On-Aircraft Shot Peening Application using the Stressonic® Process

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ABSTRACT
Aerospace operators are always looking at methods of reducing the down time of their components while ensuring a high level of control and safety in their maintenance operations. Until recently, shot peening of components while fully assembled on the aerospace (aircraft/helicopter) has resulted in a process that was either lacking in control or that created a very high risk of foreign object damage (FOD).
We will show the potential interest by using ultrasonic technology for reducing maintenance cost and increase fatigue life.

SUBJECT INDEX
Stressonic®, Ultrasonic Shot Peening, Fatigue life enhancement, Residual Stress, Repair.

INTRODUCTION

This article looks at different shot peening technologies used in maintenance operations. Conventional peening and Stressonic® peening are evaluated using case examples on typical aerospace such as landing gears, lower wing skins and aero engine components. The different technologies are evaluated using parameters such as process control, ease of operation, potential for FOD, rapidity of deployment and cost. Compressive residual stress distributions, surface roughness and fatigue results are also presented for some of the components to add a technical dimension to the evaluation.

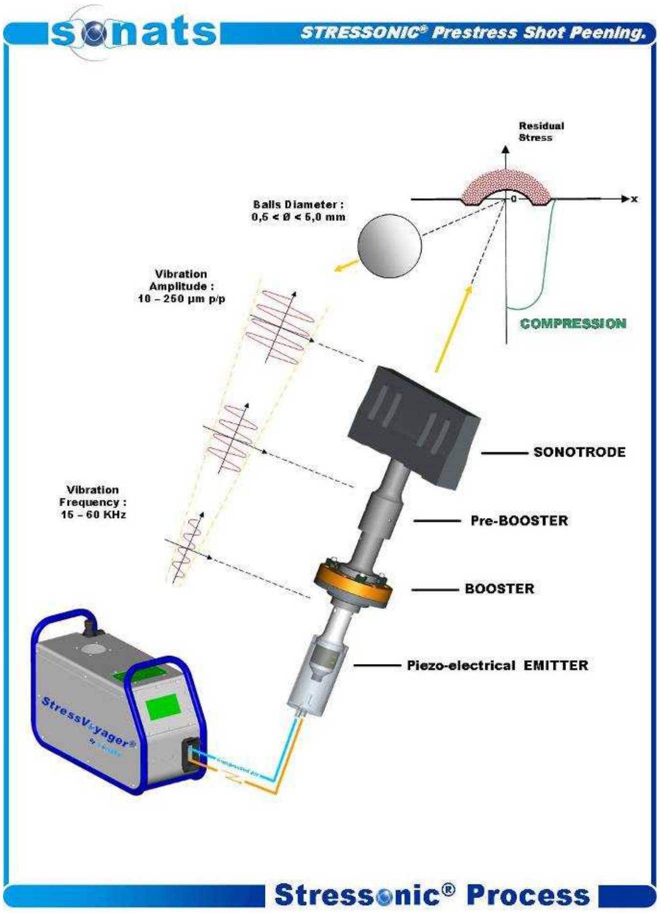
The STRESSONIC® process is a surface treatment by impacts which consist to throw projectiles on a mechanical part in order to improve its fatigue life. Projectiles are put in movement by metallic elements forming an "acoustic block" and vibrating with an ultrasonic frequency.
We can use bearing balls of projectiles named Spherils (like needle) more dedicated to hammering and straightening.
For Fatigue life enhancement of strategic components, we are using bearing balls, as described by the following drawing.

The sonotrode led to a housing containing balls and closed by :

- the sonotrode surface,
- the part to treat,
- and a treatment chamber making this enclosure ball-tight.

Longitudinal vibrations of the sonotrode surface randomly throw balls into the treatment chamber as molecules into a gas. Therefore, the treatment is homogeneous on all surfaces of the enclosure and consequently on the part area to be treated.

Finally, pieces to be treated are uncoupled from the treatment chamber and are not crossed by ultrasonic waves.
The drawing 1 presents the STRESSONIC® process principle:



Drawing 1 : Stressonic® with bearing balls for fatigue life improvement

Today a lot of application was made all over the world by Sonats into the AeroSpace, Energy, Power Generation,….

Ultrasonic Shot Peening, named Stressonic® technology [3], was developed by SONATS, France. The mainly characteristic of Stressonic® could give the smooth surface after operating compared to the conventional shot peening because of using polished bearing ball.

