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Short communication

Failure analysis of heat exchanger tubes of four gas coolers

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ABSTRACT

A Number of leaks occurred on four heat exchangers used on an off-shore platform in the south of Iran. As a result heat exchanger tubes made of Inconel 625 failed after only two years in operation. The failure was caused by pitting corrosion in two contact regions, tubes and baffles as well as in tube sheet and shell contact regions in spite of sufficiently corrosion resistance of Inconel 625 to sea water. X-ray diffraction analysis was conducted on residual corrosion products, while micro structures of propagated pits were studied using scanning electron microscope and also examination of susceptibility of Inconel 625 to crevice corrosion was performed by multiple crevice assembly and anodic polarization in crevice solution. Investigation of failed exchanger tubes revealed that leaks in the tubes were due to the phenomenon of crevice corrosion.

1. Introduction

There are four gas coolers located on a platform in seawater in the south of Iran. The gas cooler is a shell and tube heat exchanger with the gas flowing inside the tubes (inlet temperature = 66 °C and outlet temperature = 45 °C) and the seawater is driven through the shell side (inlet temperature = 31 °C and outlet temperature = 38 °C). The tubes, tube sheet and baffles are made of Inconel 625. The first indication of the leakage in the tubes was observed only 6 months after commencement of operation. After one year, plant faced shut down due to low efficiency of gas coolers during production. At this time the gas cooler exchangers were dismantled. It was found out that a number of tubes had failed due to corrosion.

One of the most common failure mechanisms of heat exchanger tubes is usually due to crevice corrosion that it encountered in tube ends and at tube-to-tube sheet joints [1]. Crevice corrosion is a localized form of corrosion that occurs within crevices or at shielded surfaces, where stagnant solution is present. Degradation of materials due to crevice corrosion may cause leakage or loss of critical tolerances which may critically affect the performance [2].

Ni–Cr–Mo alloys (Inconel 625) are used in marine environments, where corrosion resistance is essential. This class of alloys generally has excellent pitting resistance in marine service conditions. However, exposure studies have shown that nickel super alloys are susceptible to crevice corrosion in marine environments [3]. Oldfield and Sutton have refined crevice corrosion model mathematically and conceptually by describing the progression of four stages:

Stage 1: Depletion of oxygen within the crevice.
Stage 2: Increase in acidity and chloride concentration of the crevice solution.
Stage 3: Permanent breakdown of the passive film, and
Stage 4: Propagation of crevice corrosion.

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