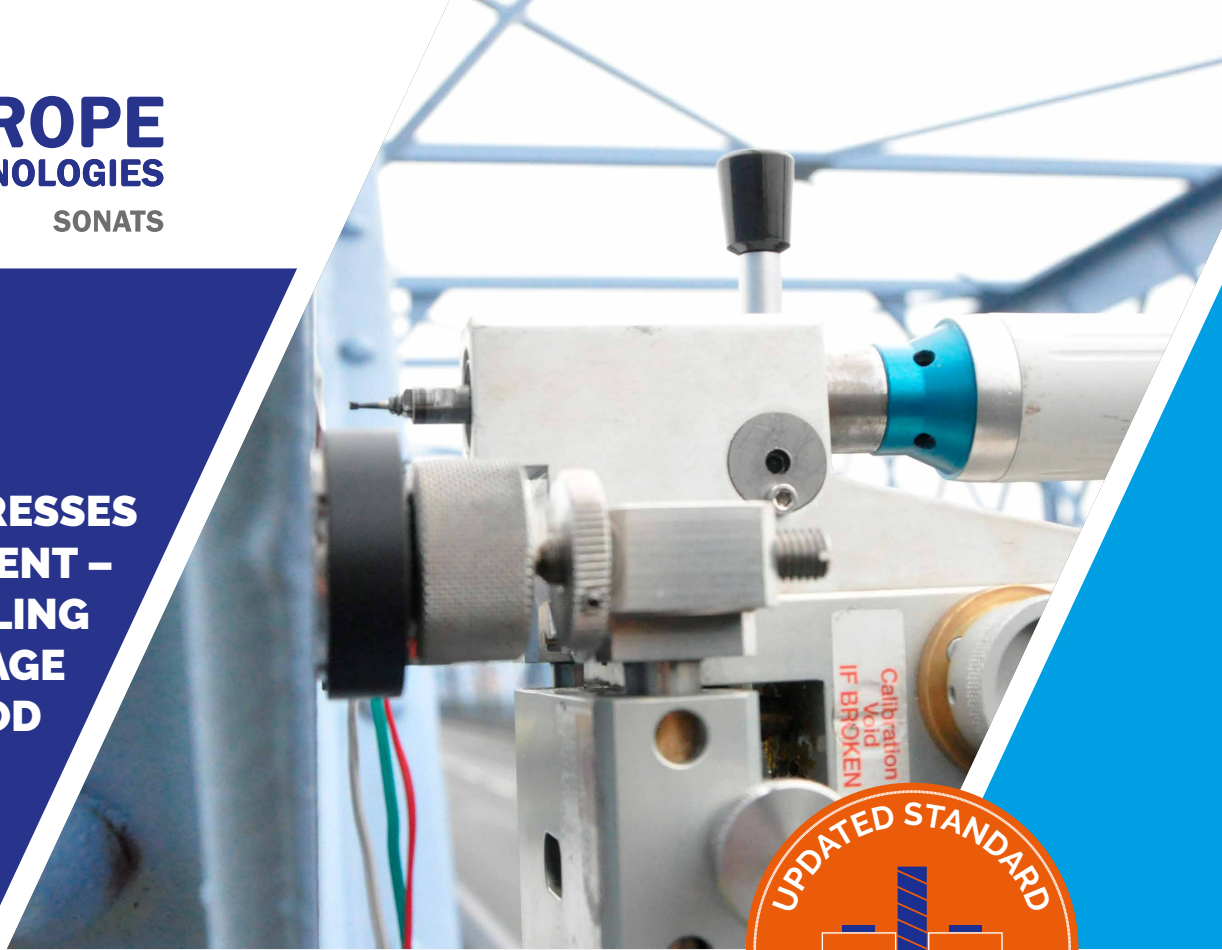




## RESIDUAL STRESSES MEASUREMENT – HOLE-DRILLING STRAIN-GAGE METHOD



### OBJECTIVES OF THE METHOD

- Product inspection and qualification
- Optimization of manufacturing process
- Preventive maintenance anticipation

The incremental hole method, also known as hole drilling followed by strain gauges, is able to determine residual stresses into depth. SONATS performs hole drilling measurement with full compliance to ASTM E837 standard “Standard test method for determining residual stresses by the hole-drilling strain-gage method”.



