DEVELOPING A MODEL TO PREDICT THE PROPAGATION OF SULFIDE STRESS CORROSION OF STEEL USED FOR PETROLEUM PIPELINES

M.B.A. Deemantha

198044

Degree of Master of Science

Department of Materials Science and 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 Master's thesis under my supervision.

Name of the supervisor: Dr. G.I.P. De Silva

Signature of the supervisor: UOM Verified Signature Date 2021.11.09

ABSTRACT

Sulfide stress corrosion (SSC) is a deleterious type of corrosion that is abundant in petroleum refineries. SSC easily attacks oil country tubular goods (OCTG) in petroleum refineries. The main factors that affect SSC can be identified as the pressure/tensile stress applied on the metal, H_2S concentration and time period. It can be identified that the environmental conditions of petroleum refineries provide optimum conditions for the initiation and propagation of SSC. Therefore petroleum refinery plants conduct time-basis routine inspections to detect the sulfide stress corrosion. When a severe corrosion is detected at an inspection routine, pipelines are required to be replaced. The unusual behavior of the propagation of SSC cracks may lead drastic failures before it is identified through an inspection routine. Therefore the petroleum industry is expecting to use an accurate model that can predict the initiation and propagation of sulfide stress corrosion. However, the mechanism of SSC has not been clearly revealed yet.

The principle aim of this study is developing a model that can predict the propagation of depth of sulfide stress corrosion in API 5L Grade B steel as a function of applied load (tensile load), pH value and time duration. API 5L Grade B steel was procured from Sri Lanka petroleum corporation as a seamless pipe. The model has been established based on the experimental values of depth of sulfide stress corrosion under different predetermined test environmental conditions kept within the pH value of 2.7 – 3.5, applied load of 400 – 800 N and time duration of 15 – 45 days. The depth of sulfide stress corrosion was measured using the scanning electron microscope images of cross sections of corroded steel specimens. The temperature and the pressure of the test environments were maintained at 24±3 ^{0}C and 1 atm respectively. Further, the model was validated by another data set obtained within the aforementioned, same ranges of parameters. All the laboratory experiments were conducted in accordance with ANSI/NACE TM0177-2016 standard test method.

In addition to the development of the model, the propagation behavior of SSC was investigated under the above mentioned different test environmental conditions. The microstructures that were observed through scanning electron microscope (SEM) and

SEM/EDAX elemental profile plots were obtained to investigate the Sulfur distribution within the crack.

According to the experimental results, it was able to develop a model that predicts the propagation of depth of sulfide stress corrosion. The model prediction values were in good agreement with the experimental values. However model tends to underestimate the depth of corrosion values when time duration closes to 30 days. Since the model has been constructed and validated within the pH value from 2.7 to 3.5, applied loads from 400 N – 800 N and time durations from 15 days to 45 days, the model is expected to be given the accurate predictions only within the aforementioned test environmental conditions.

The SEM images of cross sections of corroded specimens showed that crack initiation occurred after 15 days at all different test environmental conditions. Further, crack propagation occurred transversely, developing branches through the cross section until 30 days of time duration and the behavior of the propagation of crack was completely changed at 45 days of time duration.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES