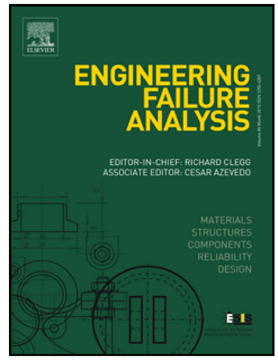

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Jose L. Otegui, Janine N. Booman, Juan Massone

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Experimental assessment of thermal grain boundary embrittlement after tubeplate failure in a petrochemical heat exchanger

Jose L. Otegui [ac]*, Janine N. Booman [bc], Juan Massone [d]

[a] Y-TEC (YPF - CONICET), *Av. del Petróleo s/n, 1923 Berisso,* Argentina
[b] Universidad Nacional de Rosario, Av. Pellegrini 250, S2000BTP Rosario, Argentina
[c] Formerly GIE S.A., Galicia 52, B7608AUB Mar del Plata, Argentina
[d] INTEMA, CONICET - Universidad Nacional de Mar del Plata. Av. J. B. Justo 4302, B7608FDQ Mar del Plata, Argentina

* Corresponding Author. E-mail address: Jotegui@fi.mdp.edu.ar

ABSTRACT

The analysis of multiple cracks in a heat exchanger tubeplate at a petrochemical plant led to experimental replication of in-service damage. High lifting stresses created a first leak that was repaired. Extended branched intergranular cracking developed from the tubeplate surface around the repair weld after few weeks of renewed operation. Chemical analyses failed to detect Na on crack surfaces, while operative conditions also allowed discarding a typical SCC cracking mechanism. Lack of radial interference between tubes and plate, lack of penetration and lack of fusion at tube to tubeplate weld roots were also thought as contributors to cracking. Microstructural analyses revealed martensite clusters in welds and HAZ, and austenite grain boundary precipitates in the tubeplate base material. Thermal cycles were applied to ex-service samples to replicate the conditions for these brittle micro constituents, which were found to be unstable at operating temperatures. Mechanical testing also replicated grain boundary weakness. This inadequate structure was related to welding without proper thermal cycles and heat treatments.

KEY WORDS

Tubeplate, branched cracks, intergranular embrittlement, experimental assessment

1. - INTRODUCTION

The purpose of this article is to explain some conflicting results after the analysis of multiple cracks found in one of the tubeplates in a three-stage heat exchanger. The failed tubeplate had been installed during the revamping of a styrene production line at a petrochemical plant, see **Fig. 1**. Process gas flows inside the tubes, below atmospheric pressure; outside water flows at 600 psi (4.14 MPa) and a maximum temperature of 440°C. Process water pH is 10.5, alkalinity is 48.2, and allowable SiO_2 is 0.3 ppm wt. The 130 mm thick tube plates are forged.

A plant revamping required larger capacity, so a new exchanger was built and put in service. This exchanger was designed according to ASME VIII Div. 1. Tube to tubeplate