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CORROSION GROWTH PREDICTION IN SEAWATER BALLAST TANK OF BULK CARRIERS USING STATISTICAL MODEL

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A project report submitted in partial fulfillment of the
requirements for the award of degree of
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I declare that this project report entitled *"Corrosion Growth Prediction In Seawater Ballast Tank Of Bulk Carriers Using Statistical Model"* is the result of my own research except as cited in references. This project has not been accepted for any degree and is not concurrently submitted in candidature of any other degree

Signature : .....

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Date : 02/05/08 .

Teristimewa untuk Ibu dan bapa tersayang; Pn. Aminah Binti Pandak Soud dan En. Ramli Bin Kassim, tunang yang banyak memberi sokongan; En. Nazrul Aizad Bin Harun serta adik-adik yang dikasihi; Mohd Shahril, Saliza, Syahirah dan Syafiqa.

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ABSTRACT

Corrosion is the major cause of deterioration in marine structures. For the past few years have seen an increase in the number of reported instances of accelerated corrosion in ship's ballast tank. This is why careful attention needs to be taken to prevent the deterioration due to corrosion of ballast tank. Therefore, corrosion growth prediction is important in failure analysis. This paper developed a statistical time dependent model for corrosion depth of seawater ballast tank in bulk carriers. The model is based on available group of statistical data for corrosion of existed bulk carriers. The proposed model is benefit for future prediction of corrosion data by eliminating the dependent factors such as environment factor, material properties and operational condition. In specific, a simple simulation procedure is implemented to predict the future distribution of corrosion depth. Based on the result in simulation stage, the result were synthesized and analyzed for validity of proposed model by comparing the actual data with predicted data. The result shows that the model is reliable and practical in predicting the distribution of corrosion depth. From the study, the proposed model seems to be more flexible comparing to the available analysis method and hopefully will facilitate the engineer in the future prediction of ship failure in marine structures.

ABSTRAK

Pengaratan merupakan faktor utama kepada masalah kemerosotan kualiti sesebuah stuktur laut. Jumlah pengaratan tangki balas kapal dilaporkan mengalami peningkatan yang drastic beberapa tahun kebelakangan ini. Ini adalah salah satu sebab mengapa perhatian perlu di titikberatkan dalam pengawalan pengaratan sesebuah tangki balas. Oleh sebab itu, ramalan pertumbuhan karat adalah penting dalam menganalisis kegagalan sesebuah struktur. Kajian ini dijalankan bagi menghasilkan sebuah model pertumbuhan karat di dalam tangki balas sesebuah kapal penumpang yang mana berkadaran dengan masa. Model ini dilaksanakan berdasarkan sekumpulan data kapal penumpang yang sedia ada. Model yang dicadangkan ini berguna dan dijangkakan dapat digunakan dalam membuat ramalan pertumbuhan karat bagi masa akan datang. Perlaksanaan model ini adalah berdasarkan faktor bilangan dan umur kapal dengan mengabaikan faktor-faktor lain seperti persekitaran, bahan dan keadaan operasi kapal. Seterusnya, sebuah prosedur penyerupaan yang mudah dijalankan ke atas model yang telah dibangunkan untuk meramal taburan pertumbuhan karat pada masa akan datang. Daripada proses penyerupaan yang dijalankan, kesahihan model yang dibangunkan dapat dibuktikan setelah keputusan yang diperolehi di sintesis dan dianalisis dengan membuat perbandingan secara grafik di antara data sebenar dengan data yang diramalkan. Hasil akhir menunjukkan model yang dicadangkan adalah sesuai dan praktikal dalam ramalan taburan kedalaman pengaratan . Melalui kajian ini, model yang dicadangkan diharap dapat memudahkan jurutera dalam ramalan kegagalan sesebuah struktur kapal pada masa akan datang.

