Engineering Failure Analysis 18 (2011) 950–962

Contents lists available at ScienceDirect

Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/engfailanal

Failure analysis of P110 tubing string in the ultra-deep oil well

S.D. Zhu [a,b,*], J.F. Wei [a], Z.Q. Bai [b], G.S. Zhou [a], J. Miao [a,b], R. Cai [b]

[a] School of Materials Science and Engineering, Xi'an Jiaotong University, Xi'an 710049, China
[b] Tubular Goods Research Institute, China National Petroleum Corporation, Xi'an 710065, China

ARTICLE INFO

Article history:
Received 3 September 2010
Received in revised form 27 November 2010
Accepted 28 November 2010
Available online 4 December 2010

Keywords:
Failure analysis
Tubing
Coupling
Corrosion perforation
Scaling

ABSTRACT

A number of P110 carbon steel tubing, one of the very important parts of an oil well pipe system, suffered corrosion and scaling after being used for a relatively short times, which would result in the leakage of tubing string and the decrease of productivity. Optical metallographic microscopy, scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (XRD), combined with the weight loss method and electrochemical characteristic technology were used to determine the most probable causes of the failure. The results showed that the composition and structure of tubing and coupling were in accordance with the related parameter requirements of API Spec 5CT standards, and the circumferential annular corrosion groove at the roots of male buckle side resulted from the crevice corrosion, while the axial corrosion wide slot at the outer surface of coupling and corrosion perforation of tubing were due to the reasons that the corresponding parts were mechanical damaged firstly and then suffered the severe local corrosion, in addition, the composition of corrosion products were mainly $FeCO_3$ and Fe_3O_4, and scaling layer were composed of the heavy components of the crude oil, $CaCO_3$ and a little of corrosion products. Finally, the proper annulus protection fluid, inhibitors and paraffin removers were advised to be used for preventing this type of failure from happening again in the further.

1. Introduction

This paper reports the investigation into the failure of tubing string, which was API P110 carbon steel and was used in a certain oil well of TARIM oil field. The drilled depth was 5270 m (the formation pressure and temperature of the well at this depth were 52.74 MPa and 133.2 °C respectively), and the CO_2 content was 0.59 mol% of the gas composition.

It is found that the corrosion and scaling of some of tubing were severe when lifted from oil well, especially located in the depth from 4150 m (110 °C, 47 MPa) to 4600 m (123 °C, 49 MPa), and the number of the obvious corroded tubing reached 52/532. Some tubing and coupling have suffered the local corrosion and even punctured, e.g. the circumferential annular corrosion grooves appeared on the outer surface at the root of male buckle side, and there were also grooves on the inner surface of some tubing at the root of male buckle side. In addition, the white scaling distributed both at the inner and outer surface of tubing. Because of the leakage and scaling of some tubing about the oil well, the final result was that this oil well had to be shut down and repaired in the next 10 months from well completion.

Therefore, the objective of this paper is to determine the most probable causes about the failure of the carbon steel tubing and coupling, which maybe give some ideas to prevent this type of failure in the future.

* Corresponding author at. School of Materials Science and Engineering, Xi'an Jiaotong University, Xi'an 710049, China.
E-mail address: zhusdxt@126.com (S.D. Zhu).

1350-6307/$ - see front matter Crown Copyright © 2010 Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.engfailanal.2010.11.013