what extend does this Ultrasonic Needle Peening process differ from Ultrasonic Shot Peening?

(!) F. C.: The process uses the same base technology as USP, the STRESSONIC® ultrasonical activation of media.
The treatment principle differs in the media used: instead of using ball-bearing type media, we use one needle with a controlled impact radius. UNP is focused on the treatment of the Achilles heel of the assembly; the weld toe.
Through the localized high frequency hammering, the process induces high and deep compressive stresses at the weld toe.
Junction between base material and filler metal, as a notch effect, represents a critical stress concentration on the welded assembly. Controlled impact radius of the needle creates a smooth groove at this junction, which optimizes the applied stress spread.

(!) J. T.: Engine sub-frame, axles, chassis, and welded levers are typical parts for which UNP is an efficient alternative to processes focusing either on stress relaxation or compressive stresses introduction processes, or weld toe geometry modification.
Process qualification on these parts is really promising and our robotized solution will be ready soon!

MFN would like to thank Juliette TRICOIRE and Frédéric CHATEAU for this interview!

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