



CASE STUDY

# Grinding Burn Inspection Using Barkhausen Noise Analysis

## The problem

Company A, a reputable manufacturer of transmissions, was using traditional nital (acid) etch inspection to detect signs of grinding damage in carburized helical gears. Nital is a mixture of nitric acid and ethanol, which will corrode the gear sample and reveal micro-structure variations in steels. It is a commonly used method for detection of grinding re-temper burn. Company A found the nital etch procedure to be highly subjective, insensitive to all but the most intense defects, and completely destructive in this case. In addition, Company A found the testing to be inconvenient and costly due to a significant amount of scrap, proper chemical disposal, and use of personal protective equipment. The production engineers in this case were eager to find an alternative.

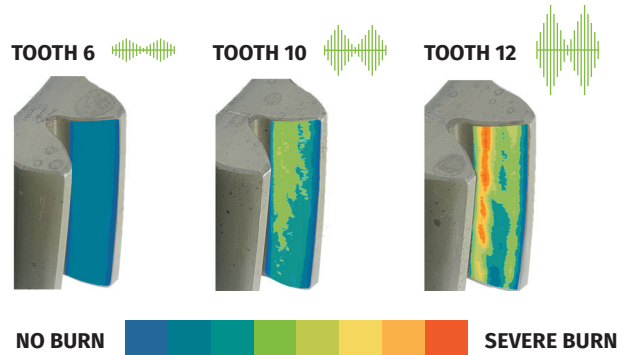
## Investigation

American Stress Technologies worked closely with Company A to demonstrate the effectiveness of Barkhausen noise analysis as an alternative to nital etch inspection. Barkhausen noise is a completely non-destructive magnetic method in which a sensor makes contact with the part and measures the response to an applied magnetic field in real time. The measured signal is sensitive to changes in both stress and micro-structure (hardness). In this case the manufacturer created gear teeth with varying levels of grinding damage by varying feed rates and coolant flow. Barkhausen noise scans were made to create full-field maps of each gear tooth from root to tip and compare to the visual nital etch results. While both methods were able to detect grinding burn, the Barkhausen method provided more quantifiable results with correlating data. Traditional nital etch only provided subjective shades of gray which were difficult to interpret.

### NITAL ETCH



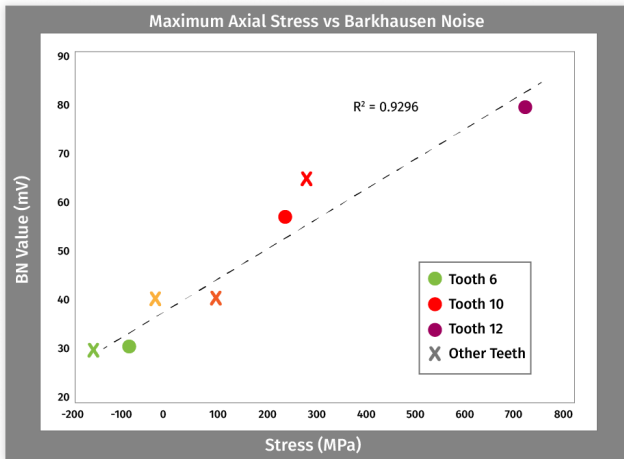
### BARKHAUSEN NOISE ANALYSIS



**TOOTH 6** shows no signs of damage via etch and corresponds to the lowest measured Barkhausen noise values.

**TOOTH 10** shows very little signs damage from etching, yet shows substantially higher Barkhausen noise analysis results as compared to tooth 6 indicating that the tooth was damaged during grinding.

**TOOTH 12** shows clear indications of grinding burn and would not pass visual inspection. As expected, this tooth had the highest measured Barkhausen noise values.



### Validation

American Stress Technologies performed X-ray diffraction residual stress measurements at the location of the maximum Barkhausen noise analysis measurement value on each tooth. As seen in the plot above, X-ray diffraction results showed that the grinding process had imparted damage with corresponding stresses of nearly 300 MPa in tension on tooth 10 in which the etching looked clean.

### Conclusion

Barkhausen noise analysis provided a more sensitive, repeatable, real-time grinding burn inspection without requiring chemicals or consumables. The strong linear correlation between residual stress and Barkhausen noise analysis allowed the manufacturer to determine a quantitative Barkhausen noise rejection threshold based on residual stress magnitudes and design requirements resulting in a more sensitive and reliable grinding burn inspection. The completely non-destructive nature of Barkhausen noise analysis resulted in a substantial cost savings by reducing scrap, and eliminating the need for chemical disposal, and personal protective equipment.

