

Downhole Sour Corrosion and Scale Deposition in Oil Wells

Tao Chen
Production Technical Team
EXPEC Advanced Research Center
Saudi Aramco
Dhahran, Saudi Arabia 31311

Frank Chang
Aramco Americas: Aramco
Research Center
Houston, TX 77084, USA

Feng Liang
Aramco Americas: Aramco Research
Center
Houston, TX 77084, USA

Steven Hochanadel
Technical Advisory Group
Upstream Business Support
Saudi Aramco
Dhahran, Saudi Arabia 31311

ABSTRACT

A downhole corrosion and scale monitoring (DCSM) tool was developed and applied in sour oil wells to monitor the corrosion and scale formation under real downhole flow conditions. The cylindrical test coupon was made of T-95 carbon steel, which was identical to the metallurgy of the downhole completion tubing. The corrosion and scale deposited on the surface of the cylindrical test coupon effectively simulated the corrosion and scale deposited on the surface of downhole completion tubing.

The DCSM was installed at a desired depth in the downhole and retrieved after three months. The retrieved coupons were characterized thoroughly to assess the corrosion and scaling mechanisms using scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS) analyses, X-ray diffraction (XRD) and surface profilometer. The results showed that a thin layer (~300 micron in thickness) of deposit, mainly composed of pyrrhotite, was formed on the surface of the T-95 coupon. However, an overall weight loss (1.3194 g) due to the combined effects of the iron sulphide deposition (weight gain) and abrasion/corrosion of the outer layer from the surface (weight loss) was observed. After removing the scale deposition, both general corrosion and under-deposit pitting corrosion were detected by the surface profile scan on the T-95 coupon, where the under-deposit pitting corrosion was considered to be the major concern.

Key words: Sour corrosion, scale, deposition, sour, downhole

INTRODUCTION

Sour corrosion and iron sulphide scale deposition are two common flow assurance issues encountered in oilfields. Sour oil wells typically produce crude along with produced water and a significant amount of acidic gases such as carbon dioxide and hydrogen sulfide. The high pressure and temperature conditions under the downhole tend to cause severe corrosion damage including metal loss and pitting, along with iron sulphide scale deposition. Iron sulfide deposition in sour wells is a corrosion induced scale problem.¹ It potentially causes production decline, restricted well intervention, well shutdown, or even severe consequences towards to the abandoned wells.²⁻⁴

The iron sulfide deposited on the downhole completion tubing in the sour oil wells is not uniformly distributed. Iron sulfide deposition becomes more severe as the well depth gets deeper along the tubular.⁵ A thin layer of iron sulfide deposit tends to be generated at the top portion of the tubular but is often negligible. It could work as a protection film to prevent the direct contact between the production fluid and tubing surface, in which it further reduces tubing corrosion. A thicker layer of iron sulfide deposition tends to be observed at the bottom portion of the tubular to cause tubing blockage which limits well intervention. The corrosion underneath the iron sulfide deposition is another issue in the sour oil wells. This underneath corrosion has been observed after mechanical de-scaling treatment. Similar to the ununiform distribution of iron sulfide deposition in the downhole tubular, more severe metal loss caused by underneath corrosion is often observed at the bottom portion of the downhole tubular⁵.

A DCSM tool was developed and deployed in sour gas wells to monitor and understand the mechanisms of corrosion and iron sulfide deposition under downhole conditions⁶.

Different from the conventional corrosion monitoring tools, such as coupon testing, electrical resistance, ultrasonic measurement and caliper Surveys,^{7,8} the DCSM tool is designed to ensure the coupons are not only made of the same metallurgy as the tubing material, but also are they experiencing the identical flow dynamics as the tubing wall. It allows direct corrosion and scaling monitoring in the real downhole condition. The data generated by this tool provides meaningful technical information about the aspects of the corrosion and scale tendency under real downhole conditions in sour wells.

Table 1 summarizes the advantages and limitations of the major corrosion monitoring tools applied in the oil and gas industry, along with DCSM. Coupon testing is a simple and inexpensive way for corrosion monitoring. However, it may not be the best representative experiment due to multiple factors such as experiencing different testing conditions in terms of temperature, pressure, flow regime and flow fluid composition. Electrical monitoring methods using electrical resistance (ER) and linear polarization resistance (LPR) measurement allow continuous and instantaneous corrosion rate monitoring. However, being an indirect measurement, the results do not always precisely correlate with the real corrosion rate, nor indicate pitting corrosion. Additionally, challenges still exist to deploy electrical monitoring tools to the downhole and get reliable corrosion rate under high-temperature and high-pressure environment. In review of the currently available corrosion monitoring techniques, there are limited monitoring methods for detecting scaling, especially monitoring both scale and corrosion using the same type of tools.

Table 1
Summary of the Advantages and Limitations for the Currently Available Corrosion Monitoring Methods⁹

Monitoring method	Advantage	Limitation
Coupon test	Simple and inexpensive	• Surface measurement • Not be the best to represent actual downhole conditions • 2-point monitoring
Electrical monitoring • Electrical resistance • Linear polarization resistance • Etc.	Allow continuous and instantaneous corrosion rate monitoring	• Results do not always correlate directly to the real corrosion rate • May not indicate pitting corrosion precisely
Ultrasonic tool	Non-destructive Continuous monitoring	• May not indicate pitting corrosion precisely
DCSM	Direct corrosion and scaling monitoring under real downhole condition	• 2-point monitoring

This paper discusses a study of using DCSM tool to monitor the corrosion and iron sulfide surface deposit in the downhole completion tubing in a sour oil well. It allows a direct corrosion and scaling monitoring in the real downhole conditions.

METHODOLOGIES

The DCSM tool is designed and developed for measuring corrosion and scale formation under downhole conditions in sour gas wells. It is applied to monitor and evaluate the performance of the corrosion inhibitor batch treatment in sour wells under actual downhole environment and multiphase flow regime. The schematic of DCSM design is shown in Fig. 1.