GNR OPTICA

ANALYTICAL INSTRUMENTS GROUP

StressX

StressX

www.gnr.it

About us

G.N.R. S.r.l., thanks to its 30 years of experience, is a worldwide market manufacturer of advanced analytical instruments, developing procedures of analysis for various applications, supplying the corresponding laboratory equipment and providing consulting and Customer support worldwide, through its well established sales and post-sale network.

G.N.R. S.r.l. projects and manufactures Optical Emission Spectrometers (OES) and Rotating Disc Electrode Optical Emission Spectrometers (RDE-OES) for the measurement of elemental composition of metal alloys and the analysis of contaminants, additives and wear metals in oils and lubricants, coolants and hydraulic fluids.

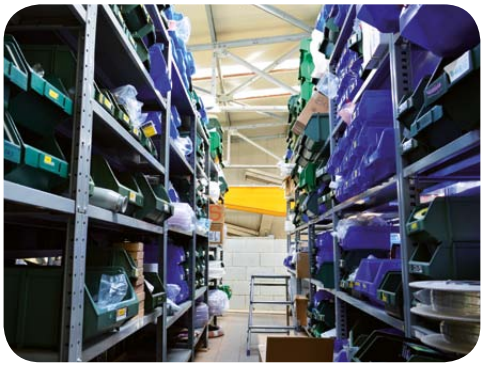
G.N.R. S.r.l. designs and produces X-Ray Diffractometers (XRD) and X-Ray Fluorescence Spectrometers (XRF) for the study of material structure and elemental composition for both scientific and industrial applications.

GNR Head Office and Production Site is located in Agrate Conturbia (Novara), near Lago Maggiore; 20 minutes from MALPENSA Airport.

Certified Company

Highest quality in our products and services is a core value for GNR.
Full commitment is dedicated to support our quality system in the overall process and continuous improvement is fundamental to guarantee GNR compliance to the internationally accepted quality management standard ISO 9001.

GNR periodically organizes at its facility courses and training for technicians and agents as well as seminars and demontrations.



Thanks to an extensive network of agents GNR provides technical support and delivers spare parts worldwide.

GNR Analytical Instrument offers equipment based on X-Ray Diffraction for measuring residual stress state and retained austenite content.

Residual stress could be induced by machining, grinding, rolling, deep drawing, welding, thermal hardening and shot peening; its quantification allows to prevent fatigue damage and to control material's durability and safety.

X-Ray Diffraction is the conventional and time proven technique for measuring residual stress. Using the interatomic spacing as the ultimate gage length, the X-Ray technique is ideal for and applicable to crystalline materials, especially for metals, but also for ceramics. It measures the absolute stress without the need of an unstressed calibration sample.

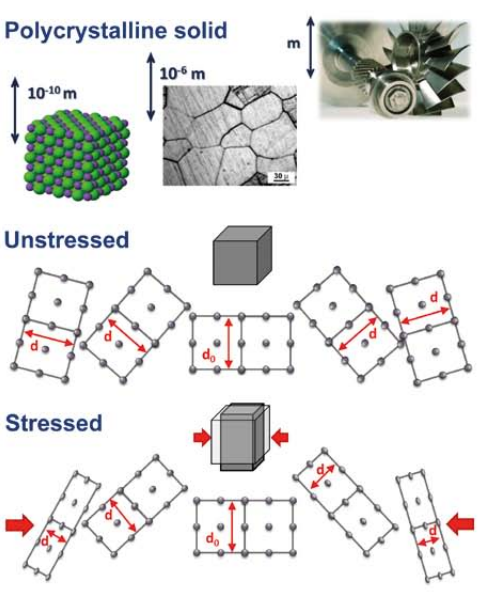
GNR StressX provides a flexible solution to residual stress determination on samples of any dimensions by the synergy between compact X-Ray diffractometer and 6-axis anthropomorphic robot.

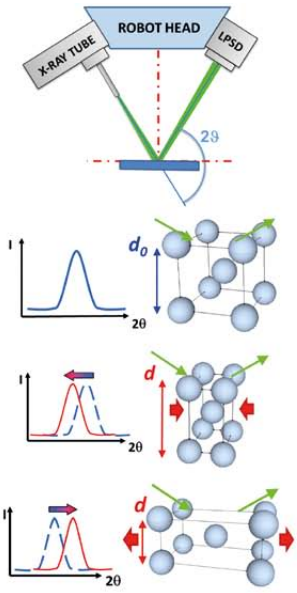
The goniometer mounted on an 6-axis anthropomorphic robot provides the possibility to analyze samples of any dimensions and shapes.

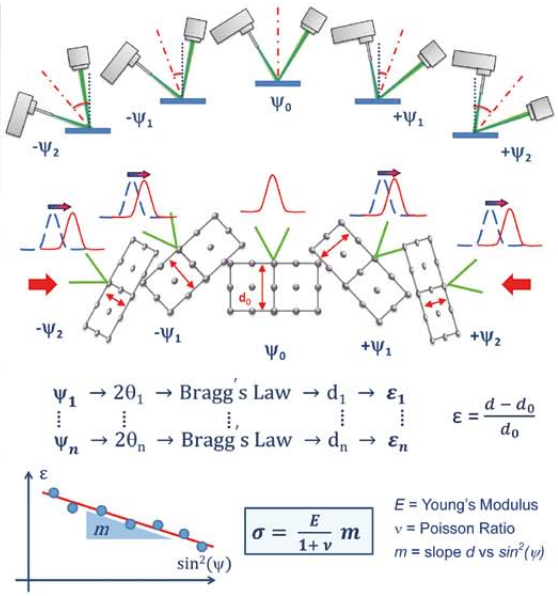
GNR StressX unit includes everything needed for making residual stress or retained austenite measurements by X-Ray diffraction.

GNR StressX system is equipped with the following main components:

- Main Unit
- 6-axis anthropomorphic robot
- Psi Goniometer
- Linear position sensitive detector
- Laser
- Software







Main Unit

StressX main unit can be mounted on a trolley or inside a cabin according to customer requirements.
It contains:

- Power Supply
- HV Generator
- Cooling System
- Control Electronic
- Controlling Unit

6-axis anthropomorphic Robot

The compact, powerful and high precision 6-axis anthropomorphic robot offers superior performance and allows to reach the measuring point with an accuracy and a repeatability in positioning better than 20 microns.

The robot handles all the goniometer functions such as tilting and rotation.
Automating mapping on complicated components can be also easily performed.
Robot is an absolute positioning reference system because an alignment procedure by zero-stress reference sample is not required whichever configuration is used.
Available in two different configuration working ranges, 895 mm or 706 mm.

Psi Goniometer

GNR StressX is equipped with a Psi goniometer with different radius available (120, 140, 160 mm).
The 2Theta value can be manually changed from 125° to 164° in order to analyze Fe (ferrite, austenite) Al, Ni, Cu, Ti and Mg alloys.
The robot head has been designed in such way that the user can easily change in few minutes the X-Ray tube without any special tools.

Detector

GNR StressX is equipped with a Multi Strip Detector. GNR integrates Dectris Mythen X-Ray Detector.

Mythen, linear silicon strip detector, based on single photon counting technology, provides noise-free performance, high intensity measurement and fast data acquisition.

The high efficient 1-dimensional multi strip detector simultaneously captures a large angular range and reduces measurement time from hours into minutes.

- The Mythen can decrease measurement time significantly down in comparison with a scintillator detector without affecting data quality like intensity, resolution and peak shape.
- Compact size, air cooled (no gas, water o liquid nitrogen needed) and maintenance-free detector.
- The Fluorescence background suppression by setting an appropriate energy threshold

MYTHEN2 R	1D
Sensor thickness [µm]	320
Strip width [µm]	50
Strip length [mm]	8
Dynamic range [bit]	4-24
Energy range [keV]	5-40
Readout time [µs]	300
Frame rate [Hz]	25
Point-spread function [strip]	1
Cooling	Air
Dimensions [WHD mm]	38x62x22
Module Weight [g]	100

As option other type of linear silicon strip detector is available on request.

Laser

The laser allows aligning the sample avoiding collisions between sample and measurement system.
The laser positioning system allows to align the instrument without any contact between the robot head and the sample.
Main advantages of this set up are:

- minimal time consuming for instrument alignment procedure
- possibility to measure components with non conventional geometries without any sample preparation
- possibility to avoid undesired collision between sample and measuring system

The laser accuracy is better than 2 microns with a measuring range of 150 +/- 40 mm.
The alignment procedure is done with a distance X-Ray collimator/sample of 70 mm and it is performed automatically without requiring any calibration.

