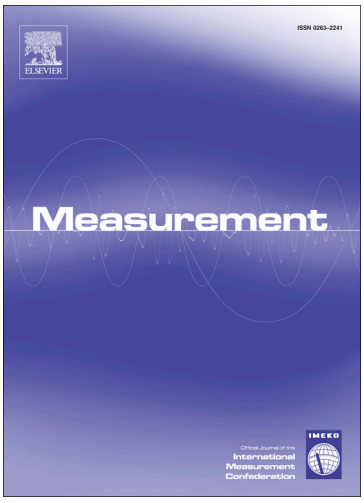

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PII: S0263-2241(17)30405-0
DOI: http://dx.doi.org/10.1016/j.measurement.2017.06.019
Reference: MEASUR 4819

To appear in: *Measurement*

Received Date: 24 April 2017
Revised Date: 21 May 2017
Accepted Date: 13 June 2017

Please cite this article as: X. Hong, J. Zhou, G. Huang, L. Ni, Synergetic damage recognition approach for messenger wire in icing environment using piezoceramic transducers, *Measurement* (2017), doi: http://dx.doi.org/10.1016/j.measurement.2017.06.019

Synergetic Damage Recognition Approach for Messenger Wire in Icing Environment Using Piezoceramic Transducers

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Abstract: In recent years, high-speed electric railway has become a major means of transport. Messenger wire is the main bearing part of electrified railway catenary, and once the damage occurs, it will easily cause a major accident. In the harsh areas of climate, the messenger wire is covered with ice for a long time. To identify damages of electrical messenger wire in the icing environment, a synergetic damage recognition approach is put forward. On the basis of the synergetic principle, this approach establishes a dynamic decision-making mechanism, studies the feature extraction and evaluation method for active acoustic emission signal. Subsequently, a reconstruction method of damage status vector by using training sample fusion algorithm is introduced. Experiments were conducted in icing environment. Firstly, the impact of messenger wire galloping on identification performance was studied and found that such influence can be ignored. In experiment of damage type recognition, results show that the proposed approach can identify different types of damages well, and compared with the cluster learning algorithm, the correct rate of recognition has risen 5% when training samples fusion method is adopted. This proposed approach demonstrates a strong anti-noise-interference ability, and it can provide a theoretical basis for the separation of stress wave modals in subsequent messenger wire structural damage monitoring imaging.

Keywords: Icing environment; Messenger wire; Damage recognition; Synergetic

1. Introduction

In pantograph-catenary system, the messenger wire is the primary load-bearing part of electrified railway [1], which may travel through an extreme climate of ice [2]. Since 2008, many provinces in southern China's power grid system have suffered a serious threat of repeated ice disaster. Continuous cold weather will make the messenger wire covered with ice, and different types of damage such as crack, abrasion, broken wire will inevitably appear over the course of structure's lifetime, which has made severe impact on safety during the operation of electrified railway [3]. It creates new measurement challenges for on-line damage monitoring in icing environments and requires effective new monitoring methods to solve. Identifying damages timely and accurately is crucial to ensure the safety of messenger wire by using detection system [4-6]. Therefore, studying the damage identification method for messenger wire in icing environment is becoming an urgent problem.

New damage identification approaches for stranded messenger wire are constantly emerging in recent years [7-8]. Especially various artificial intelligence and pattern recognition technologies [9-11] have been applied frequently. For example, Vallan *et al* [12] researched the principles of damage detection with camera method and identified damages of strands by using imaging offline processing algorithm. Lee *et al* [13] measured the magnetic field of the surface to detect and identify structural damages. Abdullah *et al* [14] analyzed the post-breakage dynamic behavior of a prestressing strand by finite element analysis. And by simplifying the laboratory experiment and analyzing the model, the disconnection detection method based on anchor strain measurement was verified [15]. Zhou *et al* [16] studied damage recognition of metal strands by eddy current testing method and established a BP neural network, then took damage features as input of the network. Zhang *et al* [17] used Hall element to detect the surface magnetic field of messenger wire with strands, and developed the identification RBF-based model for structural conditions.

But in icing environment, most of the current research mainly focus on identifying icing-thickness of messenger wire by applying image recognition and wavelet analysis methods, etc. For example, Zhang *et al* [18] proposed an algorithm for image recognition of the thickness of ice conductor for transmission line insulators. Hao *et al* [19] proposed a wavelet analysis image recognition method for the icing thickness of transmission lines. Song *et al* [20] established a long-term prediction method for grid overlay based on fuzzy