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λ	=	Exponential parameter also known as failure rate
μ	=	mean
β	=	shape parameter
δ	=	location parameter
d_{ave}	=	linear regression model of defect depth average
d_g	=	degree of freedom.
E	=	expected frequency
ϕ	=	standard normal probability
f	=	probability density function
F	=	cumulative distribution function
k_n	=	number of classes.
μ_x	=	mean value
N	=	class size
O	=	observed frequency
θ	=	scale parameter
R^2	=	coefficient of determination
σ^2	=	variance
std_d	=	linear regression model of defect depth standard deviation
σ_x	=	standard deviation
t_v	=	age of vessel
u	=	random variables generated
x_o	=	an offset, which is assumed to be known a priori (the smallest value)
Y_u	=	upper limit of selected class

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CHAPTER 1

INTRODUCTION

1.1 Corrosion of Marine Structures

Corrosion is the major cause of deterioration in marine structures. The past few years have been seen an increase in number of reported instances of accelerated corrosion in ship's ballast tank (Cleland, 1994). Vessels are often made of steel and therefore these structures are too exposed to suffer various types of damage as they get older.

In many forms of corrosion, pitting or grooving is forms of corrosion major involved to marine corrosion especially for ballast tank of oil tanker and bulk carrier. This localized corrosion may have serious consequences in ship's structures. It can cause severe cracking or extend wider to produce general structure deterioration. Such failure may associate with higher cost of maintenance including lost lives in some cases.

The area of ballast tank that most exposed to corrosion are wing part of ballast tank which situated between the holds and the shipsides. Ballast tank is the outer hull, which create the external shape of ships. Usually, the inner water ballast tank surface area is very large. To make sure the quality of ballast tank, it needs a careful attention. (Singh, 1990). Corrosion has to be avoided. It is due to the complex structure of it with frequent wetting and drying in highly corrosive salt water environment.

1.2 Problem Statement

Ballast tank is one of vessel's parts that highly subjected to corrosion. Maintenance of ballast tank to prevent corrosion involves very high cost, therefore only relevant types and level of maintenances should be done to avoid excessive cost.

To predict corrosion growth in ballast tank in the future, it is necessary to have a relevant estimate of the corrosion rate. An inspection to measure corrosion depths in a number of vessels' ballast tank of various ages has been made. Data gathered from the inspection will be used to develop a statistical time-dependent corrosion model. This model will provide the statistical characteristic such as mean, variance, distribution of corrosion rate as a function of time ship age, making it possible to predict the corrosion rate of ballast tank of any age.

Statistical and probability analysis have been suggested by previous researchers to achieve better understanding and predict the exact depth of corrosion growth. Even though this method can gives better interpretation of corrosion growth, wide application is still uncommon. The statistical model is the best method

to improve the complex parameter. Thus, this study is motivated by several problems existed in the corrosion failure analysis as listed in the following:

a) Difficulty for plant engineer to understanding the available analysis method because of the complexity of corrosion empirical models and statistic technique.
b) Errorneous data of corrosion for seawater ballast tank
c) Lack of inspection data
d) Corrosion models are generally developed based on experimental work at laboratory and will not gives a practical and exact simulation to the real event on site.

1.3 Objectives and Aim

The aim of this study is to develop a probability time-dependent model of corrosion depth in bulk carrier's ballast tank. To achieve the aim, the following objectives have been listed which are:

a) To identify the distribution of real inspection data using statistical approach.
b) To develop a model for representing the growth of corrosion depth using probability method.
c) To predict the future corrosion distribution using Inverse Transformation Simulation procedure.
d) To compare the actual data with the predicted data generated using the proposed model.

