THE INTEREST TO USE TUNGSTEN CARBIDE BALLS WITH STRESSONIC® ULTRASONIC SHOT-PEENING PROCESS : APPLICATION TO AERO ENGINES PARTS.

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1 - ABSTRACT

Ultrasonic Shot Peening, Stressonic®, developed by Sonats, is applied in industry since several years.
In this paper we are presenting the principal of the Stressonic® process. We are focusing also on the application for aero engines parts, especially blades, Blisks and disks and the interest to use Tungsten Carbides bearing balls for cost reduction and fatigue life improvement.

2 - SUBJECT INDEX

Stressonic®, Ultrasonic Shot Peening, Fatigue life enhancement, Residual Stress, Tungsten Carbide, Aero Engines, Nuclear.

3 - Stressonic® PROCESS

The STRESSONIC® process is a surface treatment by impacts which consist to throw balls on a mechanical part in order to improve its life time. Balls are put in movement by metallic elements forming an "acoustic block" and vibrating with an ultrasonic frequency.

A generator delivers a sinusoidal electric field which excites a piezo-electric transducer to convert this electric energy into an ultrasonic vibration (the frequency can reach 15, 20 or 40 kHz).

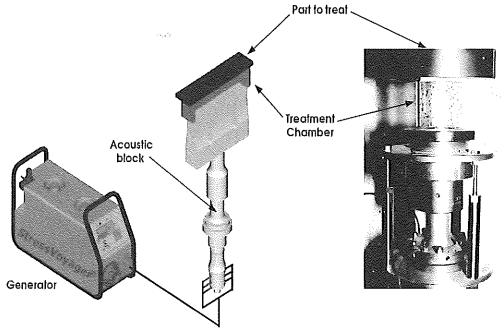
However, the vibration delivered by the emitter is too small to put balls in movement. Indeed, this vibration must be increased by a serial of pre-booster and booster in order to transmit an enough efficiency vibration to the terminal part of the acoustic block. This part named sonotrode is directly in contact with treatment balls.

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 treat.

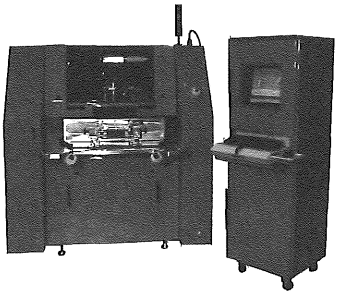
Finally, pieces to treat are uncoupled from the treatment chamber and are not crossed by ultrasonic waves. The following drawing 1presents the STRESSONIC® process principle:



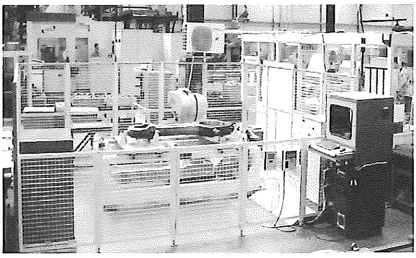
Drawing 1

4 - APPLICATIONS

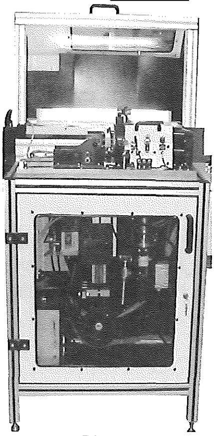
Today a lot of application was made all over the world by Sonats into the AeroSpace, Energy and medical fields.
We are introducing hereinafter some examples of application.