Additional Components

Optics

Exchangeable 0.5, 1 and 2 mm monocapillary diameter collimators are supplied as standard. Special collimators with different spot sizes are available as an option.
A high focusing and brilliance polycapillary collimator with a focal spot of 120 microns can also be mounted to measure residual stress on very small detectable areas.

USB Video Camera

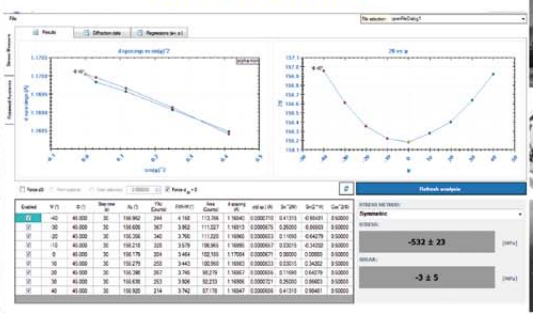
A professional USB video camera with a resolution of 5.2 megapixels is mounted on the robotic goniometer head and allows thanks to the laser to see the measurements area on the sample surface.

GNR StressX can be mounted either in a closed cabin, suitable for laboratory analysis, or on a four-wheel trolley for on-site analysis.

StressX TROLLEY
300 W transportable instrument
4 wheel trolley for on-site analysis
Integrated cooling system
6 axis anthropomorphic robot
Auto-alignment laser system

APPLICATIONS
Non destructive analysis for:
• Automotive, Naval and Railways
• Aerospace, Oil&Gas, Power and Nuclear
• Bearing and Gear Industries

StressX Software



StressX CABIN
300 W laboratory instrument
X-Ray proof closed cabin
Integrated cooling system
6 axis anthropomorphic robot
Auto-alignment laser system

Residual Stress Applications

Residual stress plays an important role with respect to the operational performance of mechanical parts; it affects material properties like fatigue, fracture, corrosion and friction.

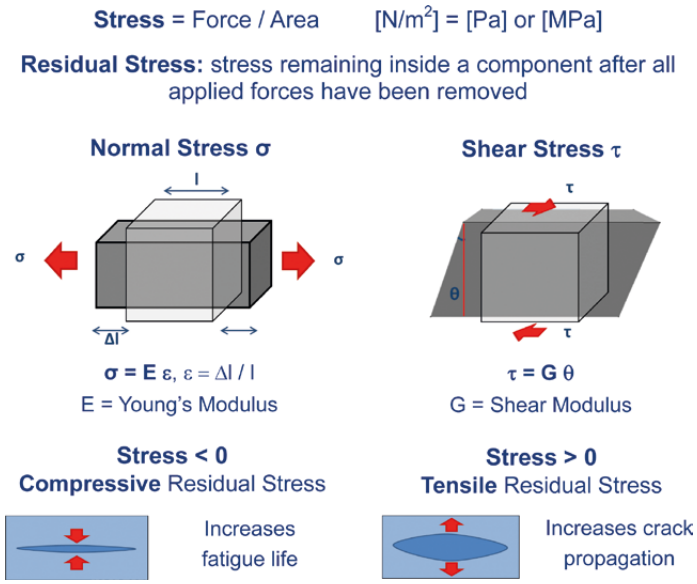
Residual stress is the compressive or tensile stress that remains in a compontent once an external load has been removed. Most of the manufacturing processes (mechanical, thermal, chemical), which lead to deformations and volume changes, induces residual stresses into components.
Knowledge of residual stress state is required to ensure that these processes have been correctly applied. Small changes in the residual stress state can often have a significant effect on the life of a component.

Mechanical processes to be considered in industrial applications are surface treatments, drawing, rolling, grinding and mechanical polishing, machining, and assembling.

Thermal processes residual stresses may arise from thermal gradients as well as from phase transformations, e.g. in the case of heat-treated steel. Examples are quenching, casting, butt welding, tempering, ageing, etc.

Chemical processes like oxidation, corrosion, electroplating, etc, are sources of residual stress too.

Effects vary from “near surface” region, caused by machining, grinding, to inner component regions caused by casting, welding, heat-treatment, etc.



Compressive residual stress increases fatigue life and stress corrosion because it delays crack initiation and propagation and helps to reduce stress level of the layers where the highest loads are applied.
Instead, tensile stress reduces the mechanical performance of components.

Different methods are available to measure residual stress but only X-Ray diffraction has the appropriate spatial and volumetric resolution to fully and adequately characterize the residual stress distributions often found in the areas.

