**Presented at NDE2002, to predict. assure. improve. www.nde2002.org**
**National Seminar of ISNT, the Indian Society for Non Destructive Testing**
**Hotel Taj Connemara and Raja Muthiah Hall, Chennai, 05. – 07. 12. 2002**

# Online monitoring of High Cycle Fatigue in Mild Steel by Magnetic Barkhausen Emission Technique

**S. Palit Sagar[*], N. Parida,, P. Kumar, S. Das, G. Dobmann[a] and D. K. Bhattacharya**

National Metallurgical Laboratory, Jamshedpur, India
[a]Fraunhofer-Institüt für Zerstörungsfreie Prufverfahren, IZFP, Germany

## Abstract

Fatigue, one of the most common materials degradation mechanism in industry, occurs when material experiences lengthy period under repeated or cyclic stresses which can lead to failure at stress level much lower than the tensile or yield strength. It has long been recognised that nearly 90% of industrial component failure takes place due to fatigue. Hence the importance of evaluation of fatigue damage in metallic components by nondestructive way is increasing day by day to avoid catastrophic failure [1-6]. During fatigue, microstructure of materials experience continuous changes till failure. Generally the fatigue damage process can be divided into several consecutive and partly overlapping stages namely formation of dislocations and their rearrangement, dislocation cell, slip band, extrusion and intrusion, microcrack nucleation, growth and coalescence, macro crack initiation and crack propagation [9]. These microstructural changes strongly influence the magnetic properties of ferromagnetic materials. Hence the magnetic non-destructive techniques (NDT) such as magnetic Hysteresis and magnetic Barkhausen emission (MBE), are emerging as potential tools for fatigue damage evaluation of materials [4-8]. Though several studies have been made in recent past to apply magnetic techniques for assessing the fatigue damage, no clear definition has yet been found for the initial stages prior to nucleation of micro-crack. During high cycle fatigue (HCF) the formation of Persistent Slip Bands(PSBs), known as crack sites, modify the surface layer properties[10] so in this study an attempt was made to apply MBE technique to monitor the fatigue damage in low carbon steel (C=0.16%) under HCF since MBE evaluates the surface properties than the bulk. The variation of rms voltage of MBE was correlated with the microstructural features as observed by TEM. The experiments were carried out on flat specimens annealed at 800$^{o}$C for 30 minutes. High Cycle Fatigue test were performed with a high frequency pulsator, model 100HFP5100 from RK Amsler, Germany at room temperature with load ratio R=-1 and at a frequency of 84 Hz. The rms voltage of MBE was measured by a surface probe using μ-Scan 500-1 from American stress Tech., USA at an excitation frequency of 40Hz and the Barkhausen noise was filtered in the frequency range of 1kHz-300 kHz. It was observed that initially the rms voltage was increased with the increase in dislocation density and the peak corresponded to the formation of cell structure. Subsequently the rms value of MBE decreased with the increase in % of fatigue damage and attained the minimum when slip bands were formed. With further fatiguing the rms voltage increased till the failure of the specimen. The above observations were noticed in several specimens loaded in similar conditions. Hence the minimum in the rms voltage vs. % of fatigue damage plot can be considered as the onset of micro crack initiation. This work, therefore, revealed that MBE could be a potential technique for online monitoring of fatigue damage in ferromagnetic materials to avoid catastrophic failure in industry.

References:

1. R.Grimberg, S.Leitoiu, B.EBradu, A.Savin and A.Andreescu, Sensors and Actuators, 81(2000) 371
2. T. Ohtani,H. Ogi, Y. Minami and M. Hirao, J. alloys and Compounds,310(2000)440
3. Ye. Duyi, W. Zhenlin, International Journal of Fatigue, 23(2000)85
4. Y. Bi, M. R. Govindaraju and D. C. Jiles, IEEE Trans. Magn.,32(1997)3928
5. C. C. H. Lo, F. Tang, Y. Shi, D. C. Jiles and S. B. Biner, J. Appl. Phys.,85(1999)4595
6. P. Ruuskanen and P. Kettunen, Rev. of Progress in QNDE,14B(1995)947
7. Y. Tomita, K. Hashimoto and N. Osawa, NDT & E Int., 29(1996)275
8. J. Blachnio, J. Dutkiewicz and a. Salamon, Materials Sci. & Engg A323(2002)83
9. Otto Buck, Rev. of Progress in QNDE,17A(1998)1
10. M. Klesnil and P. Lukas, J. Iron and Steel Institute, (1965)1043