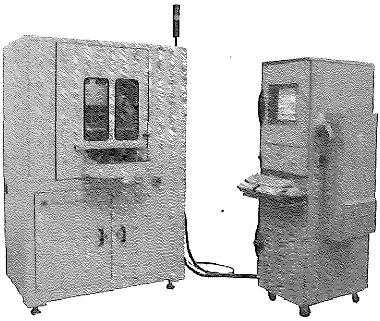
Picture 1 : textile parts



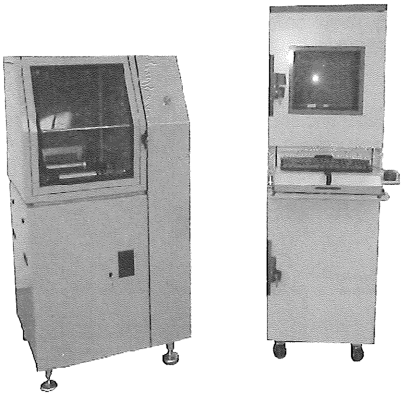
Picture 2: Energy Con Rods



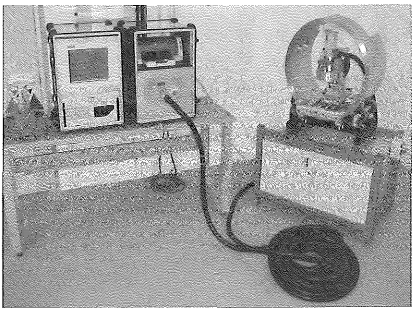
Picture 3: Automotive con-rods



Picture 4: HP/LP Blades



Picture 5: Rollers

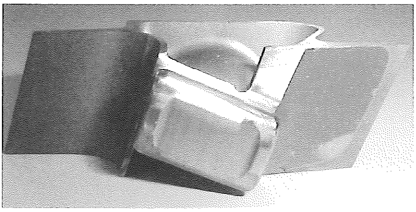


Picture 6; Nuclear Pipes repair

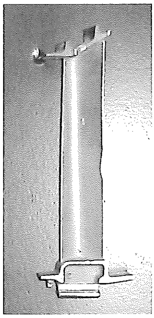
The main target for Aero Engines manufacturers is to have the higher fatigue life associated to a high cost reduction for their parts.
If we are considering parts with:

- Low radius to be peened with high intensity
- no edge rollers after peening
- avoid chemical decontamination,

Then there is no choice than to use balls with high density, high hardness associated to a multiaxis impact.
Tungsten carbide (WC) bearing balls are expensive, so only Stressonic® can be used with WC because we are using only a few grams of WC balls and the process creates a "gas" of balls.
We will introduce hereinafter a study we made on an application for Aero Engines blades.
Target is to introduce at least the same stress profile than Conventional Shot Peening.
The Pictures 7 and 8 introduce the Blade where the peening must be done.



Picture 7



Picture 8

The target is to peen the **blade root**.

Conventional peening parameters is described hereinafter

CONVENTIONAL SHOT PEENING CONDITION	
Type of test strip	A
Shot size	S110
Arc height (mm)	0.152-0.203
Coverage	More than 100%

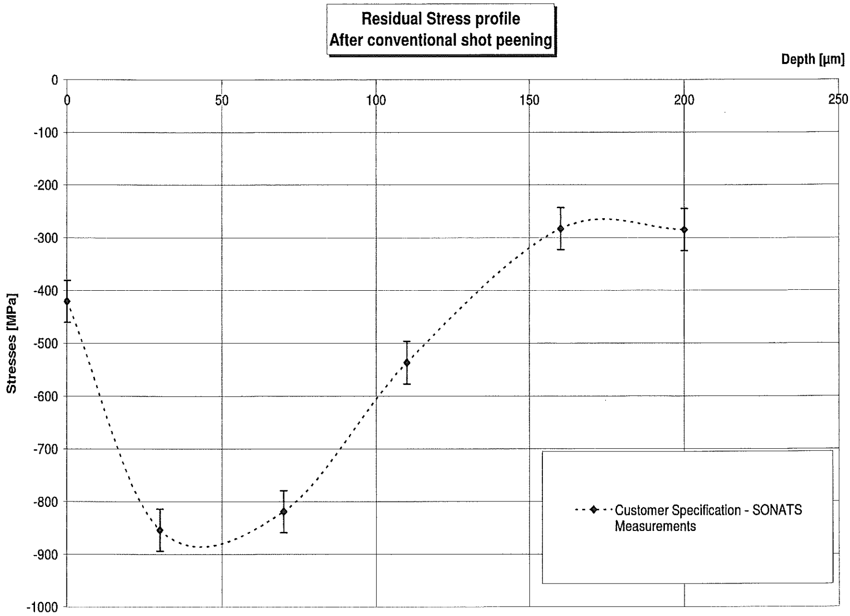
Table 1

The Strategy for Stressonic® development was to compare Conventional shot peening vs Stressonic® in the way to achieve at least t he same results.

