

A STUDY OF ATMOSPHERIC CORROSION INDOOR AND
OUTDOOR

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We certify that the project entitled “A Study of Atmospheric Corrosion Indoor and Outdoor “is written by Mohd Fahies bin Ismail. We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering.

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I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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Dedicated to my parents

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ABSTRACT

Atmospheric corrosion may cause serious damage to metallic structures and equipments. Because of the huge impact of corrosion, it is imperative to have a systematic approach to recognizing and justifying corrosion problems as soon as possible after they become apparent. In this study, the impact of atmospheric corrosion on aluminum, copper and zinc was investigated by exposing the sample in indoor and outdoor atmosphere. Each sample undergoes environmental exposure for 28 days before the surface morphology investigation was conducted. Then the cleaning process follows prior to the final analysis. Scanning Electron Microscope (SEM) was used to study the surface morphology. Corrosion rate was determined for all samples. In indoor environment, it was found that zinc possess the highest corrosion rate; 1.440 mpy while aluminum is the less corrosive sample with only 0.2645 mpy. The outdoor environment investigation yield similar polar of result where the value increase in almost double the result from indoor investigation. Corrosion rate of zinc is 2.103 mpy and the less corrosive sample; aluminum is 0.417 mpy. Any features of corrosion failure give significant clue of the possible corrosion factor. This article details a proven approach to properly determining the effects of the environment and material types to the corrosion rate, and includes surface microstructure of the most common corrosion types, including general corrosion, pitting, and erosion. In conclusion, properties of outdoor and indoor influence the corrosion rate. Indoor environment shield the samples from rain and dew hence decrease the corrosion rate compare to open or outdoor environment where the samples subjected to the dynamicity of weather. Aluminum proves to be the most protective sample and corrosion durable. Hence it may suggest that for both indoor and outdoor application, aluminum is highly recommended.

ABSTRAK

Kakisan boleh memberikan kesan yang serius terhadap struktur dan peralatan besi. Disebabkan oleh kesan yang ketara ini, adalah wajar bagi mengesan dan menjustifikasikan seawal mungkin kemunculan karat dengan menggunakan pendekatan sistematik. Dalam penyelidikan ini, kesan kakisan atmosfera ke atas aluminium, kuprum and zink dikaji dengan mendedahkan sampel kepada persekitaran terbuka dan tertutup. Setiap sampel didedahkan selama 28 hari sebelum analisis morfologi permukaan dijalankan. Proses pembersihan dilakukan sebelum analisa akhir. "Scanning Electron Microscope (SEM)" atau mikroskop imbasan elektron digunakan dalam kajian morfologi permukaan. Kadar pengurangan ditentukan bagi setiap sampel. Bagi persekitaran tertutup, zink mengalami kadar kakisan tertinggi iaitu 1.440 mpy manakala aluminium mengalami kadar kakisan terendah iaitu sebanyak 0.2645 mpy. Persekitaran terbuka pula memberikan polar keputusan kajian yang sama tetapi dengan nilai kadar kakisan hampir mencecah dua kali ganda kadar pengurangan persekitaran tertutup. Kadar kakisan zink ialah 2.103 mpy dan aluminium pula ialah 0.417 mpy. Sebarang ciri pengurangan mendedahkan faktor penyebab kakisan itu. Artikel ini memberikan pendekatan yang terbukti dalam menentukan secara tepat kesan persekitaran dan jenis bahan terhadap kadar kakisan. Ini termasuk struktur mikro kakisan seperti kakisan umum, pitting dan kakisan kimia. Kesimpulannya, ciri-ciri persekitaran mempengaruhi kadar kakisan. Bagi persekitaran tertutup, kadar kakisan adalah rendah kerana sampel terlindung daripada hujan dan embun. Persekitaran terbuka pula memberikan bacaan hampir dua kali ganda kerana wujudnya faktor cuaca. Aluminium terbukti sebagai sampel yang mempunyai daya tahan kakisan tinggi. Oleh itu, penggunaan aluminium dalam aplikasi di ruangan terbuka dan tertutup adalah sangat disyorkan.

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LIST OF SYMBOLS

P	Pressure
$^{\circ}C$	Degree Celsius

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Nowadays, the defects and losses that cause by atmospheric corrosion always are topics of conference and discussion. Atmospheric corrosion of metal is most commonly observed phenomena in our life. However, the mechanism of atmospheric corrosion of metal has not been clarified because of the difficulty in experimental work.

From the standpoint of economics, safety, and aesthetics, the importance atmospheric corrosion and its control is well recognized. More structure and material are exposed to the atmosphere than to any other environment. It is not surprising, therefore, that a vast body of exists on the performance of materials in the atmosphere and the characterization of such environments. Society interests in the performance of material in the atmosphere were active well before the formation of committee G-1 on corrosion of metal in 1964. The International Organization standardization (ISO) has also been very active in the development of standards for atmospheric testing methods and classification of atmospheres. It seemed a natural follow-up for subcommittee G 01-04 to organize another symposium on atmospheric corrosion, held in November 1993 in Dallas, Texas.