1.4 Scope of Study

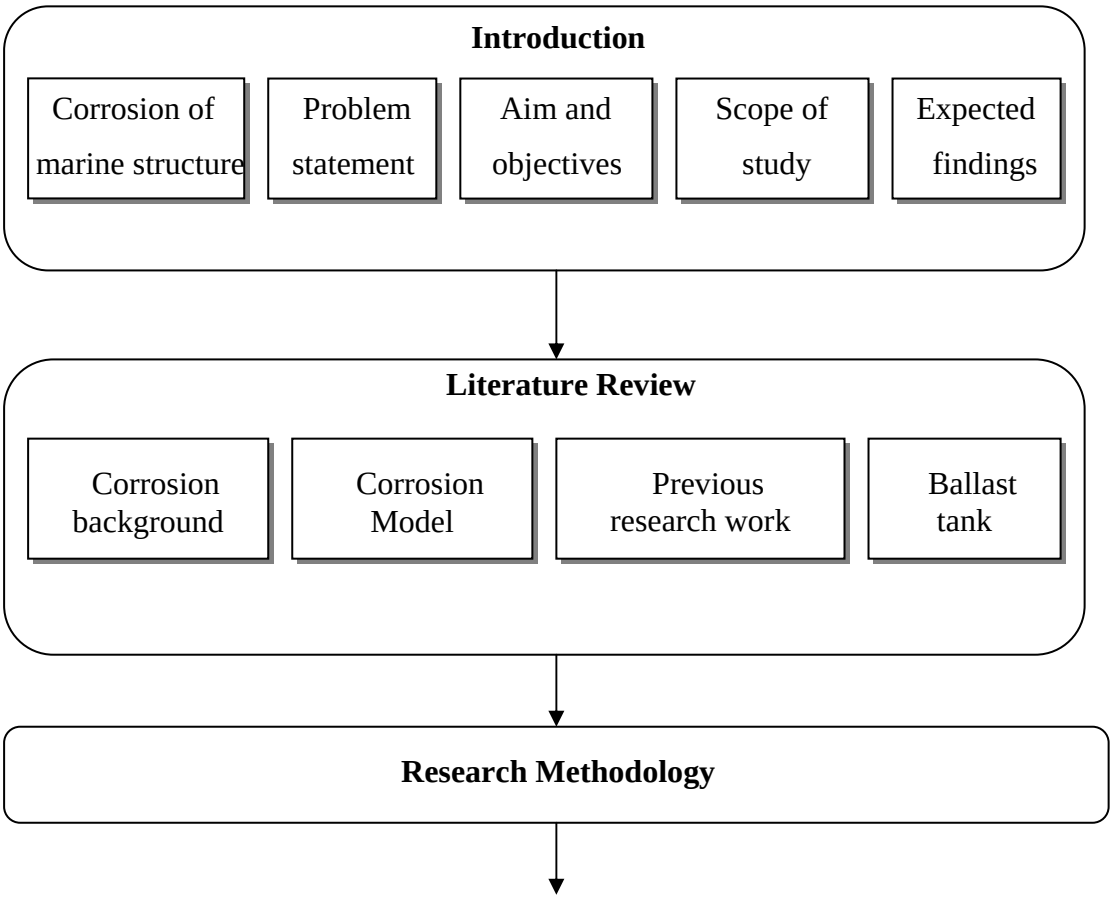
This study will be focusing on the corrosion depth of bulk carrier's seawater ballast tank. The data used to develop a statistical model are the real data that gathered during the site inspection by ship's owner. The types of corrosion that have been considered are marine corrosion. Method that are going to be use in development of statistical model is linear/theoretical method which not consider the environment parameter. The development of statistical model in this research will enable the prediction of corrosion depths at any point of time (ship's age). Then Inverse Transformation Method which is one of element in Monte Carlo simulation will be used to assess and predict the future corrosion depth at any age of vessels' ballast tank. The prediction of future distribution of corrosion depth is based on the proposed time-dependent growth model.

1.5 Expected Finding and Importance of Research

The expected finding from this study is a time-dependent growth model of marine corrosion in vessels' sea water ballast tank. This corrosion model will be reliable in predicting the corrosion rate of seawater ballast tank of bulk carriers at any point of time. The model is specifically tailored to be simple yet practical for on site assessment of structure remaining life-time upon corrosion attack. The proposed method is a provisional tool in predicting the future growth of corrosion defect until more data can become available. Hence, enable the use of more advance and intricate model in corrosion modeling.

1.6 Conclusion

Figure 1.1 shows the work flow of the study. This study begins with an introduction to corrosion of marine structures, followed by a discussion on problem statement, aims, objectives and scope of study. The introduction is followed by Chapter 2, covering reviews of all topics related to corrosion and previous studies. Then, the research methodology is presented in Chapter 3. Chapters 4 covers the statistical and probability analysis of corrosion data from seawater ballast tank of bulk carriers. The steps in development of proposed model were discussed in detail in Chapter 4 together with the result of simulation then, followed by Chapter 5 with discussion and recommendation to improve the proposed model. The study ends in Chapter 6 conclusion to the study.



