CONSTRUCTION DEFECT ANALYSIS OF INSULATION PANELS FOR CARGO TANKS ON LIQUIFIED NATURAL GAS CARRIERS

ZULMAN BIN MOHD SHIDEK

UNIVERSITI TEKNOLOGI MALAYSIA

CONSTRUCTION DEFECT ANALYSIS OF INSULATION PANELS FOR CARGO TANKS ON LIQUIFIED NATURAL GAS CARRIERS

ZULMAN BIN MOHD SHIDEK

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering (Marine Technology)

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

JANUARY 2014

ALHAMDULILLAH…….

I dedicate this work of mine to:

My beloved Wife and My beloved "Prince"

My Late Father and My Mother

My Father and My Mother in Law

My Brother and My Sister

My Brother and My Sister in Law

Whom I always remember for the help, courage, strength that they have given me throughout my studies, emotionally, prayers, support, loves, understanding, and assistance.

ACKNOWLEDGEMENT

بسم الله الرحمن الرحيم

In the name of Allah, the most Beneficent and the most Merciful.

First and foremost I am very grateful to Allah the Almighty for the blessings and guidance. He has bestowed upon me throughout the entire period of my research undertaking.

My deepest appreciation goes to my supervisor Ir. Dr. Faizul Amri Adnan and my co-supervisor Associate Professor Dr. Mohd Zamani Ahmad for their continuous support and kindness in supervising and reviewing my work and guiding the course of my research to the utmost quality of the research. Special thanks to UTM panel of supervisors for their feedback, helps and contributions towards the accomplishment of my research study.

I am very thankful to MISC Berhad for the sponsoring and study leave that has enabled me to pursue my academic dreams. Not forgotten to my office colleagues and friends who also played a role, always being supportive and encouraging me when I was down, and providing much needed distraction when I was feeling burned out.

Last but not least, great gratitude expressed to Nadia Harun for her constant support, patience, encouragement and sacrifices that became the source of my strengths in undertaking and completing this task successfully. To the memory of my late father Haji Mohd Shidek, to my mother Hajjah Fatimahtul Zahara, family and my in-laws, I express my highest gratitude which no words can utter for they had shaped my thought processes to always strive for the best. THANK YOU for being there when I needed you.

ABSTRACT

Detection and inspection of physical defects on newly installed insulation panels of liquefied natural gas (LNG) containment system on LNG ships is carried out in pursuance to the contractual conditions aims at achieving quality, reducing risk and ensuring safety. It is carried out throughout the installation process and the defect data are processed for the purpose of initiating the rectification process. Detection and inspection could be strategised to focus on the more serious defects, frequently occurring defects and areas which are defect prone. The research analyses four types of physical defects, namely, foam defect, plywood defect, rigid triplex defect and supple triplex defect and predicts the chances of occurrence at strategic locations. Physical defects data gathered during the installation of 2541 insulation panels on two LNG ships are analysed. Linear and polynomial prediction lines on chances of detecting the defects have been produced. The results indicate that supple triplex defect is most common (61.3%) and defect is likely to be found at the tank bottom (30.4%). The chance of discovering defect on the insulation panel inspected is 1%. While for supple triplex defect, the most common defect type is also 1%. There is an indication that the defects at the tank bottom will be found on certain area only.

ABSTRAK

Pengesanan dan pemeriksaan kecacatan fizikal pada panel penebat yang baru dipasang dalam sistem pembendung gas asli cecair (LNG) di atas kapal LNG dijalankan menurut kepada syarat-syarat kontrak yang bertujuan untuk mencapai kualiti, mengurangkan risiko dan memastikan keselamatan. Ia dijalankan sepanjang proses pemasangan dan data kecacatan diproses bagi tujuan memulakan proses pembetulan. Pengesanan dan pemeriksaan boleh dirancang dengan memberi tumpuan kepada kecacatan yang lebih serius, lebih kerap berlaku dan kawasan-kawasan yang terdedah pada kecacatan. Penyelidikan ini menganalisis empat jenis kecacatan fizikal iaitu kecacatan jenis buih, papan lapis, '*rigid triplex*' dan '*supple triplex*' dan meramalkan peluang terjadinya kecacatan di lokasi yang strategik. Data kecacatan fizikal yang dikumpul semasa pemasangan 2541 panel penebat pada dua kapal LNG dianalisis. Garis ramalan linear dan polinomial mengenai peluang mengesan kecacatan yang lebih penting telah dihasilkan. Keputusan menunjukkan bahawa kecacatan jenis *'supple triplex'* adalah yang paling biasa (61.3%) dan kecacatan berkemungkinan besar dijumpai pada dasar tangki (30.4%). Peluang menemui kecacatan bagi panel penebat yang diperiksa ialah 1%. Manakala bagi kecacatan jenis *'supple triplex'*, jenis kecacatan yang paling biasa, ia juga adalah 1%. Terdapat petunjuk bahawa kecacatan pada dasar tangki akan ditemui di beberapa kawasan tertentu.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Research Background

