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Role of Eddy Current Non- Destructive Testing in the Fitness-For-Purpose Assessment of Steel Components

M. A. Khattak[*,1,a], *M. Khan*[2,b], *T. Subhani*[2,c], *K. Azam Khan,*[3,d] *and A. Mukhtar*[4,e]

[1]Department of Nuclear Engineering, Faculty of Chemical & Energy Engineering, Universiti Teknologi Malaysia, 81310 Skudai Johor, Malaysia
[2]Department of Materials Science and Engineering, Institute of Space Technology, 44000 Islamabad, Pakistan
[3]Department of Mechanical Engineering, University of Engineering & Technology, Peshawar, Khyber Pakhtoonkhwa , Pakistan
[4]Faculty of Engineering & Technology, HITEC University, Taxila Pakistan
[*,a]*muhdadil@utm.my*, [b]*mahmoodkhan77@yahoo.com*, [c]*tayyab.subhani@ist.edu.pk*, [d]*khizarazam@nwfpuet.edu.pk*, [e]*aniquemukhtar@hotmail.com*

Abstract – *In-service material degradation limits the service life of steel components. The condition assessment of installed components can be performed by non-destructive testing and in-situ metallography. Limitation of metallography in surface region has persuaded the researchers to find out a reliable non-destructive method. The work presented in this paper demonstrates capabilities eddy current test sensitivity to material properties. Samples of carbon steel SA 106B have been taken and annealed with various soaking period for inducing variation in microstructure of samples. The annealed samples have been subjected to hardness and eddy current test. Results showed that increasing soaking time decreases the hardness which is an indication of grain growth, and eddy current test response has also been found sensitive to varying microstructure.*

Keywords: *Eddy Current Testing, Material Degradation, Fitness-for-Purpose, Steel*

1.0 INTRODUCTION

Service environment produces degradation in properties of steel due to change in microstructure [1-3]. Nucleation growth and coalescence of carbides, and micro voids also take place [4] as well as irradiation of reactor pressure vessel [5,6] and increase the possibility of fracture [6].

At present, micro structural determination, in general, is evaluated surface replication method. This technique reveals the microstructure of the surface region and requires several samples for reliable results. The results obtained by this method represent surface only whereas micro-structural degradation is not limited to surface Impact tests are also performed to evaluate the shift in ductile

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to brittle transition temperature. However, absence of the preinstalled charpy specimens requires the establishment of another reliable technique [5].

The applications of non-destructive testing [NDT] techniques are not limited to cracks detection only and researchers are interested in development of NDT for examining the in-service material degradation to assure safe operation of in-service component. The technique based on magnetic properties measurement has gained attention because magnetic properties depend upon several metallurgical factors [1].

Coercively, conductivity and permeability, hysteresis loss and remanence are some of the structure sensitive properties [1]. Electromagnetic, ultrasonic and liquid penetrant tests are some of the common tests which don't cause any damage to the test material. All these tests penetrate electromagnetic or sound waves into the test material to extract the properties [8].

Among all the non-destructive testing methods eddy current stands at a unique position. In eddy current test, an alternating current is passed through a coil to form a fluctuating magnetic field. This magnetic field induces eddy current in the test sample when the sample is brought to it. Eddy current form another magnetic field. The interaction of both field changes the impedance of the coil. Eddy current testing (ECT) is a typical non-contact nondestructive testing method and is considered to be a powerful approach for the nondestructive testing of pipe wall thinning. This paper deals with the applicability of eddy current testing (ECT) technique to assess and quantify the research work which has been done to study the effect of material properties on eddy current test response.

2.0 METHODOLOGY

For carrying out experimental work 2.76 mm thick strips of carbon steel SA106B pipe have been taken and subjected to heat treatment by using muffle furnace. Each sample has been heated to 7100 C and given soaking time of 50, 100, 200 and 300 minutes. Different soaking periods have been given to produce different microstructures. Hardness of the heat treated samples has been measured by using Rockwell hardness tester as per ASTM standard E-18. Eddy current test response has been observed. Eddy current test was performed for material sorting of ferrous material by following standard ASTM E-566.

3.0 RESULTS AND DISCUSSION

The hardness values of the heat treated samples have been shown in Figure 1. Hardness of the steel is decreasing with increasing soaking time. The decrease in hardness is an indication of grain growth [9].

Eddy current test response has been observed for all heat treated samples. Results are shown in Figure 2. The curves marked as 50, 100, 200 and 300 are of the heat treated samples, whereas

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others are standard calibration curves. Calibration curves are different for different materials. Conductivity in %IACS is increasing from for ferrite to alloy 1100.

The calibration curves are different from each other because of the difference in material. However, the difference in the curves of test samples is due to variation in microstructure of the same material. There will be an indirect relationship between material's properties, structure and eddy current test response (figure 1)

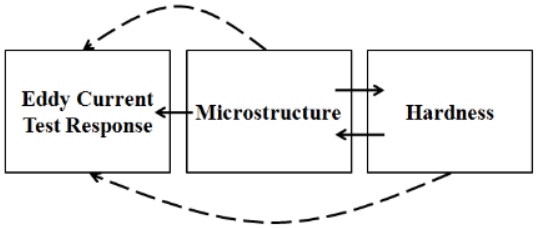

Figure 1: Relation between microstructure, hardness and eddy current response

This dependency of eddy current test response could be used to develop a good relationship between eddy current test response and material properties. This relation will help in determining material properties by performing eddy current test only.

The research in this area will be very advantages because eddy current test is practically instantaneous; where as other non-destructive tests are time-consuming. This test can also be performed without direct physical contact of the test sample with sensor. Availability of portable instruments has also made the use of this test easy [5].

4.0 CONCLUSION

High temperature applications degrade the microstructure of the steel which directly affect the hardness and strength properties. The conventional tests available to determine the material properties are destructive. Researchers are in search of a non-destructive technique to determine the properties of the material. In present study, the eddy current test response has been observed for samples of same material having different microstructure and hardness (figure 2). Impedance plane analysis of test samples showed that eddy current test is sensitive to microstructure and hardness of the material (figure 3). A good relationship has been established between eddy current test results and properties of material by extending research work in this direction. This relation will be helpful in determining material properties without performing destructive tests.

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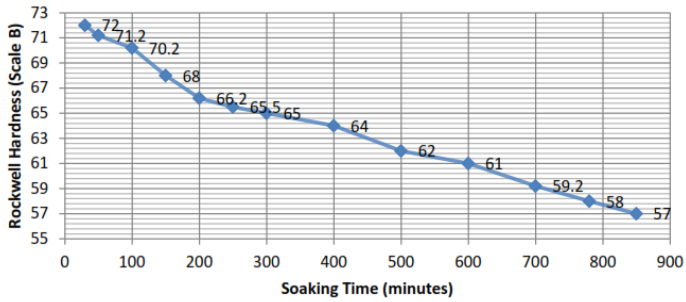

Figure 2: Hardness variation in samples of SA 106B steel annealed at 710

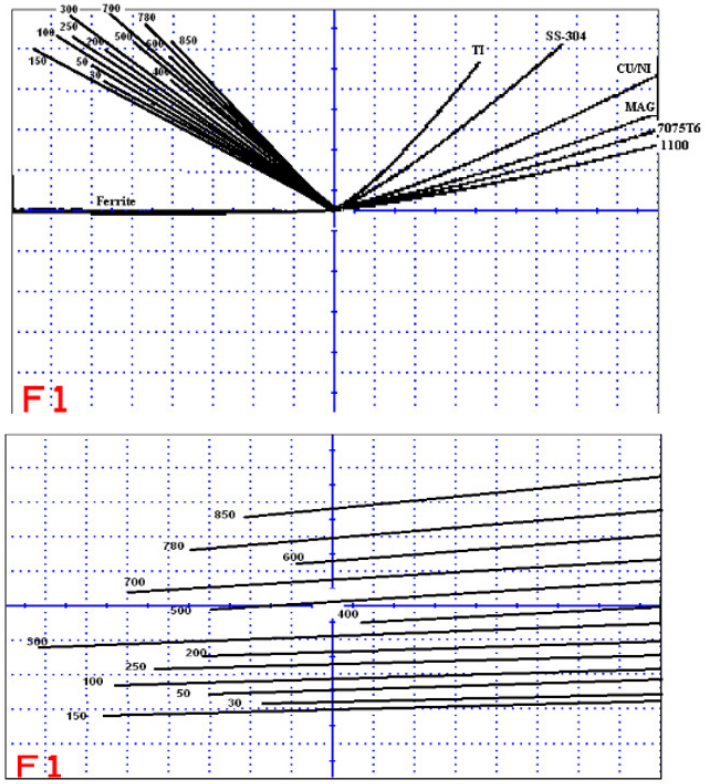

Figure 3: Impedance Plane Analysis of Heat Treated Samples

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