#### Other methods for measuring residual stresses at SONATS

- Non-destructive X-ray for surface analyses only
- X-ray diffraction + electrochemical etching → analyses into depth
- Deflection method
- Mechanical relaxation methods
- Access to large scale facilities for specific applications requiring non-destructive in-depth measurement (synchrotron X-ray, neutron)



## HOLE-DRILLING STRAIN-GAGE METHOD – HOW IT WORKS

Our fully-automated advanced measurement system can be used as a laboratory-based or portable system. SONATS performs hole drilling measurement with full compliance to ASTM E837 standard “Standard test method for determining residual stresses by the hole-drilling strain-gage method”.

Testing procedure involves attaching a strain gages rosette to the surface, drilling a hole at the center of the rosette and measuring the resulting relieved strains. The residual stresses within the removed material are then calculated using inverse calculation method, based on data derived from finite element modeling of the elastic and isotropic behavior of the material.

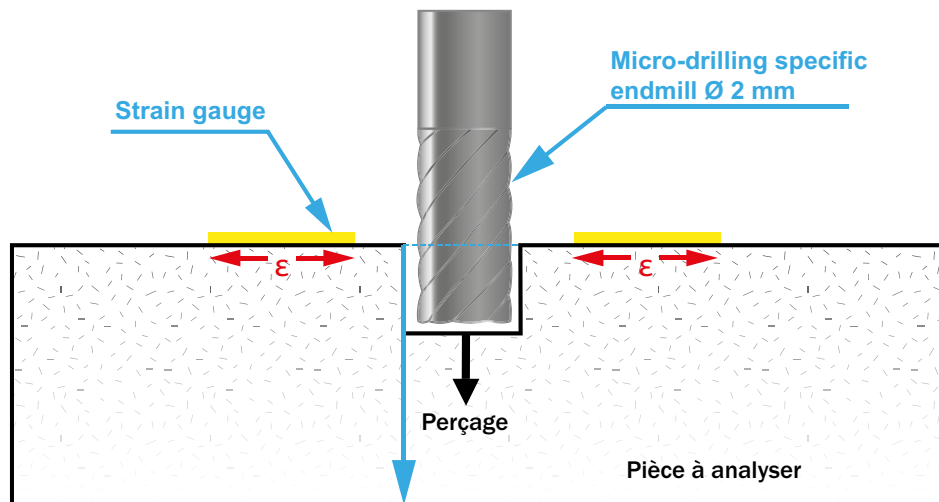


Figure 1 : Hole-drilling strain-gage method

### BENEFITS

**Fully-automated advanced measurement system**  
(SINT Technology)

#### High quality drilling

Process repeatability: ultra-high speed of drilling, milling cutter specially designed for testing

**Fast and cost-effective method**

#### In-situ / Ex-situ

Our system can be used as a laboratory-based or portable system

**Applicable for wide range of materials**

Polymers, composites, glass, metals, ceramics

### APPLICATIONS



**Metals** : Residual stresses in-depth profile after shot-peening process



**Polymers and composite materials** : Residual stresses analysis after manufacturing and shaping process



**Heat treatment**: Measurement before and after treatment

## OUR MEASUREMENT SYSTEM



Our fully-automated advanced measurement system (MTS3000) can be used as a laboratory-based or portable system.

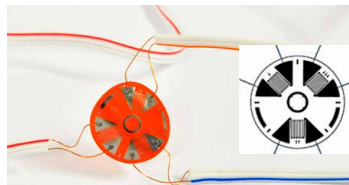
SONATS performs hole drilling measurement with full compliance to ASTM E837 standard “Standard test method for determining residual stresses by the hole-drilling strain-gage method”:

- Motorized mechanical system with air/electric turbine/motor for drilling and microscope for positioning
- Electronic control module
- Amplifier to record material strains
- Control and calculation software
- Dedicated measuring modules (hard materials, polymers, composites, special inside-pipe installation)

