DOCTORAL DISSERTATION

博士論文

ATMOSPHERIC CORROSION SENSOR BASED ON STRAIN MEASUREMENT WITH AN ACTIVE-DUMMY METHOD

アクティブダミー法を用いたひずみ測定による大気

腐食センサーに関する研究

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2019

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Abstract

Atmospheric corrosion is the degradation and gradual destruction of a steel material and its vital properties due to electrochemical reactions of its surface with the elements of the atmosphere surrounding the material. Corrosion changes the micro structure and drastically reduces the mechanical strength and useful life of the steel materials. The effects of atmospheric corrosion process enhance a problem significantly. Furthermore, everyday it encounters with form of degradation, costly maintenance, and expensive overdesign. It can also endanger safety and hinder technological progress. Since the corrosion damages the material of the structures in outside condition, the studies about the corrosion process had paid special attention from the researchers. In addition, many researchers develop the sensors to detect the atmospheric corrosion using a radio-frequency identification (RFID) sensor, passive wireless sensor, corrosion potential sensor and the other atmospheric corrosion monitoring such as atmospheric corrosion monitoring (ACM). Beside developing the sensors, several techniques for atmospheric corrosion monitoring such as weight and thickness loss, electrochemical impedance spectroscopy (EIS), scanning electron microscope (SEM) and X-ray diffraction (XRD) are necessary to used.

In addition to these techniques, electrochemical methods are useful because they allow in situ corrosion monitoring. However, precise monitoring is difficult because electrochemical methods are very sensitive to corrosion reactions. Once an electrode begins to corrode, the redox reactions of the corrosion products affect the current density signals. In the case of steel, ferrous and ferric ions coexist in the corrosion product. These factors ultimately prevent precise evaluation of atmospheric corrosion. Thus, a highly accurate in situ sensor capable of monitoring atmospheric corrosion is needed. The sensor for the atmospheric corrosion monitoring that the author focus on is atmospheric corrosion monitoring based on strain measurement (ACSSM).

This the ACSSM study, the theoretical, numerical and experimental approach in order to develop the atmospheric corrosion sensor based on strain measurement which not affected by the temperature drift as a proposed study were presented.

Therefore, the purpose of this study is to develop an amplifier circuit for atmospheric corrosion monitoring based on strain measurement by using the active-dummy method, which has high sensitivity and can reduce the effect of temperature drift on the measurement environment. A dummy circuit compensated for the temperature drift in the signal with an active circuit was successfully designed and the configuration of active and dummy sensor to accurately measure the thickness reduction in low-carbon steel test pieces was compared with the analytical results obtained by the finite element method (FEM).

The experiments involving galvanostatic electrolysis and under dry wet condition were conducted by using the strain measurement circuit which consist of active circuit, dummy circuit and differential circuit to determine the thinning of test pieces through strain measurements. In addition, the effect of the temperature on the measurement environment on the signals, was investigated simultaneously with the strain.

The result of the experiment using ACSSM with strain gauges and FBS sensors in conducting the galvanostatic electrolysis and under dry wet condition experiment had the same tendency for each experiment. In electrolysis Galvanostatic result the initial measurement that without applying the DC current, the signal is lightly constant and after applied the DC current, the strain increased gradually by elapsed time. When the ACCSM applied the dry wet condition using 5% NaCl, the tendency of strain was different worth galvanostatic electrolysis experiment. There are three stages in this experiment result. Stage I is the initial condition before spraying a salt water. Stage II is the condition after spraying a salt water and corrosion products were generated. the thickness reduction shows the negative trend. It indicated that the thickness on the test piece increased due to corrosion products. Stage III is the condition of further progress of corrosion, resulting the thickness reduction due to the corrosion including corrosion product. The thickness reduction shows the positive trend. According to mechanical theory it indicated that the thickness on the test piece decreased due to corrosion including corrosion product.
Keywords: Atmospheric corrosion; strain measurement; active dummy method, electrolysis Galvanostatic, dry wet condition

Acknowledgement

First of all, I would like to express my sincere gratitude to my supervisor Assoc. Prof. Naoya KASAI for the continuous support of my Ph.D study and related research, for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my Ph.D study.

I would be thankful to my collaborated supervisor Prof. Shinji OKAZAKI Prof. Yukihisa KURIYAMA and Prof. Hiroshi KIHIRA for their availability, constant support, and constructive suggestions which were determinant for accomplishment of the work presented in this thesis.

Besides my supervisor, I would like to thank the rest of my dissertation committee: Prof. Hideo OTANI, Prof. Atsumi MIYAKE, Assoc. Prof. Tadahiro SHIBUTANI for their insightful comments and encouragement, but also for the hard question which incented me to widen my research from various perspectives.

I thanks to KASAI laboratory member for the stimulating discussions and teach me how to make a simulation with my limited knowledge of computer language, for the sleepless nights we were working together before deadlines, and for all the fun we have had in the last four years.

The last, I would like to thank my family: my beloved husband Dasa Putra Andius, my sons Muhandis Bayu ADJIE, Dwikashinta Purwanda PUTRA, Abqari Althof Wianda PUTRA, my parents in heaven and to my brothers and sisters for supporting me spiritually throughout writing this thesis and my life in general. Thanks to Directorate General Resources of Science, Technology and Higher Education, Ministry of Research, Technology and Higher Education Republic of Indonesia for financial support and the University of Lampung for the valuable support and give a chance to take this opportunity.

TABEL OF CONTENT

LIST OF TABLES

LIST OF FIGURES