IT SUPPORT OF NDE AND SHM WITH APPLICATION OF THE METAL MAGNETIC MEMORY METHOD

Miroslaw WITOS [1], Mariusz ZIEJA [1], Bartlomiej KURZYK [1]
[1] Air Force Institute of Technology, Warsaw, Poland
Fax: +48 261851612, e-mail: witosm@itwl.pl, maiusz.zieja@itwl.pl, bartlomiej.kurzyk@itwl.pl

Abstract

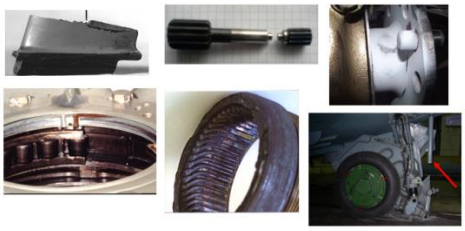
The paper has been intended to introduce a complex research problem, that is present in aviation, power engineering, mining and transport, with regard to assurance of operational safety for ageing technology, which is exposed to different form of material degradation. Theoretical reasons of active control of material fatigue and selection of reliable state observer have been outlined. The Metal Magnetic Memory Method (MMM) and the scope of scientific research, that are conducted in polish scientific centers in order to confirm and extend its operational possibilities to diagnose early stages of progressive material degradation, have also been presented. Taking the MMM Method into account, IT support of non-destructive testing has been considered with particular interest in the necessity of objective quality assessment and reliability of non-destructive testing performed by external companies (outsourcing). The presented topic has been illustrated by means of practical examples regarding problems in aviation, power engineering, mining and transport.

IT SUPPORT OF NDE AND SHM WITH APPLICATION OF THE METAL MAGNETIC MEMORY METHOD

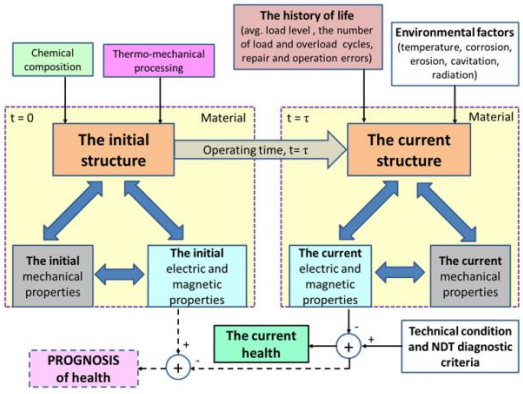
Mirosław WITOŚ Mariusz ZIEJA, Bartłomiej KURZYK
Air Force Institute of Technology, Warsaw, Poland, e-mail: witosm@itwl.pl; mariusz.zieja@itwl.pl; bartlomiej.kurzyk@itwl.pl

Introduction

How to detect level of fatigue of ferromagnetic alloys before damage?



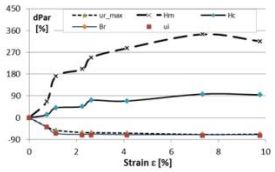
Metal magnetic memory method

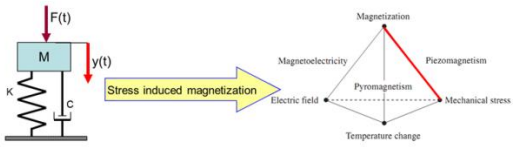


In the macroscopic scale a constitutive law is copying magnetic properties of the testing element

$$\mathbf{B} = \mu\mathbf{H} = \mu_0(\mathbf{H} + \mathbf{M})$$

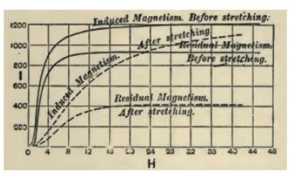
with
μ_0 – magnetic permeability of vacuum,
M – material magnetization [A/m],
H – external magnetic field [A/m],
B – magnetic induction [T].