APPLICATION FOR STEEL COMPONENTS: STRESSONIC® APPLICATION FOR AEROSPACE COMPONENTS. EXAMPLE FOR LANDING GEARS

For these tests we chose the alloy E35NCD16 (thermal treatment to reach Rm 1800 MPa) and electrolytic chromium with a 100 µm grinding of residual chrome.

The sample FRE50 with a Kt = 1,035 had been chosen as described by the figure 2 :

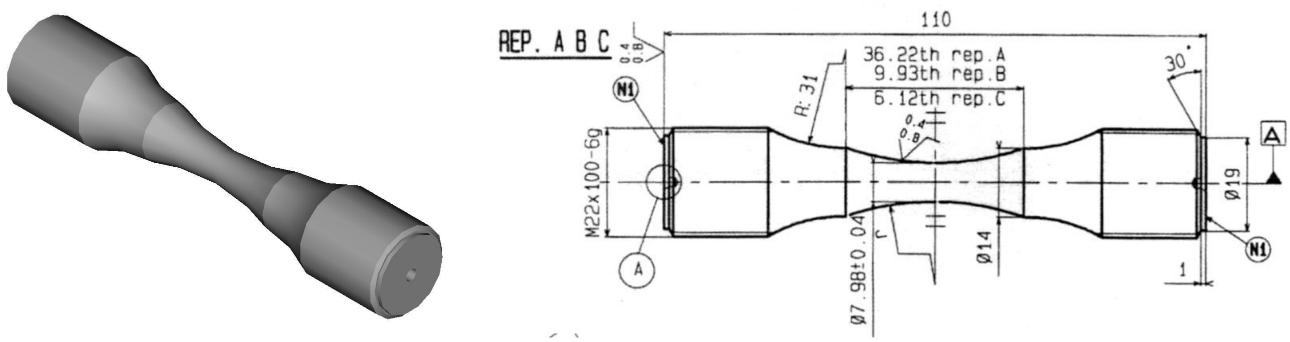


Figure 2 : Fatigue sample FRE50 (Rep A : Kt = 1,035)

For these test we made a comparison between conventional shot peening and Stressonic®. To be sure that the comparison between the 2 processes is perfect, we decided to take-off all fatigue samples into the same forged part in E35NCD16 steel, into the same direction (longitudinal direction).

Fatigue samples where peened by conventional peening and Stressonic® with the target to achieve a F30-50A Intensity.

For Stressonic®, the following tooling (Figure 3) where built to be able to peen the fatigue sample:

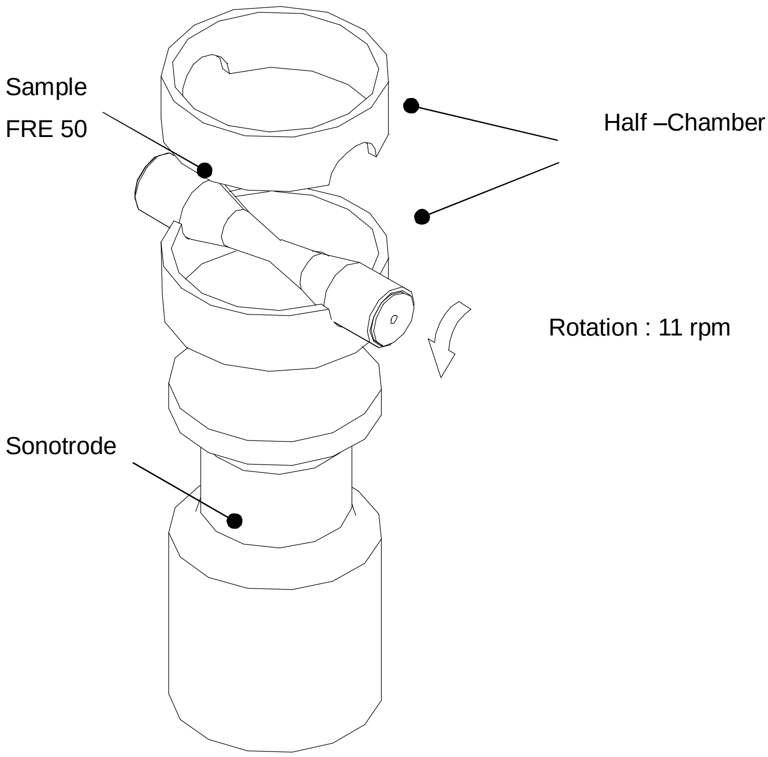


Figure 3 : Tooling

The following table (Table 1) show the parameters used for the fatigue sample peening for each process : conventional and Stressonic® :