XRD measurements allow to determine residual stress by investigating the distribution of deformations of the crystal structure and enable to control and optimize the process parameters performing a non-destructive analysis in the near-surface region of the component.

The small penetration depth of X-Ray enable also to draw depth profiling curves by measuring the stress state at different depth after electrochemical polishing of the component surface.

All materials with a sufficient degree of crystallinity can be analyzed; XRD measurement reliability depends on crystallinity degree, surface roughness, non-flat surfaces, highly textured material, coarse-grained material, broad diffraction lines.

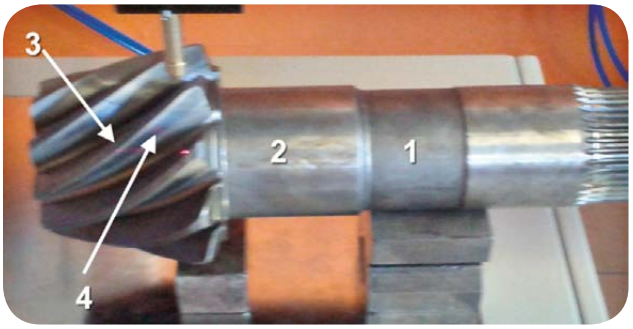
GNR StressX equipment has been designed to be a fast and reliable solution for Quality Assurance and Quality Control practices in manufacturing process for both laboratories and on the site use.
It is easy to use but at the same time it will be able to cover most demaning customer requirements.

Application Sample 1 > Transmission

Effects of grinding not properly performed

Residual stress measurements on different areas of the pinion, reported in the picture below, show as the grinding treatment performed on the teeth is not homogeneous; the stress state between the two sides is completely different and low values are recorded on the burned side.

Area	Treatment	RS (MPa)
1	GRINDING	-236 ± 6
2	SHOT PEENING	-648 ± 4
3	SHOT PEENING + GRINDING: Burned	-316 ± 13
4	SHOT PEENING + GRINDING: not Burned	-561 ± 3

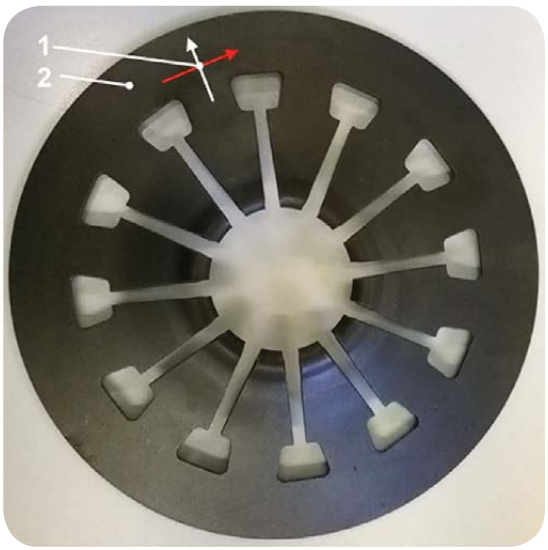


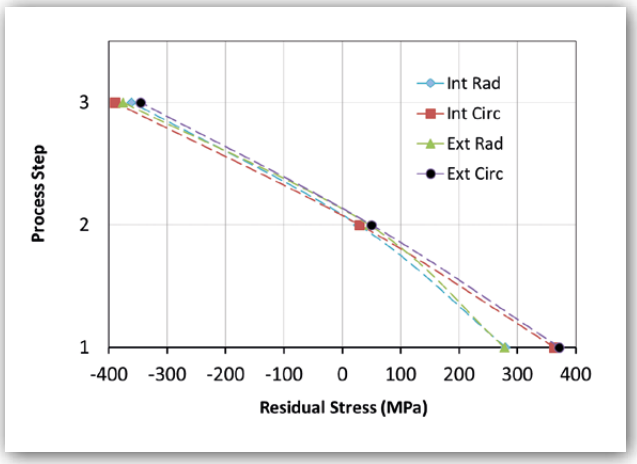
GNR StressX equipment, adopting X-Ray diffraction control, allows **investigating and understanding manufacturing process issues.**

Application Sample 2 > Diaphragm Spring

Residual stress measurements on disc spring at different manufacturing steps: casting (1), induction hardening (2) and shot peening (3). Sample has been analyzed along radial and circumferential direction (white and red arrow respectively) on both external (as reported in picture) and internal side.

Results show how during the production step tensile residual stress state can be transformed in compressive one.





