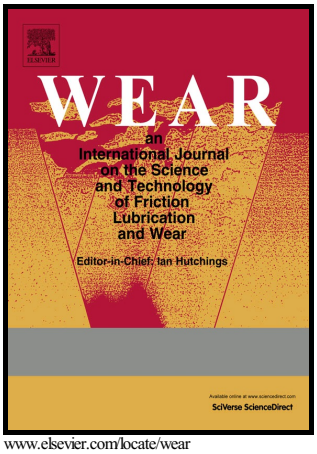
Erosion-corrosion interactions of X65 carbon steel in aqueous CO_2 environments

Joshua Owen, Callum Ramsey, Richard Barker, Anne Neville



www.elsevier.com/locate/wear

PII: S0043-1648(18)30586-6
DOI: https://doi.org/10.1016/j.wear.2018.09.004
Reference: WEA102503

To appear in: *Wear*

Received date: 16 May 2018
Revised date: 21 August 2018
Accepted date: 7 September 2018

Cite this article as: Joshua Owen, Callum Ramsey, Richard Barker and Anne Neville, Erosion-corrosion interactions of X65 carbon steel in aqueous CO_2 environments, *Wear,* https://doi.org/10.1016/j.wear.2018.09.004

Erosion-corrosion interactions of X65 carbon steel in aqueous CO_2 environments

Joshua Owen[a], Callum Ramsey[b], Richard Barker[a], Anne Neville[a]

[a] *Institute of Functional Surfaces, School of Mechanical Engineering, University of Leeds, Leeds, LS2 9JT, United Kingdom*

[b] *Shell U.K. Limited, 1 Altens Farm Road, Nigg, Aberdeen, AB12 3FY, United Kingdom*

Abstract

When sand is present in carbon dioxide (CO_2) corrosion environments in carbon steel oil and gas pipelines, wear rates can be particularly severe. The wear mechanism when surfaces are exposed to impact by a solid-laden corrosive fluid is known as erosion-corrosion and consists of erosion and corrosion components with total erosion-corrosion degradation enhanced by interactions between erosion and corrosion. The causes of corrosion-enhanced erosion and erosion-enhanced corrosion of carbon steel, in this regime, are not fully understood and are the subject of study in this work in a 60°C, pH 4.7, 2% NaCl solution, containing 1000 mg/L of sand particles with an average diameter of 250 µm, flowing through a submerged impinging jet (SIJ) nozzle at 20 m/s. Particle impact angles and velocities were predicted on the SIJ sample surface using computational fluid dynamics (CFD) to improve the understanding of how particle impingement contributes to erosion-enhanced corrosion and corrosion-enhanced erosion. Corrosion-enhanced erosion accounted for up to 20% of total erosion-corrosion degradation, with focused ion beam scanning electron microscopy (FIB-SEM) analysis showing that removal of work hardened layers and subsurface cracking were causes of enhanced degradation. Erosion-enhanced corrosion was not significant in the conditions tested.

1. Introduction

Erosion-corrosion is a complex mechanism of material degradation that affects many industries, including oil and gas. The process consists of electrochemical and mechanical degradation, as well as their potential combined synergistic effects [1]. The presence of carbon dioxide (CO_2) in oil and gas produced fluids results in a corrosive environment, and the entrainment of sand particles in the corrosive flow results in a highly aggressive wear