In the building of cargo tanks for LNG carrier, quality entails a vital important role as to guarantee a useful tanks' design life of more than 40 years with very small margins of defect. Quality needs to be controlled during the course of constructing the cargo containment system in particular during installation of insulation panels. The consequences of a defect can be potentially critical for the vessel operation, maintenance and with consequence commercial impact to the vessel that could finally tarnish the reputation of the parties involves especially the ship owner, shipbuilder as well as the designer. This not only has implications on final built products, but also impacts on remedial and repair work, time delays and additional cost (Stephenson, 2002). Yet, such defects including physical defects occur despite close inspection and supervision during the construction period.

Inspection engineers or supervisors must consider a combination of uncertain factors, such as tools, equipment, workers, installation sequence and work procedures to achieve the successful completion of a quality cargo containment system on time. Each of these uncertain factors influences the defect recurrence at all stages in the construction commencing from initial fabrication process till the tanks' completion.

Physical defect inspection during construction emphasizes on defect types and defect locations. Each defect has to be recorded for traceability as well as for future quality improvement being a lesson learnt. The defect encountered during construction must be repaired in accordance with the approved repair procedure.

Physical defects occur due to many reasons and are believed to be random in nature. However, over a long period, defect patterns could be detected and established. The aim of this research is to analyze the occurrence of physical defects and to produce a defect prediction and to highlight the diverse forms of, often causal, evidence during cargo containment system installation process in a natural and efficient way. Defect data has been statistically analyzed and prioritized according to the establish frequency or chances of defect occurrence.

1.2 Problem Description

It is the interest of both shipbuilders and ship owners that new vessels are delivered with zero defects to all parts of the vessels. In LNG carrier construction, a lot of effort is put on supervision and inspection to ensure zero physical defects on cargo tanks. It is a common practice that defects discovered on cargo tanks construction are systematically recorded and shipbuilders are notified to make good the defects. The process of detecting defects, notifying shipbuilders, making good of the defects and re-inspection is as continuous cycle until both parties are fully satisfied.

Currently, defect detection and inspection is not carried out strategically. Defects have not been strategically categorized and types and locations where the defects are discovered have not been correlated. As such, efforts on defect finding and inspection have not been focused on the more important defect in term of chances of occurrence or weight of importance.

Hence, defect data has to be analyzed so that pattern of chances of occurrence could be established. By establishing the pattern of chances of occurrence, inspection engineer could be more strategic in locating defect. This could save resources in the form of cost and time saving.

1.3 Research Objective

The objective of the research is to analyze establish categorization and prediction of occurrence of physical defects on LNG containment system on board LNG vessels during construction process.

1.4 Research Significance and Contributions

The research is focused on:-

i) Categorizing defects found on LNG cargo tanks during construction stage.
ii) Identifying the type of defect that is most likely to be discovered during inspection.
iii) Establishing a regressed correlation line between the number of insulation panel inspected and the number of defects to be discovered.

As such, the most significant contribution of the research are:

i) The correlation lines could be used as a mean of predicting the number of defects likely to be found given the number of insulation panels inspected.

ii) The prediction will allow inspection engineers to focus his or her effort detecting the most important defect and concentrating on the most likely locations.

iii) The effectiveness and efficiency resulting from the above will bring direct monetary advantage to parties involved in detection and inspection of physical defects on LNG containment system on board LNG vessel during construction process.

1.5 Scope of Research

The research is attempting to draw a generic relation between the numbers of defects that is likely to be found on insulation panels of LNG cargo tanks against the number of insulation panels inspected during construction stage. The data however is extracted from the information records on inspection carried out during the construction of cargo tanks for two (2) LNG carriers belonging to MISC Berhad. Each vessel has four (4) tanks and data for the current research is extracted only from the records of inspection of these tanks.

The analytical method resorts to basic yet sufficient mathematical approach in detecting frequency of defect occurrence and regression correlation between number of defects and number of insulation panels inspected. Simple normalization approach using average expected values against observed data, as explained in Chapter 3, is used to make adjustment to defect data as a result of inconsistency due to the fact that two (2) different tank construction contractors are involved in the installation of insulation panels.

