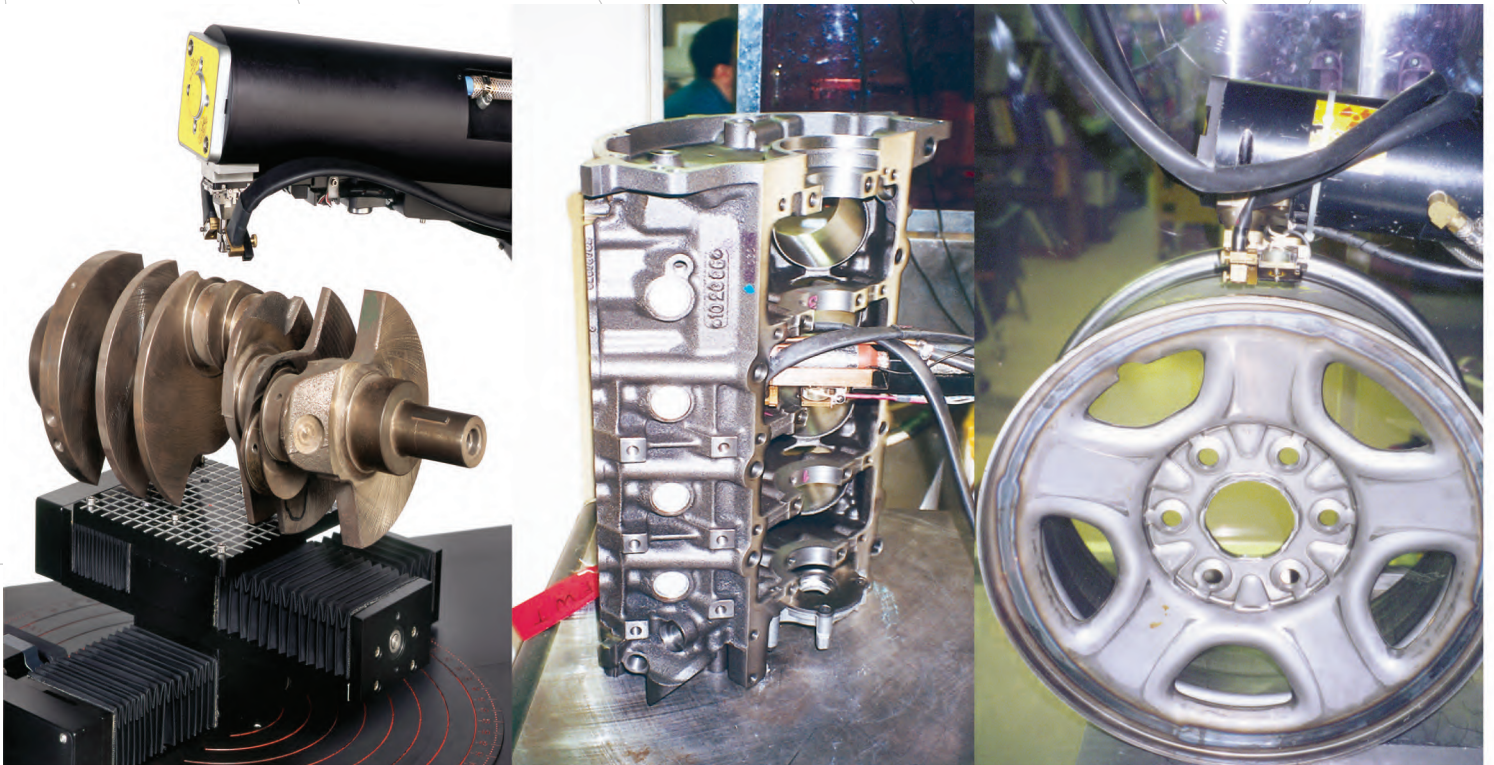


**AUTOMATED RESIDUAL  
STRESS ANALYSIS**

# *X-ray Diffraction Residual Stress Measurement* **AUTOMOTIVE**



*A world of solutions*

# AUTOMOTIVE



## HISTORY

Since its founding in 1968, Proto Manufacturing (Proto) has been involved in the development and application of non-destructive evaluation (NDE) technology.

In the early eighties, Proto recognized that many of the problems requiring the palliative application of (NDE) had undesirable residual stresses as their root cause. It was reasoned that measurement and management of residual stress could prevent these problems altogether, or at least more efficiently direct additional (NDE) efforts.