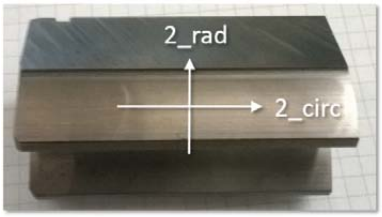
In some case, the residual stress induced by manufacturing processes can be predicted.
It remains often necessary to adjust the theoretical calculations through experimental results obtained by XRD measurements.
GNR StressX equipment, adopting X-Ray diffraction control, allows **the optimization of process parameters.**

Application Sample 3 > Surface Finishing

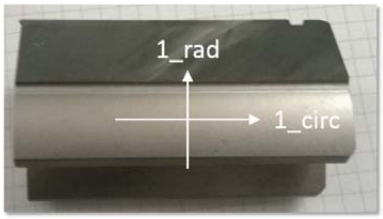
Effects of shot peening on gear teeth

Sample 1 and Sample 2 are representative of a gear before and after shot peening treatment.
Measurement performed on at pitch diameter show the effect of shot peening is to increase of a factor of three the compressive residual stress state of the sample surface. Moreover, the samples show homogeneous behavior in both the measurements directions.

Measuring Point	Residual Stress [MPa]
Sample 1_rad	-417 ± 13
Sample 1_circ	-399 ± 12
Sample 2_rad	-1267 ± 15
Sample 2_circ	-1253 ± 12



Sample 1

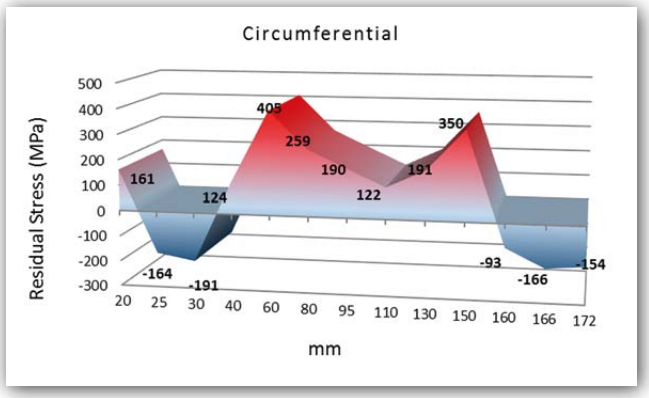


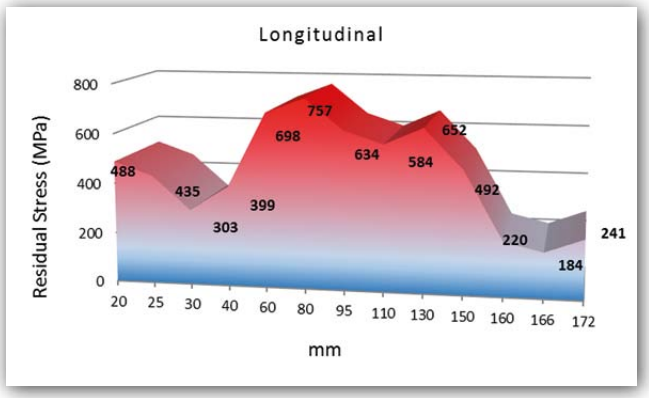
Sample 2

Compressive residual stress **increases the fatigue** life and stress corrosion because it delays crack initiation and propagation; it allows to reduce the stress level of the layers where the applied load is the highest. Instead, **tensile** stress **reduces the mechanical performance** of components.
Shot peening increases resistance to fatigue and corrosion of mechanical parts, hitting by steel or ceramic spheres induces a state of compression. XRD measurements allow to control and optimize the parameters of shot peening treatment in such a reliable way that nowadays it is a routine practice in automotive and gears manufacturing.

Application Sample 4 > On site Measurements

GNR StressX is a suitable solution also to perform on site measurements.
Set up to measure weld bead on turbine shaft and relative residual stress results are reported in the picture below.
The measurements has been performed along longitudinal and circumferential directions at different point along the shaft axis (by courtesy of FOMAS Group).