The accuracy of the results depends on the environment factors governing the construction of the eight (8) LNG tanks considered. Such factors may include number of tank constructors, equipment used and number of defect inspection engineers. These could be considered when improvement on the prediction is required.

1.6 Research Outline

This thesis is organized as follows Chapter 1 gives the background of the research including the brief history of LNG cargo containment system, objective, problem description, significance and contributions of the research, scope of research and lastly research outline. Chapter 2 is dedicated for the review of literature. The research methodology employed in this research is fully discussed in Chapter 3. In Chapter 4, research results are presented statistically in the form of illustration including defect data plotting. Finally, the discussion and conclusion from the presented work are drawn and further research works are proposed in Chapter 5 and 6 respectively.

REFERENCES

Bruls, E.M.J.G., (1993), Reliability aspects of defect analysis, Proceedings of European Test Conference, 1993, 19-22 April, pp.17-26

Cornyn, W. S., Barrett, J. S., Brabston, D. C., Camana, P. C., McAferty, J. M., Nelson, S. P. and Schy, S. T., (1984), U.S Patent Application Sr. 188, 651,

Desoli, G.S., (1993), A system for automated visual inspection of ceramic tiles, Proceedings of the IECON '93, International Conference on Industrial Electronics, Control, and Instrumentation**,** 15-19 November, pp.1871 – 1876, Vol.3

GAZTRANSPORT & TECHNIGAZ, (2009), LNG Carrier Containment System – Land Storage – Pluto II, http://www.gtt.fr/content.php?cat=34&menu=60 (retrieved on 15/02/2013)

IGC Code (International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk). MSC/Circ.604 and MSC/Circ.845.

IHI, (2012), IHI-SPB Tank System for FLNG, http://injapan.no/bizdelegation-day2/files/2012/09/6.-Watanabe-IHIMU.pdf (retrieved on 15/02/2013)

Ipalo Enertech, (2013),TGZ Mark III System, http:// ipalo-enertech.com/services.html (retrieved on 15/02/2013)

Ishimaru, J., Ohira, H., Kawami, M., Matsuo, Y., Morita, H., Nagae, K., (1994). Designing LNG Carriers for 21st Century with Emphasis on Economical and Safe Operations. Gastech94.

Jalote, P. and Agrawal, N. (2005), Using Defect Analysis for Improving Quality and Productivity in Iterative Software Development, Department of Computer Science and Engineering, Indian Institute of Technology Kanpur, Kanpur, 208016; India, http://www.cse.iitk.ac.in/users/jalote/papers/DefectPrevention.pdf, retrieved 10th February 2013.

Kandt, R. K., (2003), A Software Defect Detection Methodology, Jet Propulsion Laboratory, California Institute of Technology.

Kidnay, A., Parrish, W. R., (2006). Fundamentals of Natural Gas Processing. CRC Press, Taylor, and Francis Group, LLC.

LIQUEFIED GAS CARRIER, (2011), Carrying liquefied natural gases by various type LNG ships, http://www.liquefiedgascarrier.com/Liquefied-Natural-Gas-Carriers.html (retrieved on 15/02/2013)

Noble, P. G., Ronning, L., Paulling, J., Zhao, R. and Lee, H., (2005), A Novel LNG Tank Containment Design for LNG Carriers, ABS Technical Papers, American Bureau of Shipping.

Runeson, P., Andersson, C and Thelin, T., (2009), What Do We Know about Defect Inspection Methods, IEEE Xplore, ?????

SARJEEVANSAINBIHI, (2013), Kvaerner-Moss Type Containment System-Details, http://sarjeevansainbhi.webs.com/apps/photos/photo?photoid=136217466 (retrieved on 15/02/2013)

Stephenson, P., Morrey, I., Vacher, P., Ahmed, Z., (2002). Acquisition and Structuring of Knowledge for Defect Prediction in Brickwork Mortar. Engineering, Construction, and Architectural Management, Vol. 9 Issue: 5/6, Pp.396-408.

YENRA, (2013), Q-Max LNG Tank, http://www.yenra.com/wiki/Q-Max_LNG_carrier (retrieved on 14/02/2013)

Stern, O., (1994), Simulation results of an efficient defect analysis procedure, This paper appears in: 1994. Proceedings, International Test Conference, Institute. of Computing Structures, Siegen University, 2-6 October, pp.729-738

Wei, Y. L., Yan, Y. H. and Cong, J. H.,(2011), Development of a Surface Defect Inspection System for Cold Rolled Strip Based on Bright-Dark Filed Mode, Advanced Materials Research, 118-120, pp.762.]