Reduction of Thermal effect on Rail Stress Measurement Based on Magnetic Barkhausen Noise Anisotropy

Song Ding, Ping Wang, Yang Lin, Dingyi Zhu

PII: S0263-2241(18)30140-4
DOI: https://doi.org/10.1016/j.measurement.2018.02.041
Reference: MEASUR 5289

To appear in: *Measurement*

Received Date: 19 June 2017
Revised Date: 2 February 2018
Accepted Date: 21 February 2018

Reduction of Thermal effect on Rail Stress Measurement Based on Magnetic Barkhausen Noise Anisotropy

Song Ding[1], Ping Wang[2,*], Yang Lin[2], Dingyi Zhu[3]

[1] School of Automation and Electrical Engineering, Nanjing Tech University, Nanjing, Jiangsu, 211816, China
[2] School of Automation Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing, Jiangsu, 210016, China
[3] School of Mechanical and Power Engineering, Nanjing Tech University, Nanjing, Jiangsu, 211816, China

Abstract: High-speed railway and seamless track acquire quick and accurate method for stress measurement and evaluation. Magnetic Barkhausen noise (MBN) is considered appropriate to measure the stress state of rail track. But the temperature variation not only produces thermal expansion or contraction but also affects the Barkhausen jumps at the same time. Based on the theory of thermal effect on magnetic properties, the longitudinal RMS of MBN signals divided by the transverse RMS, called longitudinal and transverse ratio (LTR), is proposed as a new feature for track stress measurement to decrease the thermal effect on MBN signals. This new feature shows the same sensitivity as RMS, the traditional feature, and stability to temperature variation. With an on-site case study for verification LTR is proved robust in evaluating the track thermal stress accurately.

Key Words: Thermal stress, MBN signal, Longitudinal and transverse ratio, Thermal effect

1. Introduction

With the development of the high-speed railway, seamless track is widely used for high speed train[1][2]. Different from the conventional rail track, there is a mass of thermal stress (TS) inside of seamless track due to thermal expansion or contraction because the seamless track is fixed and extends dozens or even hundreds kilometer[1]. The thermal stress state detection become very important because of the relationship to the safety for train operation[1][3].

As a novel electromagnetic technique, magnetic Barkhausen noise (MBN) provides a non-destructive and fast method for material stress state and microstructure measurement and characterization. The Barkhausen noise (BN) comes from the discontinuous movement of domain wall in magnetization under varying magnetic field. As we know, applied magnetic field leads to domain wall motion and domain re-orientation. During the movement, domain wall overcomes pinning, such as grain boundary, dislocation, carbide and precipitated phase, and emits electromagnetic pulse, called Barkhausen noise [4-6]. Thus, it was considered that MBN technique is an appropriate method for rail truck stress measurement and evaluation.

For measuring residual or applied stress, the root mean square (RMS) is a traditional feature of MBN signal. But RMS decreases with the increase of temperature, especially over 60 ℃ [1,7]. In the application of rail track TS on-site detection, thermal effect not only leads to thermal expansion and contraction but also affects the domain wall dynamic behavior[8], which influences the MBN signal and makes it hard to measure the rail track stress state accurately.

The relations between temperature and magnetic properties have been carried out. Orhan Yalçın et al. studied the magnetic hysteresis loops and temperature dependence of the magnetic layer [9]. Lei Guo et al. offer the theoretical relationship between average volume of Barkhausen jump and temperature[10]. Due to the complex relationship between the thermal effect and Barkhausen noise[11], data processing

* *Corresponding Author*
E-mail: pingwangzeit@gmail.com