Atmospheric corrosion is the interaction of any material, commonly a metal, with the surrounding atmospheric environment. A well-known example is the rust formation on cars and other vehicles, but also electronic devices, construction materials, our cultural heritage and military equipment, to mention a few examples, are subjected to atmospheric corrosion. Additionally, this kind of corrosion is important to many

naturally occurring processes. Due to the massive economical impact corrosion has on society, a good knowledge of the fundamental processes involved is essential in the search for new preventative measures. Since atmospheric corrosion involves many physical and chemical processes, it requires a good knowledge in several scientific areas, and can thus be considered a truly interdisciplinary field.

The corrosion of a metal, and its transformation to the mineral it was extracted from, has been known for a long time, but it was not until the 1920's that scientific investigations of corrosion phenomena commenced. This new work was performed by Vernon, who examined the corrosion products formed upon exposure of a metal surface to corrosive gases, such as carbon dioxide (CO₂) and sulfur dioxide (SO₂) (Vernon, 1923, 1927). The researcher studied the influence of relative humidity on the corrosion rate, and realized the importance of water in atmospheric corrosion. During the following decades, the central role of electrochemical reactions was discovered. In the 1960's, instruments capable of analyzing the chemical composition of the corroded surface started to emerge, and X-ray photoelectron spectroscopy (XPS), and Auger electron spectroscopy (AES) became work-horses as surface analytical tools. Year by year, the technology to investigate the corrosion have been developed in order to analyses corrosion propagations and find the ways to prevent it.

1.2 COST OF ATMOSPHERIC CORROSION

Atmospheric corrosion may cause serious damage to metallic structures and equipments. The effect is so serious that the annual cost of atmospheric corrosion is approximately half the total annual cost of all types of corrosion of metals (W. Ke, 2003). It has been reported that more than half of the national cost of corrosion, which has been estimated at close to 4% of a nation's gross domestic product, is a result of atmospheric corrosion (J. H. Payer, 1980). As another example, around 20% of failures of aircraft electronics are thought to be due to corrosion-related causes (B. Dobbs and G. Slenski, 1984). It is difficult to estimate the cost of direct or indirect consequences caused by atmospheric corrosion on materials exposed in our environments (C. Leygraf and T. E. Graedel, 2000). It has become evident that acid deposition through rain, snow, fog, or dew has resulted in substantial deterioration of artistic and historic objects,

including old buildings and structures of historic value, statues, monuments and other cultural resources.

1.3 PROBLEM STATEMENT

Atmospheres are often classified as being rural, industrial or marine in nature. Two decidedly rural environments can differ widely in average yearly temperature and rainfall patterns, mean temperature, and perhaps acid rain, can make extrapolations from past behavior less reliable.

The corrosion of metal in the atmosphere and in many aqueous environments is best understood from a film formation and break down standpoint. It is an inescapable fact that iron in the presence of oxygen and water is thermodynamically unstable with respect to its oxides. Because atmospheric corrosion is an electrolytic process, the presence of an electrolyte is required. This should not be taken to mean that the metal surface must be awash in water; a very thin adsorbed film of water is all that is required.

During the actual exposure, the metal spends some portion of the time awash with water because of rain or splashing and a portion of the time covered with a thin adsorbed water film. The portion of time spent covered with the thin water film depends quite strongly on relative humidity at the exposure site. This fact has led many corrosion scientists to investigate the influence of the time of wetness on the corrosion rate.

Atmospheric corrosion occurs in many places such as under sea water, indoor and outdoor. Different environments have different surrounding compositions and parameters such as pH. Therefore, different environments and types of material will give the variation in corrosion rate and types that will be discussed in this thesis.

1.4 OBJECTIVE OF STUDY

The objectives of this study are:

- i. To study the atmospheric corrosion in outdoor and indoor environment.
- ii. To investigate the effect of atmospheric corrosion to the surface and microstructure of each material.
- iii. To study the effect of different environments and materials to the corrosion rate analysis of copper, aluminum, and zinc.

1.5 SCOPES OF PROJECT

The scope of this study includes:

- i. Sample preparations process including cutting, drilling and initial cleaning
- ii. Exposure of specimen indoor and outdoor
- iii. Cleaning process using specific chemicals
- iv. Corrosion analysis which will be done by weight loss method (corrosion rate) and surface observation (SEM)

1.6 SIGNIFICANCE OF STUDY

Conducting this study can contribute to the existing data on the atmospheric corrosion study and can be used as the reference in future research. Moreover, this study can contribute in order to avoid the corrosion or reduce the maintenance costs due to the further understanding about the atmospheric corrosion.