5.1 – Conventional Shot Peening evaluation

We took a blade peened by the customer and performed a residual stress analysis by X-Ray Diffraction.
The measurement was performed onto IN718 samples positioned into the right position. These samples were used because the original material structure of the blade can not allow to perform X-Ray measurement (grain sizes to big).

The curve 1 shows the residual stress profile for Conventional shot-peening.



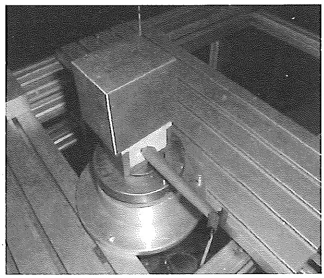
Curve 1 : Residual stress profile after conventional shot peening

5.2 - STRESSONIC® optimization

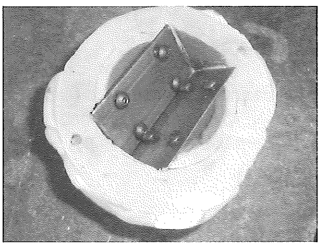
Fixtures

The pictures 9,10 and 11 present the fixtures which have been made for this study :

Picture 9 : Treatment chamber for blade's root

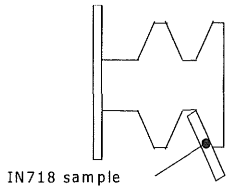


Picture 10 : Treatment chamber for blade's root



Picture 11 : Tooling for ALMEN saturation curves

The drawing 2 shows the localization of IN718 samples in the root of the blade:



Drawing 2

5.2.1 - STRESSONIC® conditions

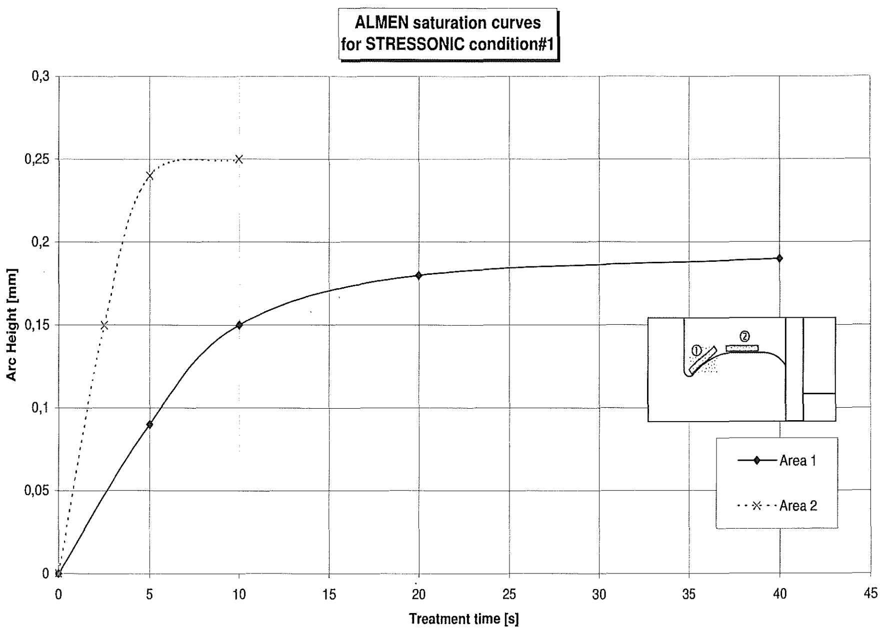
4 STRESSONIC® conditions have been tested on IN718 samples. The table 2 presents these parameters:

Condition	Sample	Type of balls	Mass of Balls [g]	Coverage rate [%]	Treatment time [s]
#1	#3	Ø 1.1/1.2 WC – 1800 Hv	11.0	125	30
#2	#4	Ø 0.91 polished WC	10.0	125	35
#3	#5	Ø 0.91 polished WC	6.0	125	35
#4	#6	Ø 0.91 polished WC	5.0	125	35

