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Sensitization induced stress corrosion failure of AISI 347 stainless steel fractionator furnace tubes

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ABSTRACT

Austenitic stainless steel tubes are used as furnace tubes in petrochemical industries mainly because of their corrosion resistance and mechanical strength. AISI 347 grade stainless steel is used as furnace heater tubes in the fractionator of hydrocracker unit. Even though this stainless steel is stabilized with the addition of niobium thus preventing sensitization related corrosion failures, operational and maintenance errors may result in premature failures if conditions prevail. The present work reports the premature failure of AISI 347 grade fractionator furnace tubes after nearly 8 years of service. The failure occurred after shutdown. Carbonaceous deposits were found on the inner walls of the tube and circumferential cracks were found beneath the deposit. The service exposed 347 SS alloy tube was in the sensitized condition as confirmed by microstructure and double loop electrochemical potentiodynamic reactivation test. The tube material got sensitized possibly by localized overheating at the carbon layer deposited site. During shutdown of hydrocracker unit polythionic acid formation occurred possibly due to errors in shutdown procedures. Sensitized alloy 347 tube undergone polythionic acid induced intergranular stress corrosion cracking (PASCC).

1. Introduction

Austenitic stainless steels (ASSs) though corrosion resistant, undergo corrosion in presence of certain specific corrosive agents and conditions encountered during service leading premature component failures. When exposed in the critical temperature range of 500–800 °C for a reasonable time, formation of chromium carbides at grain boundaries and depletion of chromium adjacent to it occurs, a phenomena known as sensitization [1–4]. Even shorter exposure in the critical temperature range is enough to nucleate carbides without a damaging degree of Cr depletion. The nucleated carbides may grow during service exposure at temperatures below 500 °C leading to severe Cr depletion, a phenomenon identified as low temperature sensitization (LTS) [5]. Sensitized grain boundaries in stainless steels are more prone to intergranular corrosion attack (IGC). Stressed and sensitized materials are prone to intergranular stress corrosion cracking (IGSCC) [1–4,6]. SCC occurs if the material is in susceptible condition, subjected to tensile stress and aggressive environment [1–3]. Intergranular stress corrosion cracking (IGSCC) of austenitic stainless steel in petrochemical components are well recorded [6–8]. Stabilized stainless steel (SS) grades are also prone to IGSCC once they become sensitized and environmental conditions favor it [9,10]. Reports on sensitization induced SCC failures of stabilized grades of ASS material are very few [7,13]. The present paper discusses one such failure happened in a petrochemical processing unit.

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