STRESSONIC®	
Balls used :	100C6 – Ø 2,0 mm – 63 ± 3 HRC
Mass of balls :	M_2
Amplitude :	A_2
Peening time :	T_2
Coverage :	150 %
ALMEN Intensity :	F45A ± 1

CONVENTIONAL PEENING WITH AIR TYPE	
Media used :	S230S
Coverage :	150 %
ALMEN Intensity :	F45A ± 1

Table 1 : Stressonic® and conventional shot-peening parameters

After peening with the two processes, the samples had a chromium process, then grinded. All the fatigue samples where putted into the same chrome bath to avoid any results dispersion. The grinding was made with the same direction and the same tools for all samples.
The following table (table 2) shows the chromium parameters applied:

CHROME 120A	
DURATION :	7h 30
VAPOR RELIEF TIME :	24h
VAPOR RELIEF TEMPERATURE:	190° C

Table 2 : Chrome parameters

All different treatment (peening + chrome + grinding) where made onto the all surface except the fillets and faces.

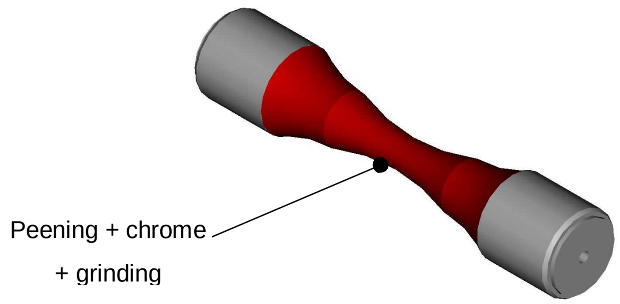
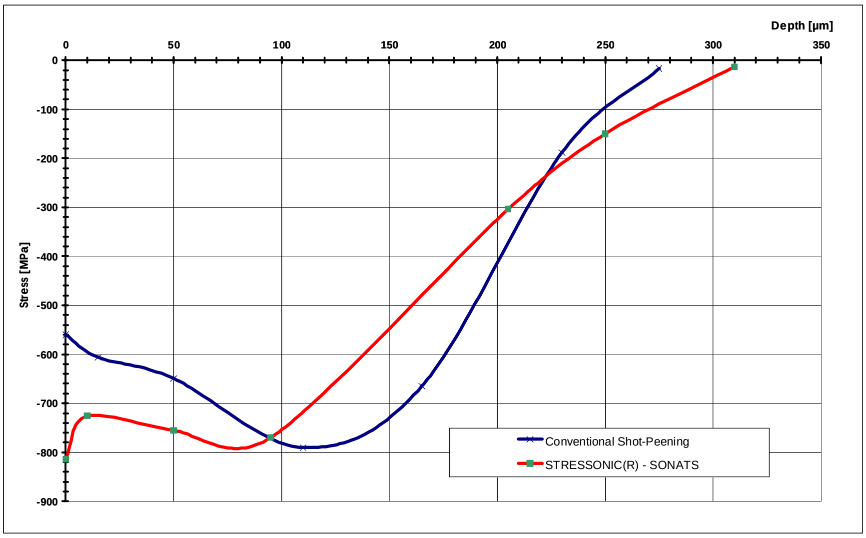