Proto selected x-ray diffraction (XRD) technology because of its promise for providing quantitative measures of residual stress (RS) both safely and non-destructively. Proto set a goal to develop XRD technology sufficiently to allow practical problem solving in laboratory, factory and field environments.

A continuous and considerable development effort has over the years succeeded in advancing the state-of-the-art to achieve this goal.

It is safe to say that Proto's XRD systems are the lightest, fastest and most advanced in the world today and are successfully applied in many sectors; aerospace (including military and civil) automotive, marine, medical, power generation, nuclear and structural.

## Measuring Residual Stress in Automotive Components

Residual stresses created during the manufacturing process can lead to stress corrosion cracking, distortion, fatigue cracking, premature failures in components, and instances of over design. The nondestructive nature of the x-ray diffraction technique has made the residual stress characterization of automotive components a useful tool for process optimization, design improvements and failure analysis.

## Managing Residual Stress

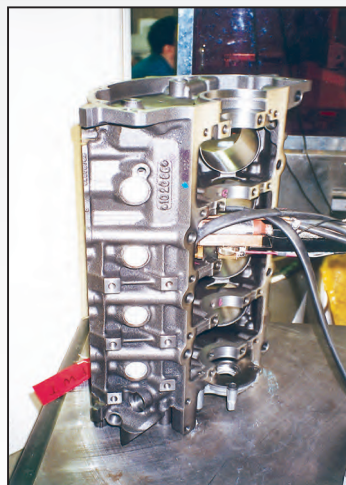
Numerous techniques, such as heat treating, are applied to help manage potentially harmful residual stresses created during manufacturing. Other techniques, such as shot peening, are used to introduce beneficial residual stresses into a component to help increase fatigue life. Knowledge of the residual 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.

## Fatigue Life and Stress Concentrations

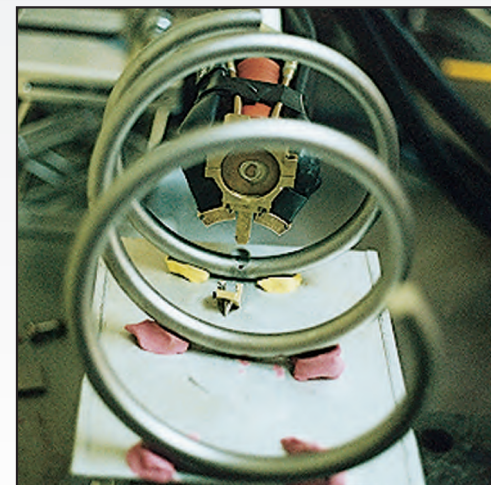
The residual stress state in automotive components is critical when stress concentration geometries exist that can magnify the effects of applied loads. When issues of fatigue cracking are considered, potentially harmful tensile residual stresses alone or in combination with stress concentrations can lead to fatigue crack initiation and propagation.

## Heat Treatment

Heat treatment processes are also commonly applied to automotive components to lower or reduce the residual stresses present. Residual stress measurement can be used to ensure that such processes have been correctly applied and that any harmful residual stresses have been reduced to an acceptable level.



MEASURING RESIDUAL STRESS  
ON A CYLINDER BORE

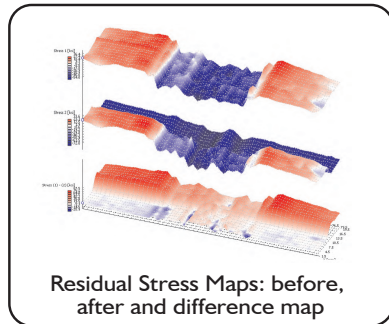


MEASURING RESIDUAL STRESS  
ON A SPRING

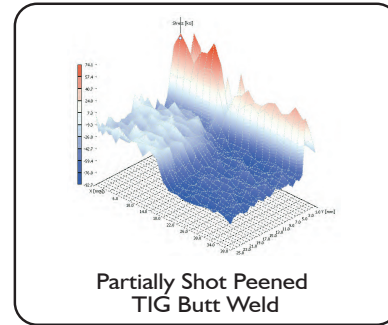
# X-ray Diffraction Residual Stress Measurement

## Residual Stress Mapping

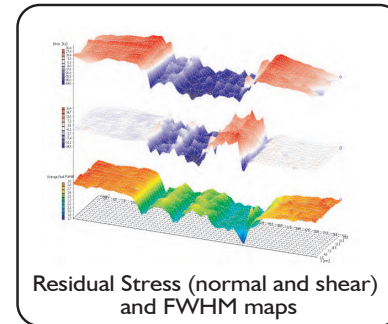
Proto's patented Automated Residual Stress Mapping technology can generate a comprehensive picture of the residual stress state of any sample. Even curved surfaces such as welds can be automatically mapped allowing designers and engineers to visualize and manage problem areas.