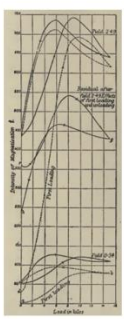


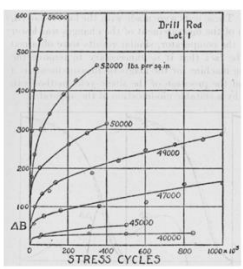
$$\mathbf{M} = \mathbf{M}_i + \mathbf{M}_r = (1 + k_H)(1 + k_\sigma)(1 + k_T)\mathbf{M_0}$$

with $\mathbf{M}_i$ – the induction magnetization; $\mathbf{M}_r$ – the residual magnetization; $\mathbf{M}_0$ – initial state of magnetizing; k_H, k_s, k_T – appropriately influence of external field, stress and temperature.



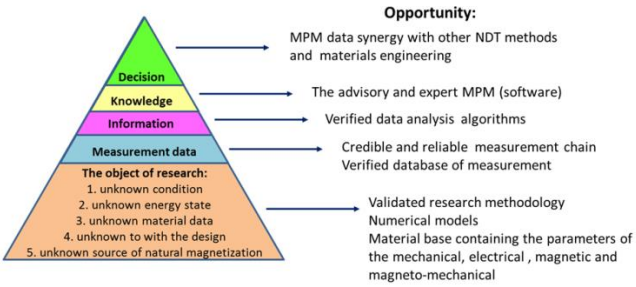
Ewing J.A. (1900): *Magnetic induction in iron and other metals.*





M.F. Fischer (1928): *Note on the effect of repeated stresses on the magnetic properties of steel.*

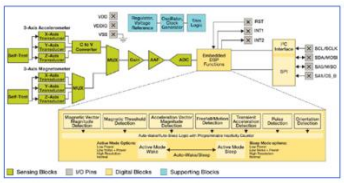
Diagnostic problem

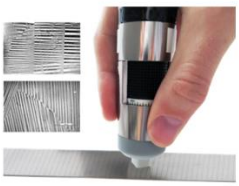


The geomagnetic field

IT support: The World Magnetic Model WMM2015, INTERMAGNET data

Measurement (3D magnetometer, array of magnetometers)

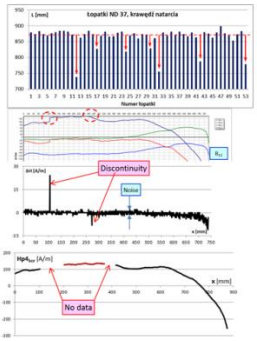




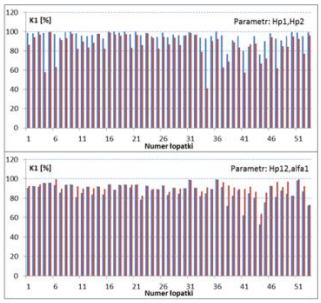
IT support: measurement procedures, data transfer (I^2C, SPI, USB 2.0, Wi-Fi, Bluetooth, …)

Information

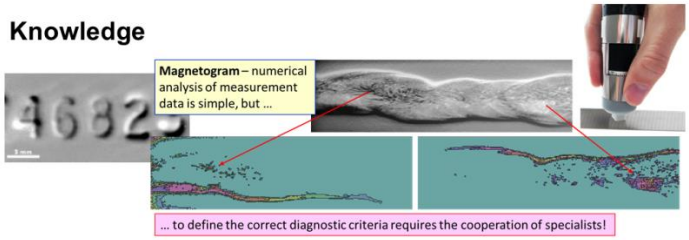
Automatic correction of errors



Analysis of the results by statistical pattern



Knowledge



Conclusion

IT support Metal Magnetic Memory method allows for new diagnostic capabilities in NDT and SHM of ferromagnetic objects.

7th International Symposium on NDT in Aerospace
16 – 18 November 2015, Bremen, Germany