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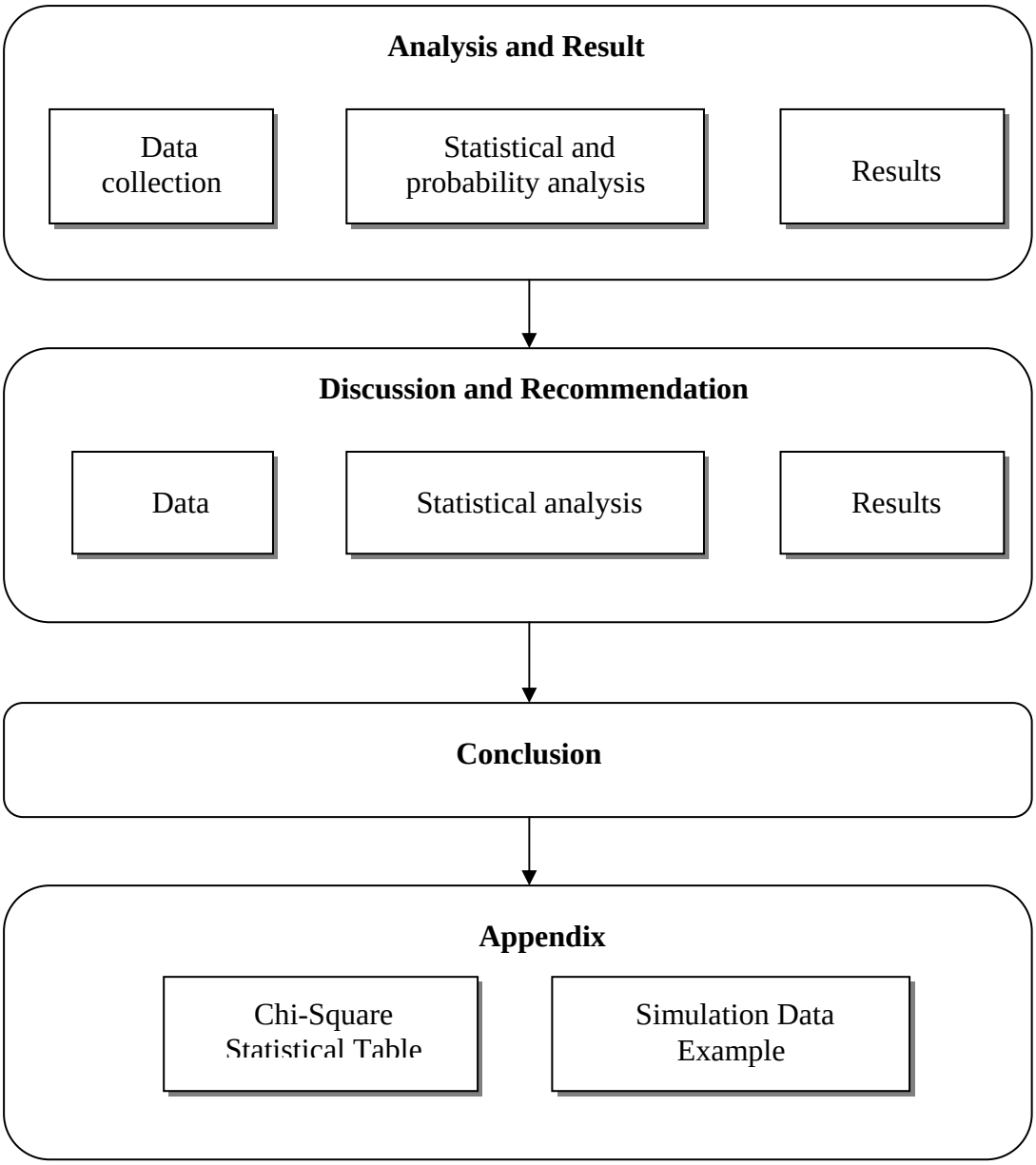

Figure 1.1: Organization of study