Non-Destructive Testing for Hardness and Carburization

Research Team

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Introduction

Case depth and surface hardness are important properties for carburized steel that must be well controlled. The traditional testing is usually destructive. Samples are sectioned and measured by either OES or micro hardness tester. It is time consuming and can only be applied on sampled parts. The heat treating industry needs a physics based, verified simulation tool for surface hardening processes to accurately predict concentration profiles, microstructure and microhardness profiles. There is also a need for non-destructive measurement tool to accurately determine the surface hardness and case depth. Magnetic Barkhausen Noise (MBN) is one of the promising way to test the case depth and hardness [1]. MBN measures the pulses generating by the interaction between magnetic domain walls in the ferromagnetic material and the pinning sites such as carbides, impurities and dislocation. These signals are analyzed to evaluate the properties of the carburized steel. For this study, samples of 1018 and 8620 were carburized to selected surface hardness and case depths. MBN was determined to be an effective method to evaluate the surface hardness and case depth. In this paper, results of this investigation will be presented and discussed.

Methodology

The project focused on three tasks:

Task 1: Investigate the current nondestructive testing technologies for case depth and hardness evaluation. Magnetic Barkhausen Noise Testing is used in the research.

Task 2: Design and prepare carburized samples that has a series of hardness and case depth conditions.

Task 3: Conduct the NDT testing and correlate the measurement with the testing results. Method of hardness and case depth prediction is provided.

Salient results

Tempered 4140 steel rods was used for the hardness testing. Diameter of the rod is 0.5 inch. They were quenched from 850℃ then tempered. The rods are measured with Magnetic Parameter (MP) which is presented in Figure 1. For tempering temperature lower than 450℃, the hardness is higher than 35HRC. It is hardly to correlate the hardness with MP. For tempering temperature that is higher than 550℃, there is linear correlation between the MP with hardness.

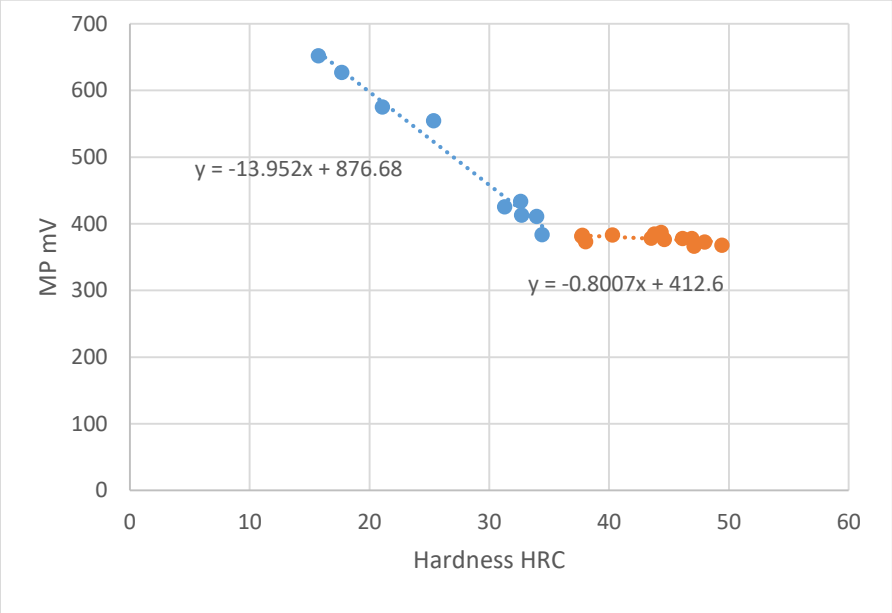

Figure 1: The MBN measurement on the hardness of tempered 4140 rods

The case depth has been studied with the Magnetizing Voltage Sweep (MVS) method. The testing method was initially proposed by Suvi Santa-aho[2]. Two frequencies were used for the testing. Each frequency will lead to a measurement depth and obtain the information corresponding to the depth. At each frequency, magnetizing voltage changes from 0 to 16 vpp and a profile as a function of magnetizing voltage was measured. There is a max slope that can be used to correlation the properties of the steel at certain depth. In the figure, 8Hz and 125Hz was used for measurement.

There are three group of samples with case depth of 0.8 1.2 and 1.8mm. The large case depth will lead to a larger slope ratio. In this way the case depth can be evaluated as Figure 2 presented.

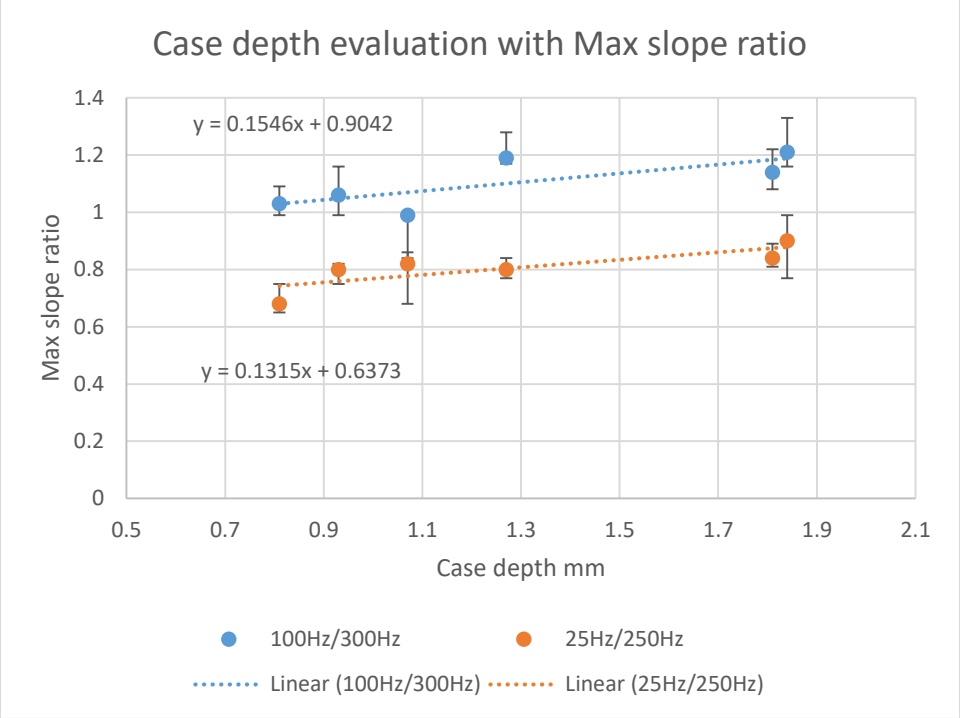

Figure 2: The case depth measurement with max slope ratio

Reference

[1] Rollscan 300 Operation instructions Version 1.6b. Nov 2011 by Stresstech

[2] Sorsa, Aki, et al. "Quantitative prediction of residual stress and hardness in case-hardened steel based on the Barkhausen noise measurement." Ndt & E International 46 (2012): 100-106.