



Failure analysis of a stainless steel hydrotreating reactor

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ABSTRACT

This paper presents an analysis of a failed AISI 316L austenitic stainless steel (SS) hydrotreating reactor that produces flavors and fragrances. Pitting and cracking were observed mainly in the vicinity of the circumferential and longitudinal shell welds on the internal surface of the reactor by dye penetrant testing (DPT). Ultrasonic evaluation revealed the cracks were within near-surface area, therefore remedial grinding was performed to remove them. In situ metallographic investigation revealed that the cracks were predominantly transgranular and multi-branching. Thickness gauge, hydraulic pressure testing, and acoustic emission validated the reusability of the repaired vessel. Analysis of the catalysts showed the source of chloride. SCC (stress corrosion cracking) susceptibility testing of the identical material proved its liability to chloride SCC in the environment of the suspect catalysts. Studies revealed that the failure was caused by chloride SCC. Recommendations are made to prevent the recurrence of the similar failure.

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1. Introduction

Corrosion failures of pressure vessel and equipment under SCC (Stress corrosion cracking) have been of major concern in petroleum and chemical process industries. Some of the vessels used in petrochemical industries are made of 3XX series stainless steels (SS). The failures in SS components often occur by pitting corrosion or SCC. Factors influence SCC involve (i) metallurgical structure and composition, (ii) stress, (iii) environmental variables [1]. Despite the fact that most engineers in the corrosion field are aware of SCC, failures due to SCC are still a common occurrence.

Hydrotreating is an important oil refinery process that oil fractions react with hydrogen in the presence of catalysts. Corrosion environment of the hydrotreating reactor is severe and deleterious to the vessel if catalysts or reactants contain hazardous elements. This paper gives a comprehensive investigation on chloride SCC failure of a hydrotreating reactor.

2. Background

The base-metal and weld material of the reactor was made of AISI 316L stainless steel. The nominal temperature is 220 °C, and the pressure 0–5.5 MPa. The supporting medium is hydrogen, of which the operating pressure is 4.5 MPa, with organic compound and catalysts.

The schematic of the failed hydrotreating reactor is given in Fig. 1. The vessel has three circumferential and two longitudinal shell butt welds. The ellipsoidal head was solution-annealed, but other parts of the reactor were not subjected to stress-relief heat treatment. After the reactor operated about 6 months, regular safety inspection found cracks and pits around the nozzles and in the vicinity of both the circumferential and the longitudinal shell welds. Dye penetrant testing

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