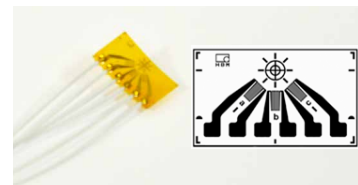
### Accessories



**Figure 2 :** (from top to bottom) endmill 4 mm diameter, endmill 1.8 mm diameter and an abrasive diamond endmill



**Figure 3 :** Strain gauge measuring up to 2.4 mm depth

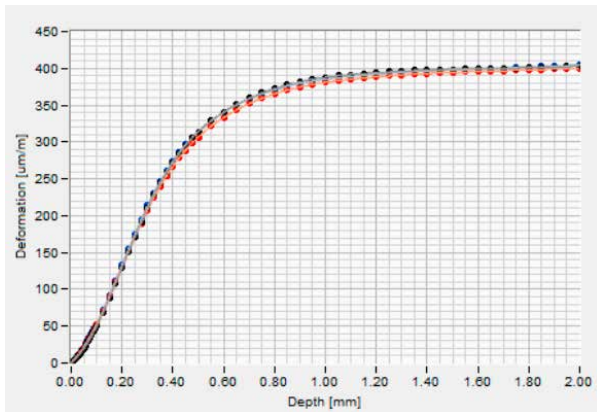


**Figure 4 :** Strain gauge measuring up to 2.4 mm depth

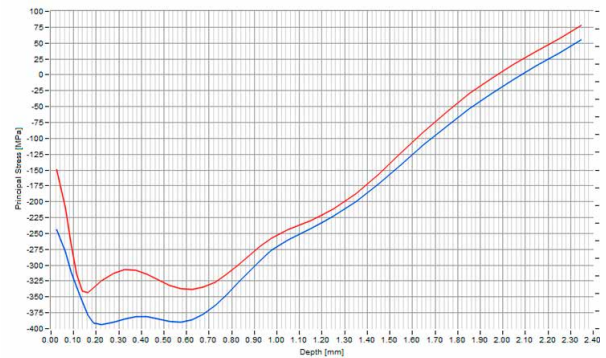
## MAIN STEPS OF THE METHOD

- 1 Bonding of the rosette and connection of the strain gauges**
- 2 Positioning of the equipment and the cutter in the center of the strain gauge rosette**
- 3 Configuring the test with the software**
- 4 Drilling and data collection**  
(automated sequence on the software)
  - Maximum hole depth
  - Number and distribution of depth increments
  - Drilling speed and feed speed
  - Kind of rosette and acquisition system
  - Waiting time for the recording of data at each increment
- 5 Measurement of hole dimensions and positioning after drilling**  
(possible eccentricity with respect to the rosette or ovality of the hole)
- 6 Calculating the stress profile with the software**  
(Uniform stress according to ASTM E837-13, Non-uniform stress according to ASTM E837-13, Integral method, Schwarz-Kokelmann method)

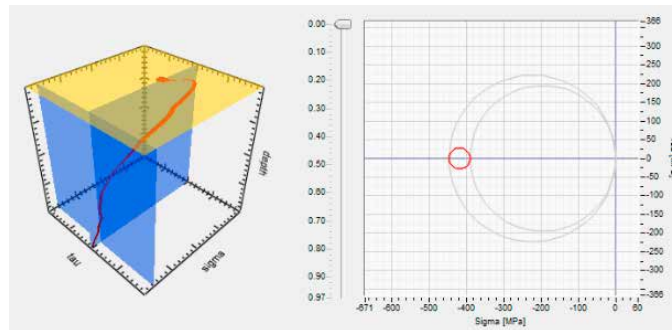
## EXAMPLE : TYPICAL RESULTS AFTER SHOT PEENING



Recorded micro-strain\*



Residual stresses profile\*  
(non-uniform stress form surface up to 2 mm depth)



Principal directions and principal stresses, Mohr's circle

\* shot peening aluminium specimen

## CERTIFICATIONS, DELIVERY TIME AND COSTS

- Analyzes are performed according to ASTM/ISO standards and international good practice (Standard ASTM E837)
- SONATS is ISO9001 and EN9100 certified
- Our residual stresses laboratory is recognized and certified by the SAFRAN aerospace group
- SONATS is an active member of GFAC (French national association for the analysis of residual stresses)
- As a result of a proactive management and strong experience, SONATS minimizes analyzes costs performed in the shortest achievable schedule.



## PERSONALIZED FOLLOW-UP AND SUPPORT

Our laboratory gathers a team of qualified and experienced engineers and Phd. They are experts in physics, mechanics, materials and metallurgy.

- Problem definition
- Drafting of specifications
- Description of the technical program for recommended analyzes
- Measurement performed according to ASTM/ISO Standards
- Results analysis and discussion
- Results valorization
- Technical outlook for product quality improvement and process optimization