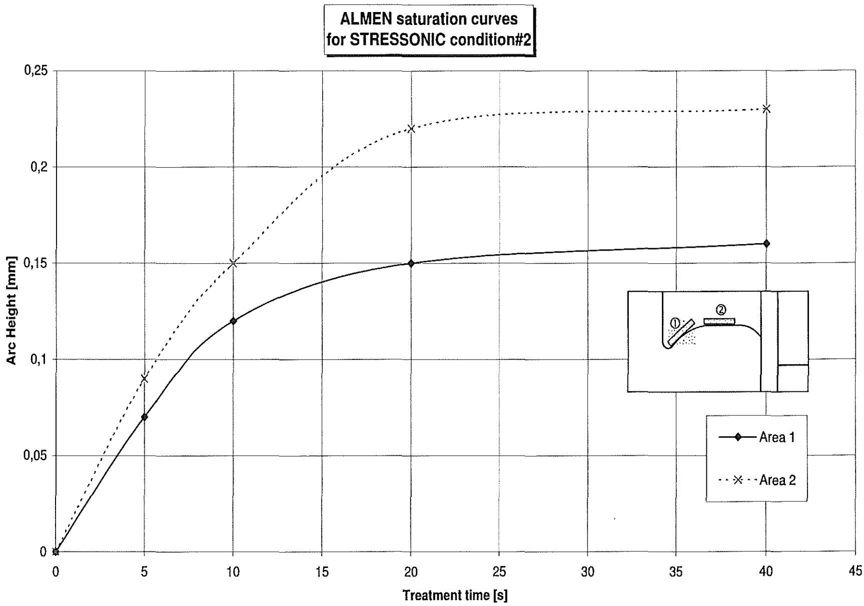
Table 2: Stressonic® parameters

5.2.2 - ALMEN intensity

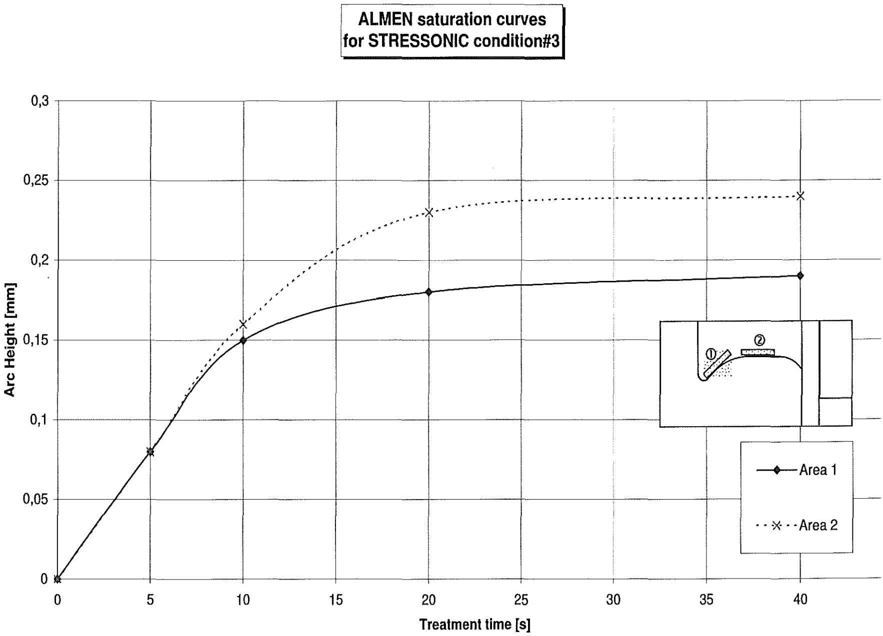
ALMEN saturation curves were made for each condition.