Figure 4 : Area peened + chromed + grinded

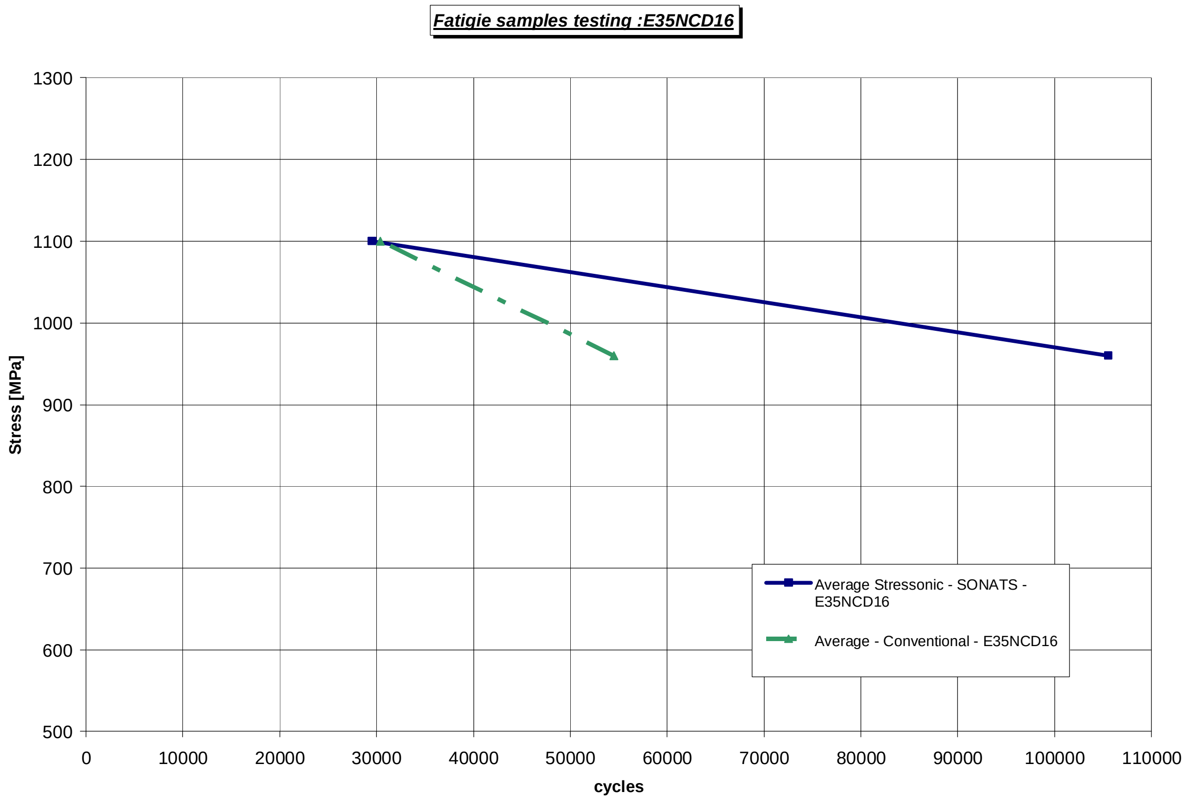
The following curves (Curve 1) shows the residual stresses profiles achieved by X-Ray Diffraction and chemical removing for measurement in depth, for each process. The curves show the stress profile for conventional shot peening and for Stressonic®.



Curve 1 : Residual stress profile for conventional and Stressonic®

Fatigue Life results where made at room temperature and with 2 dedicated stress levels. Curve 2 shows the results and difference between conventional and Stressonic®

- Tests with two (2) stress levels : 960 & 1 100 MPa with a machine stop at respectively 1 000 000 & 400 000 cycles,
- Use of 4 samples by stress level,
- Solicitation ratio : 0,1
- Frequency : 100 Hz



Curve 2 : Fatigue results for conventional and Stressonic®

The results show a fatigue life improvement of the component by using the ultrasonic shot peening method.

APPLICATION FOR ALUMINIUM COMPONENTS: STRESSONIC® APPLICATION FOR AEROSPACE COMPONENTS. EXAMPLE FOR STRUCTURAL PARTS

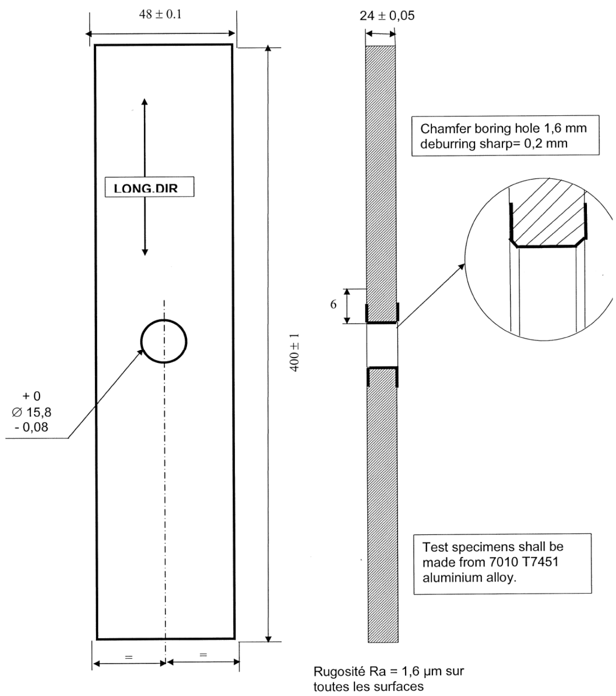
Target of this study is to demonstrate the fatigue life enhancement of a shot peening process like ultrasonic process in the way to validate the technical interest to use it in case of manufacturing but also repairing “under wing”.
We do not want hereinafter to present all test made, but to show a sump-up of test performed.