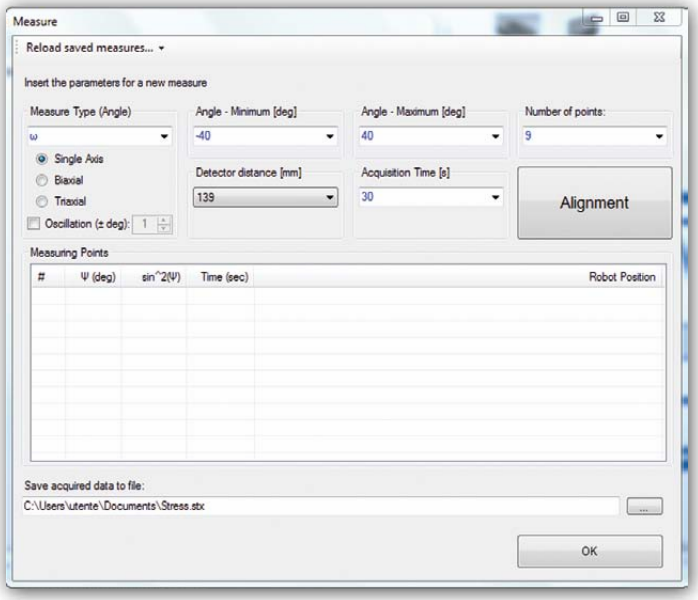


GNR StressX Software supports several tasks of analysis, from Data Acquisition, having the full control of all the process and hardware settings (robot, generator and tube, detector, measurements set up) to Data Analysis, calculating the residual stress or retained austenite values.

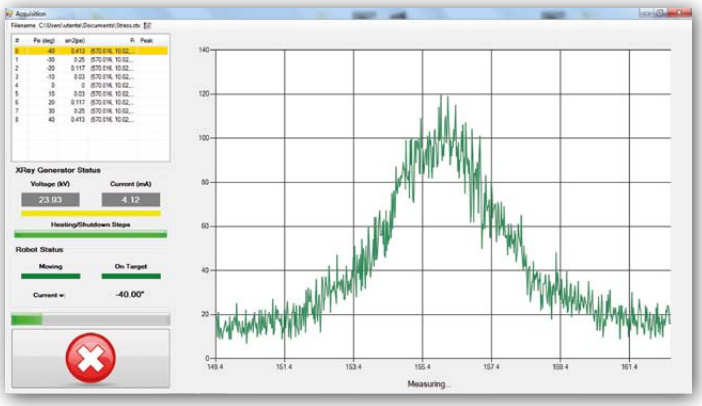
An extremely easy to use software for Uni-axial, Bi-axial and Tri-axial residual stress state analysis has been developed in compliance with ASTM E915 practice and UNI EN 15305.

GNR StressX Software allows to measure and to calculate residual stress on any polycrystalline materials:

- Acquisition time / steps: 30-120 s
- Number of steps: 5-13
- Peak position determination by profile fitting taking into account theoretical constrains
- Uni-axial, Bi-axial and Tri-axial stress state analysis
- Normal and shear component analysis available for Uni-axial, Bi-axial, Tri-axial measurements



Measure panel



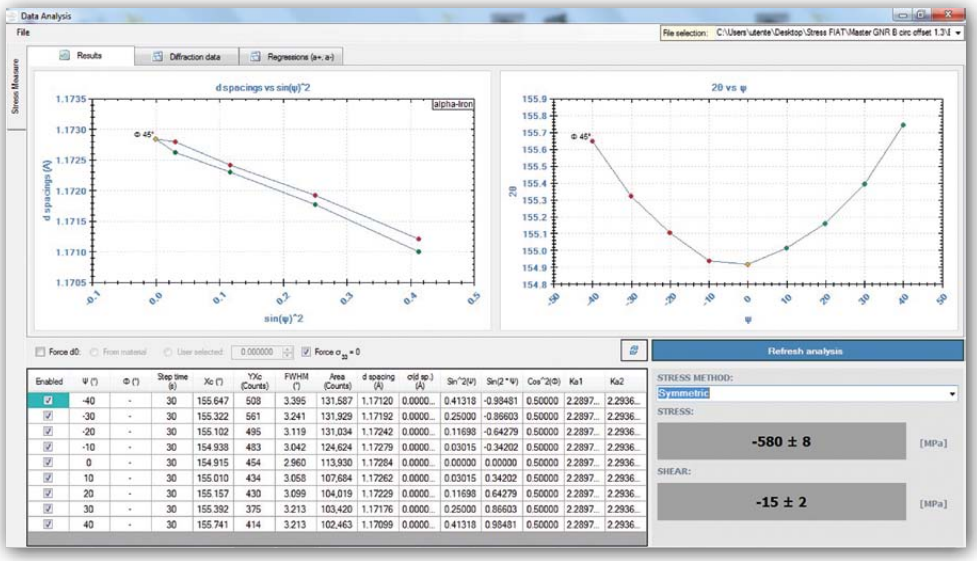
Data Acquisition

Fully featured Windows software using thread-based multi-tasking:

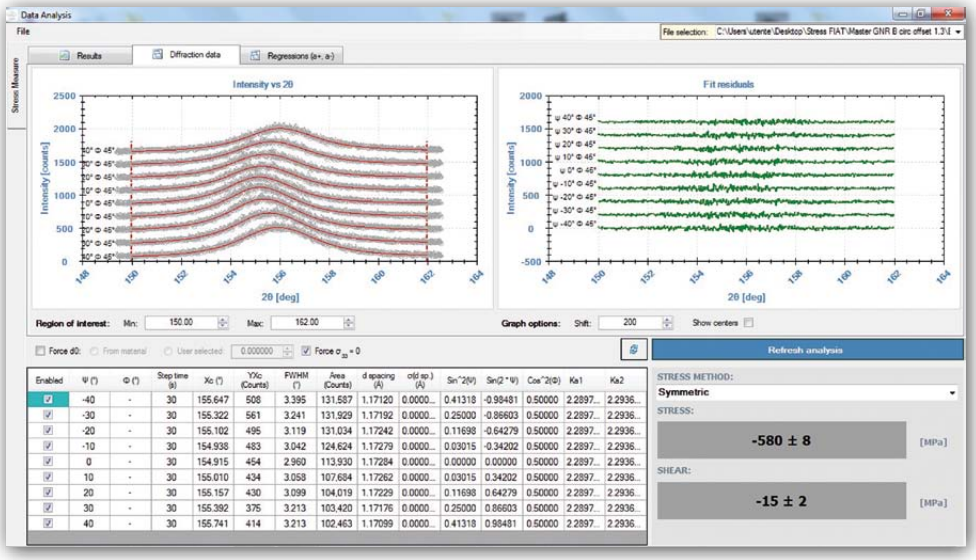
- X-Ray tube run-up and control
- Library functions for material and measurement parameters
- Detectors, DC motors, power supply, safety interlock functions, control
- Ω-mode and *X mode*
- Microsoft Windows operating system
- Project Manager
- Surface mapping with dynamic sections view
- Possibility to customize on request residual stress evaluation algorithm

Options, available with additional hardware:

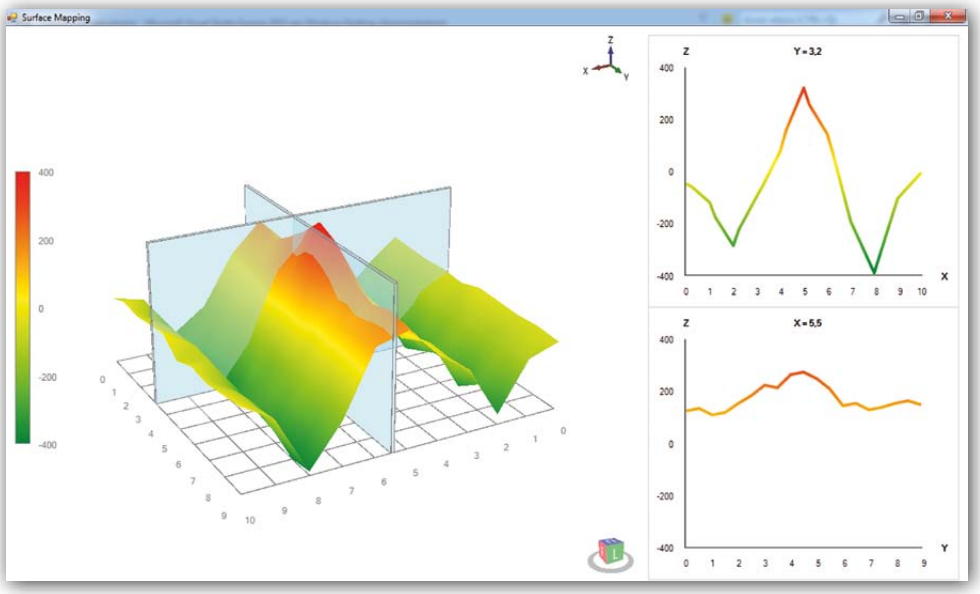
- Four Peak Retained Austenite Testing



Stress Analysis panel: results tab



Stress Analysis panel: diffraction data tab



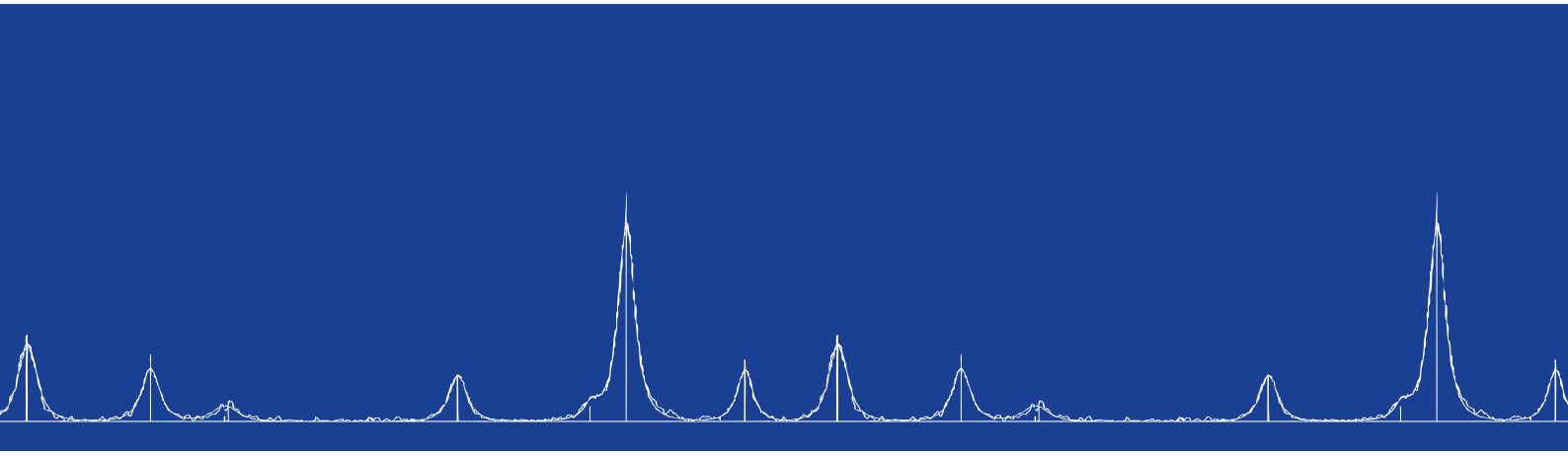
Surface Mapping GUI

Robot	6-axis anthropomorphic robot Accuracy and a repeatability in positioning better than 20 microns	
Robotic Goniometer	Programmable max. -45° / + 45° Psi scan with oscillation from 1° to 10° Selectable radius: 120, 140, 160 mm 2Theta range: from 125° to 164°	
X-Ray Generator	Maximum Power 300 W (30 kV, 10 mA) Ultra-compact design, universal input and power factor corrected Stability < 25 ppm/hr after 2 hours warm up.	
X-Ray Tube	High brilliance miniature Metal/Ceramic X-ray tube 210 W (30 kV, 7 mA) Cr anode provided as standard Cu, Co, Fe, V, Ti and Mn available as options	
Detector	Fast Detector (DECTRIS Mythen Multi Strip Detector)	
Optics	Standard monocapillary diameter collimators: 0.5, 1 and 2 mm. Other diameters available 120 microns focus polycapillary collimator	
Laser	Laser accuracy: better than 2 microns with a measuring range of 150 +/- 40 mm. Alignment procedure distance: 70 mm (X-ray collimator/sample)	
Cooling Water Supply	Self-contained re-circulating water-cooling with heat exchanger No external water supply needed	
Video Camera	USB Video Camera Resolution: 5.2 megapixels	
Processing Unit	Computer Type	Personal Computer, latest version
Processing Unit	Trolley	1.150 x 1.530 x 1.800 mm 250 kg
	Cabin	1.200 x 1.200 x 2.000 mm 350 kg

Safety Assurance

StressX complies with the complex statutory requirements regarding ionizing radiation and electrical safety. Maximum X-Ray safety with radiation level significantly below the annual dose limit for general public (1 mSv/year) following ANSI N43.3 - 1993 and other industrial standards for open beam X-Ray operation.

The radiation enclosure door cannot be opened when X-Rays are on and the system immediately switch off if the cooling water flow is not enough. This function completely protects user from radiation exposure and X-Ray tube damage.



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