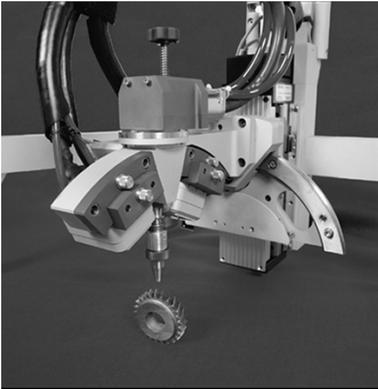


## Retained Austenite Measurements Using X-Ray Diffraction Techniques



The TEC 4000 X-Ray Diffraction System

The retained austenite content of steel can have a pronounced effect on the performance and life of steel products. In some cases, a certain amount of retained austenite can improve product performance; while, in other cases where dimensional stability is critical, any retained austenite can be detrimental to the useful life and performance of the part.

Austenite ( $\gamma$ ) is the face-centered cubic phase in steels formed at high temperatures. During quenching and other heat treating operations, austenite can be transformed into other phases such as martensite (a body-centered tetragonal phase,  $\alpha$ ). The volume of the austenitic unit cell is greater than either the martensitic or ferritic unit cells. Therefore, if the austenite transformation is not 100 percent, the retained austenite that remains after heat treating can further transform during the service life of the product into other phases, providing the potential for changes in the dimension of the part. In addition, other physical properties, such as hardness and strength, vary with the different phases, so that if the part is transformed during service, these physical properties may also change.

Retained austenite can be measured by metallography or by x-ray diffraction. Metallography, a destructive technique, can be used to

determine retained austenite content only if a sufficient quantity is present. In many steels, 10 to 15 percent retained austenite is the minimum detectable limit, although instances of measurements as low as 2 percent are cited (1). X-ray diffraction techniques are commonly nondestructive and can precisely measure retained austenite concentrations as low as 0.5 percent. Obviously, therefore, x-ray diffraction analysis of retained austenite is most often the preferred analysis technique.

Austenite, due to its structural difference from other phases in steel, produces a diffraction peak at different locations than ferrite and martensite. The amount of a phase in steel is proportional to the integrated intensity of its diffraction peak. In simple terms, the amount of retained austenite can be correlated to the ratio of the integrated intensity of the austenite peak to the integrated intensity of peaks associated with the other phases.

In principle, the amount of retained austenite in a sample can be extracted from the integrated intensities at two reflection angles (e.g., the angle for the austenite peak and the angle for the martensite peak). Unfortunately, many variables, such as preferred orientation, grain size, etc., can significantly affect the results and hence make the two-peak measurement erroneous.

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## **Retained Austenite Measurements Using X-Ray Diffraction Techniques**

Retained austenite can be automatically measured with the TEC 4000 X-Ray Diffraction System's SaraTEC™ software. This copyrighted software package has incorporated the guidelines set forth in the Society of Automotive Engineers (SAE) publication, Retained Austenite and its Measurement by X-ray Diffraction (SP-453), for reliably quantifying retained austenite in steel. Specifically, two austenite and two martensite peaks are selected for comparison. At least two austenite peaks must be measured to check for preferred orientation or large grain size in a sample. Some degree of preferred orientation is commonly present in almost all processed materials. By definition, if the ratio of the integrated intensities for the {220} and {200} austenite peaks is outside the range of 1.2 to 1.8, then substantial preferred orientation exists. The SAE manual also recommends tilting or tilting and rotating the sample to minimize the effects of preferred orientation

and large grain size. Tilting without rotating will produce satisfactory results; the converse, however, is not true. The  $\psi$  -angle oscillation feature on the TEC 4000 System provides this tilting capability to minimize the erroneous effects of preferred orientation and large grain size.

Experiments with the NBS retained austenite standards show that satisfactory measurements can be made by comparing integrated intensities of a single austenite peak to a single ferrite peak. However, experience has shown that this technique cannot be used on the majority of "real world" samples because of the prevalence of preferred orientation in materials. Thus, it is critical that at least two austenite peaks be compared when performing retained austenite measurements by x-ray diffraction. The effects of preferred orientation and large grain sizes can be minimized by using a tilting or a tilting and rotating technique.

### Reference

1. E.J. Klimek, "A Metallographic Method for Measuring Retained Austenite," Metals Engineering Quarterly, Vol. 15, Number 1, February 1975.