Two (2) kinds of fatigue samples geometries where use :

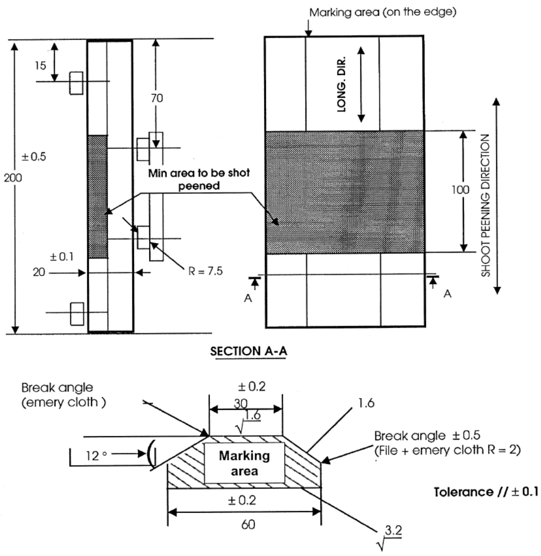
- holes samples (7010 T7451)
- four (4) point bending (alloy 7010 T7451)

For each geometry, conventional and Stressonic® where applied. Residual stresses, roughness and fatigue test where performed.

Pictures 1 show the geometries of each sample:



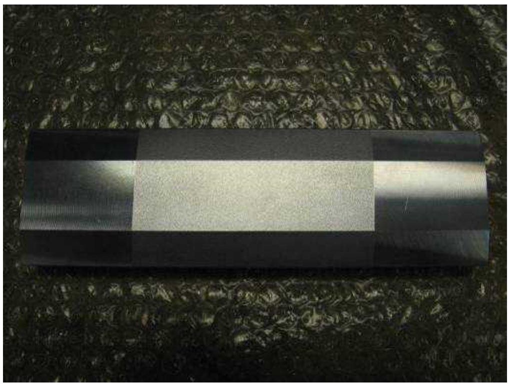
Picture 1 : hole fatigue life sample

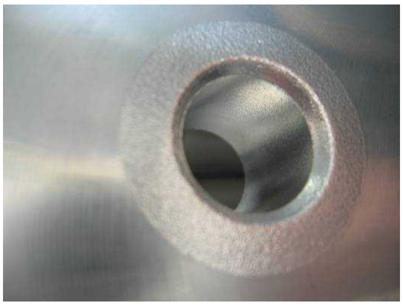


Picture 1 : 4 points bending life sample

Peening surface by Stressonic®

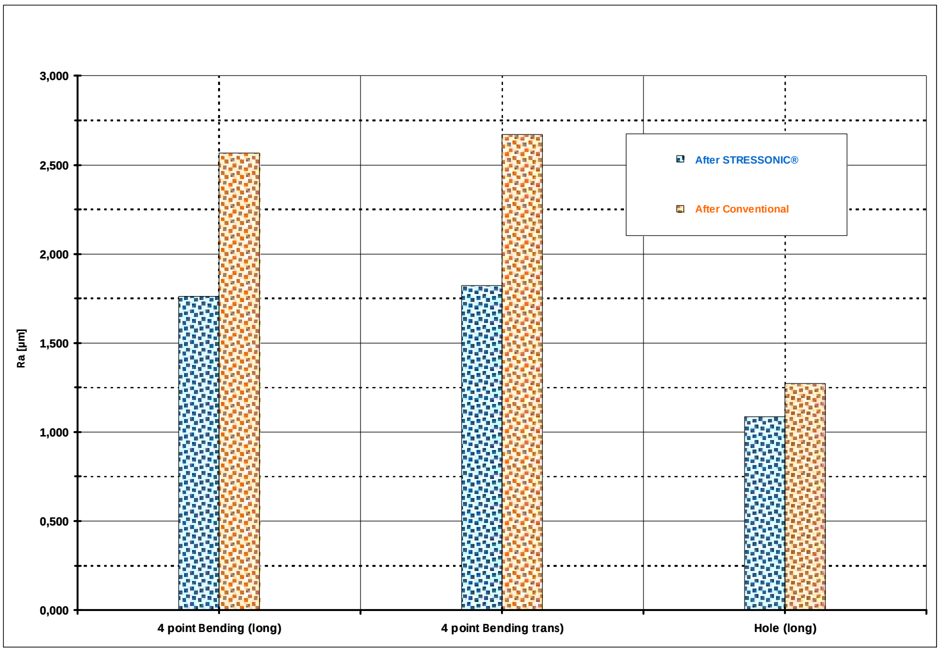
The following pictures show the peening area and surface obtained by Stressonic®



