Ain Shams University
Faculty of Engineering
Design and Production Engineering

CORROSION BEHAVIOUR OF DIFFERENT STEELS UNDER PRACTICAL MEDIUM CONDITIONS IN EGYPTIAN PETROLEUM FIELDS

A Thesis by

MEDHAT A. HEGAZI

B.Sc. in Mechanical Engineering (Materials Engineering)
Ain Shams University, June 2011

Submitted in partial fulfilment of the requirements for the degree of
Master of Science in Mechanical Engineering
(Design and Production Engineering)

Supervised by

Prof. Mohamed A. Taha

Dr. Rawya Hammouda

Dr. Fady El Sabbagh

Ain Shams University
Cairo, Egypt - September 2016

Ain Shams University
Faculty of Engineering
Design and Production Engineering

CORROSION BEHAVIOUR OF DIFFERENT STEELS UNDER PRACTICAL MEDIUM CONDITIONS IN EGYPTIAN PETROLEUM FIELDS

A Thesis by

MEDHAT A. HEGAZI

B.Sc. in Mechanical Engineering (Materials Engineering)
Ain Shams University, June 2011

Examiners' Committee

Name and Affiliation	**Signature**
Prof. Mohamed Ahmed Taha Professor Faculty of Engineering, Ain Shams University	_____
Prof. Madiha Ahmed Shoeib Professor, Central Metallurgical Research & Development Institute	_____
Dr. Ammer Khan Jadoon Materials and Corrosion Technical Authority, British Petroleum Egypt	_____

Date: September 2016

Statement

This thesis is submitted in partial fulfilment of the requirements for the degree of Master of Science in Mechanical Engineering (Design and Production Engineering), Faculty of Engineering, Ain shams University.

The author declares that he conducted all the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Student name

Medhat A. Hegazi

_____

Date: September 2016

Researcher Data

Name	:	Medhat Assem Hegazi
Date of birth	:	November 10, 1988
Place of birth	:	Giza, Egypt
Last academic degree	:	Bachelor of Science
Field of specialization	:	Materials Engineering
University issued the degree	:	Ain Shams University
Date of issued degree	:	2011
Current job	:	Materials & Corrosion Engineer
Signature	:	
Date	:	

Thesis Summary

The oil and gas industry mainly depends on carbon steels as a primary material of construction. Steels are used in every aspect of the industry from drilling to production and processing facilities hence carbon steel is the most important material used in the oil and gas industry. At least 80% of all components in the oil and gas industry are made from carbon steel because it is inexpensive, readily available, and easily fabricated. Although carbon steel is the first choice for most applications due to its low cost, availability of most products forms, high strength grades and excellent weld-ability, it corrodes. Corrosion is a severe problem in oil and gas processing it causes a major economic loss due to plant shutdowns.

In this thesis a real corrosion failure case study was investigated: On a routine inspection of an unmanned offshore crude oil producing platform, a failure was observed in one carbon steel ball valve in a 12" crude oil pipeline. The failure occurred in the valve body, where the 1.5 inch bleed plug (fitting) was found sheared off the body. This could have led to oil leak resulting probably in fire and environmental hazard.

Failure analysis procedures were designed to investigate the root cause. The procedures included visual inspection, analysis of the operating conditions including oil pressure, and metallurgical investigation, dimensions measurements, ultrasonic testing, chemical analysis, microscopical investigation (optical and SEM), testing mechanical properties. This was made on the whole valve including valve body, seat, bleed plug and ball.

It was proved that the failure was not related to any obvious personal factor and neither were any abnormal operating condition recorded; thus mechanical reasons were excluded. The internal visual inspection showed that there was a gap formed between the ball and the seat, due to the decrease in seat thickness; this was confirmed by ultrasonic test. This

indicated that the service fluid may have flowed between the ball and seat, resulting in corrosion occurring in the seat. This reason was validated by the chemical analysis where the seat was found to be carbon steel with martensitic structure. Chemical analysis of the corrosion products indicated that the main corrosion mechanisms is CO_2 corrosion.. It is also probable that over-stressing the bleed fitting due to uncontrolled manual tightening might have led to thread damage.

Another part of the thesis covers the study of the corrosion behaviour of different carbon steel with different microstructure and chromium content. Fluid and environmental conditions in one of the biggest petroleum fields in the red sea were simultaed. Weight loss experiments were used to give a comprehensive understanding of the corrosion behaviour. It was found that that 1%Cr steel decrease the corrosion rate the occurrence of a compact and self-repairable Cr-rich scale. All the martensitic microstructure have exihibited higher corrosion rates than the ferrite and pearlite microstructures.

Secondly a review corrosion types and select the most credible ones to study the effect of the most important parameters: effect of Chlorides, sulphates, and bicarbonates, and of produced water pH, and then relate the pH to water resistivity. Study effect of geometry on corrosion rates. Propose a practical system to minimize corrosion rate in petroleum facilities: corrosion management. Give new ideas and guidance to future researchers who are interested in corrosion prevention

Key words: Corrosion, corrosion in oil and gas, carbon steel corrosion behaviour, failure investigation, metallurgical failure analysis, weight loss, low alloy steel, pitting corrosion, CO_2 corrosion.

Acknowledgment

The author would like to express his sincere gratitude and gratefulness to **Prof. Dr. M. A.Taha** for his keen supervision, brilliant advice and continuous support. The author also wants to appreciate and thank **Dr Rawya Hammouda** for her continuous supervision and usual help.

Table of Contents

List of Figures