CORRELATION BETWEEN THE DEGREE OF CORROSION AND THE ULTRASONIC PARAMETERS IN STEEL

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Degree of Master of Philosophy

Department of Materials Science & Engineering

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidate has carried out research for the MPhil thesis under my supervision.

Signature of the supervisor: Date: Digitally signed by V Sivahar Date: 2020.07.29 10:41:12 +05'30'

Name of the Supervisor: Mr. V. Sivahar

Abstract

In metallurgical engineering, corrosion is considered as one of the main reasons for the failure of metallic components. The main reason for this is that, the corrosion is a phenomenon which is mainly influenced by the nature itself. It is very important to eliminate or reduce corrosion since it can lead to major disasters which can negatively affect the human lives and properties. Inaccurate estimations, inaccessibility of the areas of corrosion, limitations for the destructive tests can be identified as some of the main reasons for the wrong and misleading preliminary corrosion investigations, which lead to catastrophic failures. Conventionally, the degree of corrosion is determined using destructive testing methods. Also, most of the research work in this area has focused on the uniform corrosion/general attack faced by steels across a range of atmospheres. With those methods, the real degree of corrosion cannot be revealed since it is difficult to address regarding the corrosion penetrations or pits. Therefore, those are inaccurate up to some extent. In contrast to that, Ultrasonic testing methods would be more effective and convenient to overcome above limitations and would be able to open a new area of estimating the degree of corrosion accurately. Also this study sought to contribute to this field by examining whether the penetration of corrosion beyond the general attack has a significant effect on the load-bearing capacity of mild steel.

Also,in some cases such as in bridges and pipelines ultrasonic non-destructive method would be really advantageous since it is not only non-destructive but also it will allow reaching inaccessible locations easily. Further,an Ultrasonic wave can easily propagate through steel and its attenuation would provide a measurable reading to express the degree of corrosion including every minor detail.

The research work is basically focused on measuring the degree of corrosion accurately using ultrasound attenuation. The selected steel materials were subjected to corrosion in a standard accelerated environment for a defined period of time. Then after a set of experiments, the degree of corrosion has been represented by the weight loss per unit

area, corrosion rate and the corrosion penetration depth in to the material. Furthermore, the research work was able to cover the area of the mechanical property deterioration. The tensile samples were also corroded in the same standard accelerated environment as mentioned above, and subjected to periodic tensile testing and corrosion weight loss analyses. Further, the corroded samples were examined under optical and scanning electron microscopy to observe the penetration behavior of corrosion in to the material. The results showed that the actual breaking loads deviated negatively from the expected load-bearing capacity, which was determined through conventional methods. This deviation showed a close correlation to the increase of penetration of corrosion with time.

Meanwhile, the ultrasound attenuation related to each of those corroded samples was measured simultaneously. Finally, all the data were analyzed through mathematical software such as MATLAB and SPSS to generate final correlations. Thereby, a nondestructive method through ultrasound attenuation was developed to determine the accurate degree of corrosion and to predict the remaining load bearing capacity of corroded structures.

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LIST OF ABRREVIATIONS

ASTM - American Society for Testing and Materials

CS – Carbon Steel

CR – Corrosion Rate

DAC – Difference in Attenuation Coefficient

EDX - Energy Dispersive X-Ray Analysis

EN - European Norm

EMAR – Electro Magnetic Acoustic Resonance

EMAT - Electro-Magnetic Acoustic Transducer

FEM -Finite Element Method

GDP - Gross Domestic Product

IGC – Inter-Granular Corrosion

ISO - International Organization for Standardization

PDC – Penetration Depth of Corrosion

RAC – Reference Attenuation coefficient

SEM – Scanning Electron Microscope

SCC - Stress Corrosion Cracking

TEM - Transmission Electron Microscope

TAC - Total Attenuation Coefficient

WLPA –Weight Loss Per unit Area

XRD - X-Ray Diffractometer

ACKNOWLEDGEMENT

Foremost, I want to convey my heartiest gratitude and thankfulness to my advisor/ Head of the Department Mr. V.Sivahar, for the exceptional support given to me by guiding me to accomplish this goal. The enthusiasm and the motivation given by you are priceless and without your lead, this will not be a success. Furthermore, I would like to thank Professor R.G.N.De.S. Munasinghe, for the excellent guidance given in initialing this research work and providing useful comments, remarks throughout the learning process of this MPhil thesis. Also I would like to thank senior lecturer Mrs. Ravindi Jayasundare and to the Department of Mathematics for giving the fullest support in thesis work.

My sincere thank should also go the research committee for directing me to the right way till the end. Also I greatly appreciate the assistance that I received from the former head of the department and the academic and non-academic staff of Department of Materials Science and Engineering, University of Moratuwa.

Also, the financial support by SRC/LT/17/24 university research fund is greatly acknowledged.

The outcome of this thesis is a collection of efforts. There are lot of helpful hands behind it's success. I would like to express my gratitude to my parents, husband and all the family members for giving me the strength not only to achieve this goal, but for being with me throughout the entire way of personal, educational and career lives. Your support guided me to climb up the ladder.

Last but not least, I would like to express my warm hearted thanks to my colleagues, relatives and every one whom has supported me in every way to make the MPhil thesis a success.

Piyathilake S.A.K.V.M.