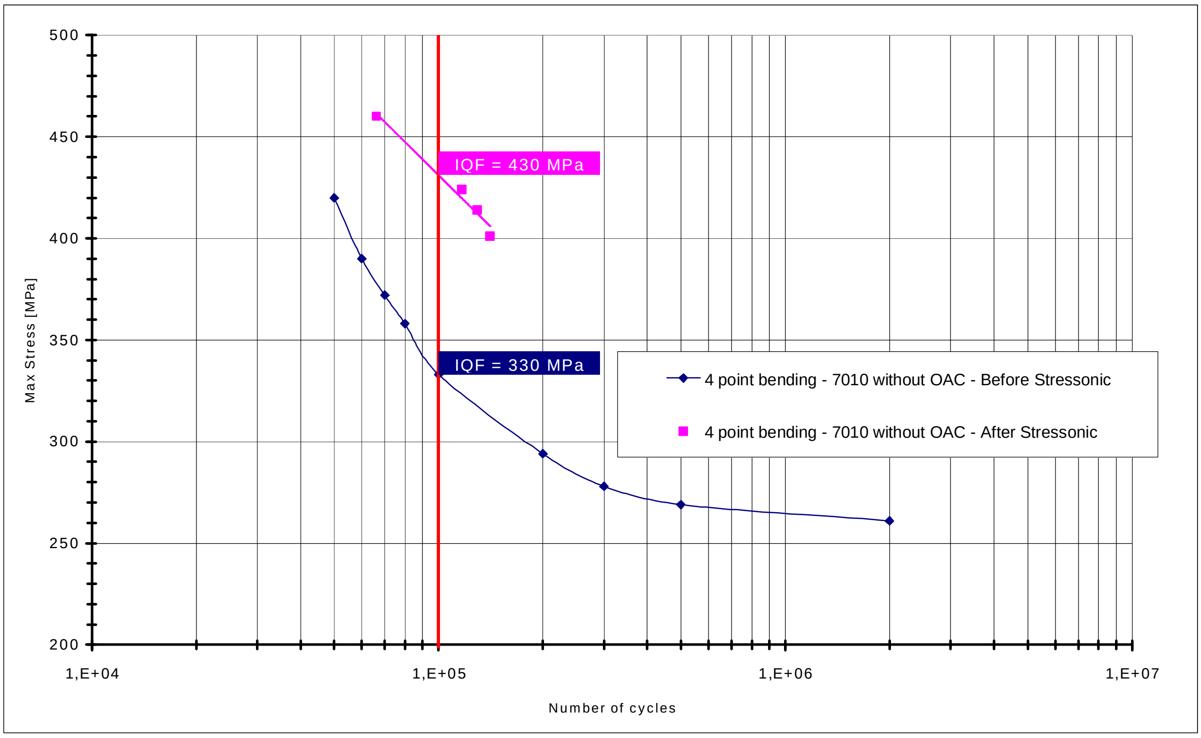


Area peened by STRESSONIC®   *Area peened by STRESSONIC®*

For both conventional and Stressonic®, and the two samples geometries, we measured roughness and residual stress profiles. Only roughness are presented here.



The fatigue test where made only onto the 4 points bending samples. It is show hereinafter.



Here the target of IQF was 390MPa. We achieved with Stressonic® 430MPa (at 10000 cycles).

CONCLUSION

We confirmed the interest for using Stressonic® on High Strength Steel and aluminum to be able to use it for both manufacturing parts and repair.
We show here in after some example of repair "UnderWing".