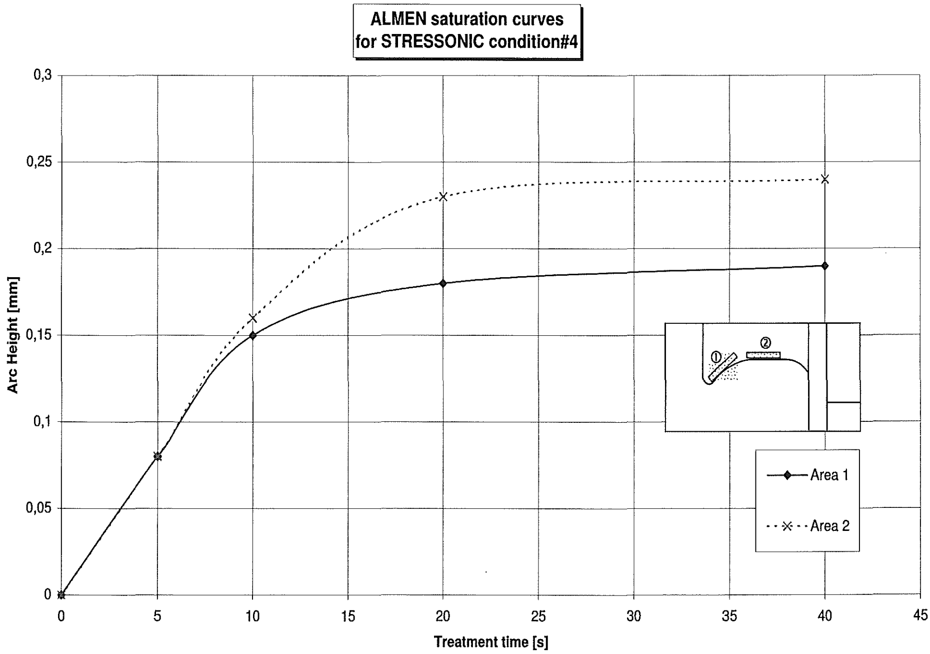
Curve 2 : Condition#1



Curve 3 : Condition#2



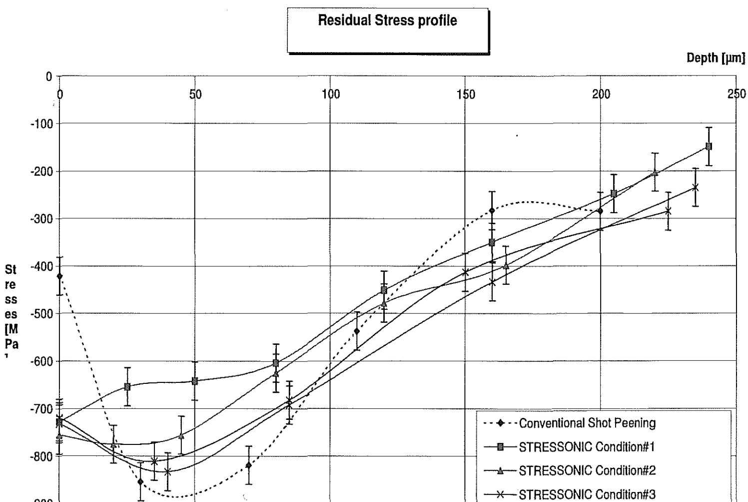
Curve 4 : Condition#3



Curve 5 : Condition#4

5.2.3- Residual stress profiles

Residual stress profiles have been determined with the measurements performed on IN718 samples, located on the root of the Blade and treated with conditions 1, 2, 3 and 4. The Curve 6 shows these profiles:



	Stressonic 3	Conventional
Ra (µm)	1,85	2,58
Almen Intensity	F18A (Real)	F15/20A (spec)
Compressive Surface Stress	732 Mpa	421 Mpa

Curve 6 : Residual stress profiles – Conventional Shot Peening vs. Stressonic®

5.3 – Conclusion for the WC study

We show that Stressonic® with WC bearing balls give a lot of advantages:

- Higher compressive residual stress on the surface
- Lower roughness
- Avoid chemical decontamination
- Possible to increase the Fatigue life because of higher compressive residual stresses (higher hardness and density of the shots) but also because that no need of chemical decontamination. Some fatigue life test was made under customer confidentiality. This will be published later of during oral ICSP9 presentation.

(1) Jean-Michel Duchazeaubeneix, Sonats, France, Proceedings of ICSP 7th , 1999