Example of a residual stress multi-map with a third "difference" map plotted by applying map algebra to the first two maps collected on the same weld before and after the weld was partially shot peened. This map overlaps the interface where the weld was shot peened and masked (i.e. not shot peened).



Example of a residual stress map on a partially peened weld.



Example of a multi-map with residual normal stress, shear stress and FWHM maps superimposed or "stacked".

## Verify Surface Enhancement Processes

The fatigue life of an automotive component is often enhanced by cold-working processes such as shot peening. XRD residual stress measurement can be used to verify that these locations have been enhanced to the specified residual stress level. A residual stress value, once established, can be specified on the engineering and processing documents.

## Finish Machining

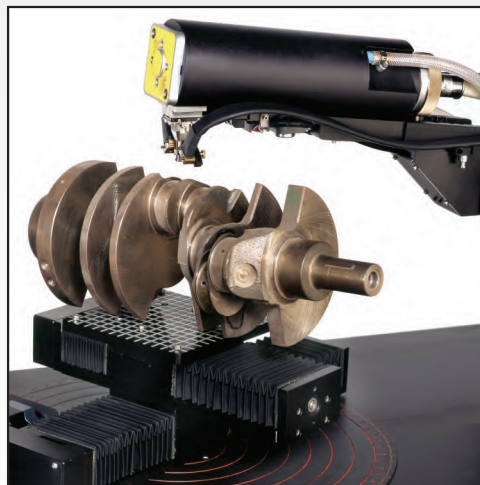
Aggressive or abusive machining can create regions of tensile stress that can make this area on a component susceptible to crack initiation and increase the rate of crack propagation.

## Design Improvements

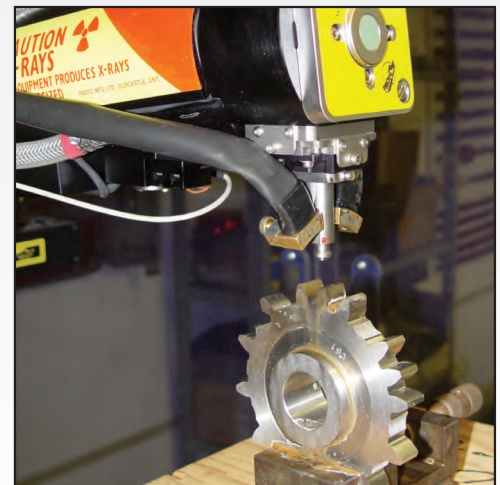
Utilizing a "Design to RS, Produce to RS and Manage to RS" philosophy helps to achieve reduced component weight, improve life expectancy and lower manufacturing and maintenance costs.



MEASURING RESIDUAL STRESS ON A WHEEL



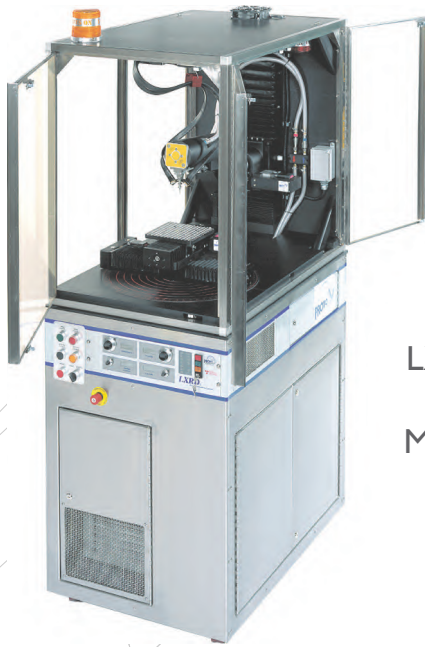
MEASURING RESIDUAL STRESS ON A CRANKSHAFT



MEASURING RESIDUAL STRESS ON A GEAR

# AUTOMOTIVE

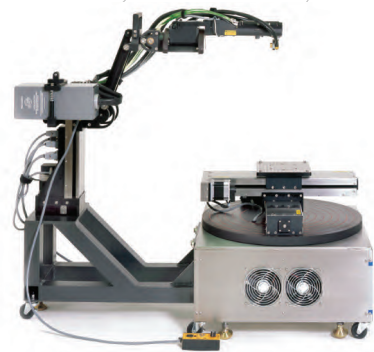
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iXRD - PORTABLE AND  
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Modular Residual Stress Mapping



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