Detection of Stress Concentration Zone for Biaxial Fatigue with Application of Discrete Wavelet Transform Technique

Sity Ainy Nor Mohamed, Azli Arifin, Shahrum Abdullah, and Ahmad Kamal Ariffin
Department of Mechanical & Materials Engineering, Faculty of Engineering & Built Environment,
Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Malaysia
Tel: +60389118411 Email: sityainy@gmail.com

ABSTRACT

This study is aimed to investigate in detail the capability of non-destructive testing on the detection of biaxial fatigue failure. Most automotive and engineering components experience and imposed to complicated loads during operations and the failure that occurs is due to the existence of the principal stresses acting in opposite directions during the loading cycle. In this study, metal magnetic memory method, is used for the monitoring and detection of stress concentration, on the specimen. The biaxial fatigue test was conducted using a combination of two types of stresses acting on the same frequency, namely the axial stress is set at 0.5σeq and shear stress acting in a 15° according to ASTM E2207. The specimen used was medium carbon steel and the preparation was based on the standard ASTM E08 method. The magnetic flux leakage signals that referring to the stress concentration zone is represented by the sudden high amplitude. Thus, metal magnetic memory can be used to determine the location of stress concentration, i.e. the early appearance of cracks during the online monitoring of components by processing signals using discrete wavelet transform method.

Keywords: biaxial fatigue, discrete wavelet transform, magnetic flux leakage, medium carbon steel, stress concentration zone.

INTRODUCTION

Fatigue cracks usually begin and propagate from the surface of the ferromagnetic components which have micro-stress concentration. When cracks growth to a critical size, structure failure will occur suddenly. Most of ferromagnetic components, for example of steel, one of the domain parameters that potentially be used to monitor the degradation of fatigue failure is the magnetic state on critical components. Magnetic measurements are non-destructive testing techniques that can be used to evaluate fatigue damage on ferromagnetic materials because the changes of dislocation density, lattice pattern and the formation of slip bands continued and affected in magnetic properties (Wang et al. 2012).

The engineering components are exposed to fatigue failure that occurs suddenly before maintenance could be carried out. Usually the stress concentration due to the existence of micro cracks in the stress reaction cannot be detected clearly in the early stages using macroscopic evaluation. Metal Magnetic Memory method (MMM) is a nondestructive testing method developed by passive magneto-mechanical effects. As the impact of the load applied and the Earth's magnetic field, the magnetic signal changes can occur spontaneously on the surface of a ferromagnetic material during the operation (Tomas et al. 2014). Fracture due to fatigue stress concentration occurred in the area where significant zones of microscopic defects became the main source in the failure development through signal processing of the filtration and decomposition of the main signals against the interference on the signal being observed.

RESULTS AND DISCUSSION

The experiments start with tensile test to obtain the monotonic behavior of the specimen as the basic input to the cyclic test as in Table 1. During the cyclic test, magnetic flux leakage for the specimen due to biaxial loading was investigated and captured by using the metal magnetic memory. The magnetic signals recorded for five readings before fracture occurs. Magnetogram of distribution graph obtained shows that the *Hp* and *dH/dx* pattern is representing the stress acting on specimens and vibration during the observations.

Changes in the observation process are caused by residual stresses that remain in the specimen even though the stress has been removed (Roskosz et al. 2014). Some levels of decomposition and filtering are performed on the original signal to show the zones of stress concentration which are represented by high amplitude point in the graph. The process flow is shown in Fig. 1.

Table 1. Monotonic properties for SAE 1045

Properties	Value
Ultimate Tensile Stress, σu	623 MPa
Yield Stress, σy	608 MPa
Young Modulus, E	218 GPa

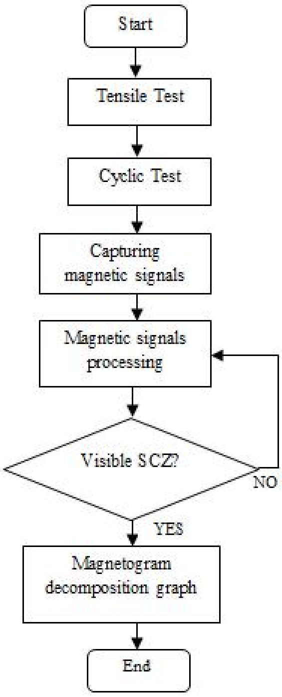

Fig. 1: Process flow in capturing the magnetic flux leakage signal

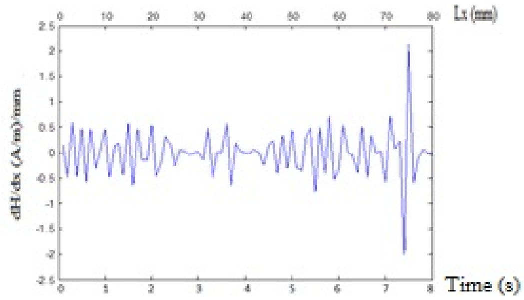

Fig. 2: Magnetogram of distribution graph for 0.5σeq stress

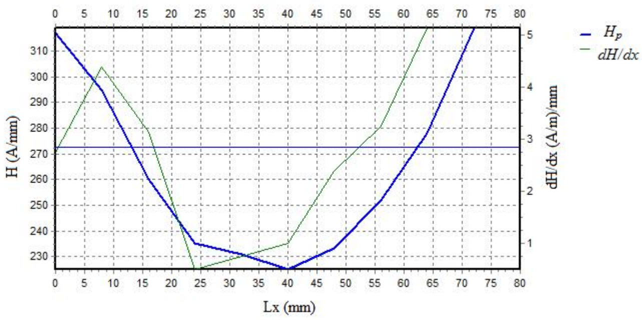

Fig. 3: Decomposition process for level 1

CONCLUSION

Magnetic flux leakage signal obtained from the existence of stress concentration zone in ferromagnetic metals are represented by magnetic intensity coefficient parameter. The location of stress concentration can be determined by using signal processing. The method used is based on the 4 level of decomposition method in DWT method. The location of stress concentration due to the existence of crack initiation can be described by a decomposition graph, where in the range of 80 to 80 mm.

REFERENCES

Wang, Z.D., Gu, Y. & Wang, Y.S. 2012. A review of three magnetic NDT technologies. *Journal of Magnetism and Magnetic Materials* 324: 382–388.

Tomáš, I., Kovářík, O., Vértesy, G. & Kadlecová, J. 2014. Nondestructive indication of fatigue damage and residual lifetime in ferromagnetic construction materials. *Measurement Science and Technology* 25(6): 065-601.

Roskosz, M., Rusin, A., Bieniek, M. & Fryczowski, K. 2014. Identification of the stress-strain state of ferromagnetic steels based on the measurement of magnetic parameters. *11th European Conference on Non-Destructive Testing ECNDT* pg. 1-8.

GUIDE FOR ABSTRACT TECHNICAL WRITING

- Title (Font Times New Roman, 16, Bold)
- Name (Font Times New Roman, 12, Bold)
- Address (Font Times New Roman, 11, Bold)
- Explanations (Font Times New Roman, 10)
- Figures (Include with captions, Font Times New Roman, 8)