Magnetec Monthly Chronicle

Issue No.10 " FROM THE FIELD " October 2005

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Excellence in Eddy Current Inspection Technology & Failure Analysis

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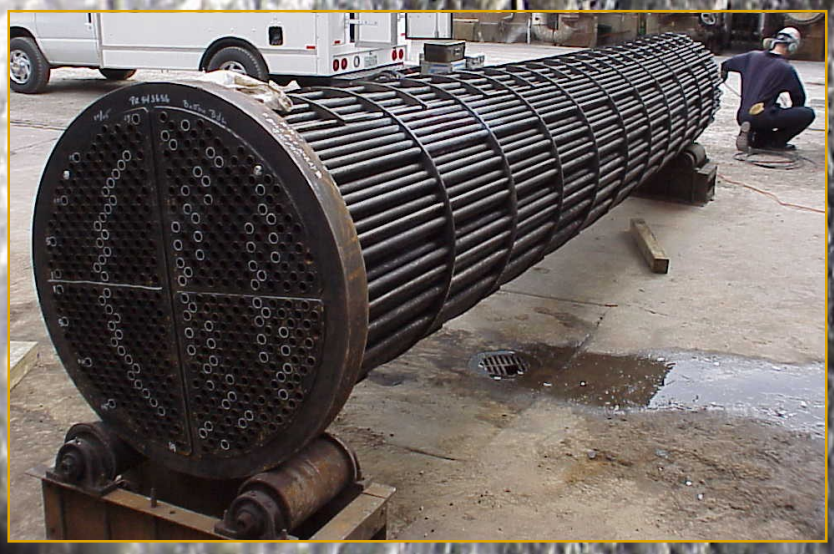
Is it Stress Corrosion, Corrosion Fatigue, or Hydrogen Induced?

Subject: Cracking

These Tube and shell exchangers were found in a major mid-eastern refinery. The bundles were inspected due to the presence of what appeared to be cracks on the O.D. surface after the visual inspection.

The exchangers operate as a 4 bundle parallel feed, series flow, through the pair of stacked ex-changers, with raw crude on tube side flow, and tower reflux on the shell. The shell side feed enters the top rear shell and travels as one pass to the lower bundle and one pass to the out-let piping. The tubing consists of 425 U-bend tubes – 1" X .083 min wall X SA-789 (2205) X 20 foot long and are 24 months old. Upon visual inspection there were numerous O.D. marks that appeared as cracks along the tube length. Secondary non-destructive methods could not discern the existence of cracks or just surface marks & an Eddy Current test was deter-mined to be the best method for con-firmation of the markings as cracks & calculate their relative depth. The relative operating pressures & temperatures were in the mid range of most pro-cesses and the 2205 material would be considered an excel-lent choice for this service. The 2205 material exhibits excellent stability in most refining pro-cesses with a low pitting poten-tial and freedom from cracking

type mechanisms, in medium temperature chloride environments. The RFET inspection was performed on 100% of the tubing to determine the presence of the cracking mechanism and determine the defect depths and remaining life of the bundle. The inspection found cracks with depths from initiation to 55% in the upper bundle and 45% in the lower bundle. The cracking was most pronounced near the rear of the upper bundle which is adjacent to the rear shell side inlet feed to both bundles and corresponds to the highest heat area for the counter current process flows. The lower bundle experienced cracking to a lesser degree with the cracking near the front of the bundle near/adjacent to the front shell side inlet. The bundle was reported with very heavy shell side fouling after being pulled which would retard the heat transfer across the tube wall and allow for high heat gradients within the tube wall.



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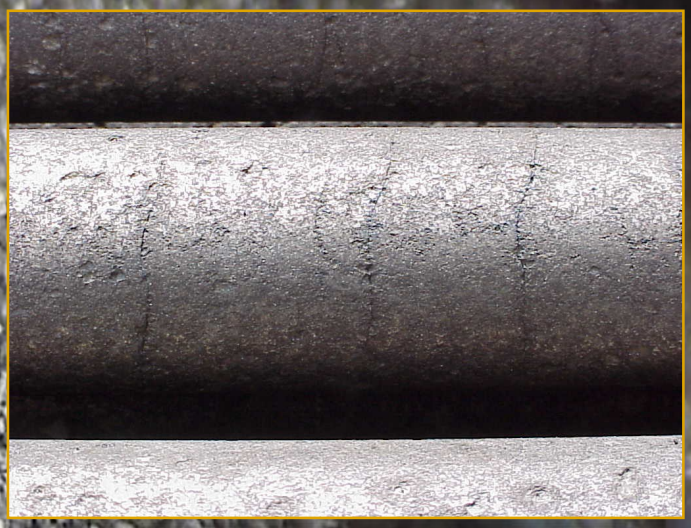
Note pitting attack along crack formation



Numerous crack formations as seen along affected tube length portion

Based on the location of the cracks, crack pattern, concentration and depth, the cracking mechanism appeared to be related to a flow process across the bundle matrix which alludes to either a corrosion/chemical attack, or a heat related phenomena, or a combination of both. The cracks appeared to be consistent in their spacing and relative crack depths as the process flows passed through their specific bundles which is indicative of the driving event diminishing across the bundle length and therefore is believed to be related to temperature gradients. The process is in the mid range of the recommended operating temperatures for the 2205 material and well below the 600 degree operating limit specified by the manufacturer and the ASME (885 ferrite embrittlement). The post bending stress relieved U-bends were noted with no cracking type mechanism in either bun-

dle which tends to indicate a heat treatment condition (straight section) from the manufacturer that is susceptible to the cracking mechanism. The inter-relationship of corrosion fatigue, stress corrosion and hydrogen embrittelment cracking mechanisms, and the wide spectrum of conditions, both in material environment, and metallurgical states, generally overlap and can be a combination of any and/or all the phenomena. There tends to be a central initiating factor that encompasses all three of the individual mechanisms and crack initiation to ultimate failure might be classified to any of the separate mechanisms as the crack progress's through stages. It should be noted that the bundles in question might have experienced a single event or limited number event cycle that initiated the crack sequence, & crack propagation has since ceased. This condition could only be determined by metallographic tests of the material and crack face for telltale signs of re-passivation or continued crack growth. The bundles were detected with O.D. pitting with depths of 15%-35% along the tube length and across the entire bundle matrix, however, this mechanism was not considered a service related problem. Cracks most probably initiated at the pit locations. Based on the age of the bundle, defect depths, and economic loss's due to re-occurring failures, both bundles were retubed.

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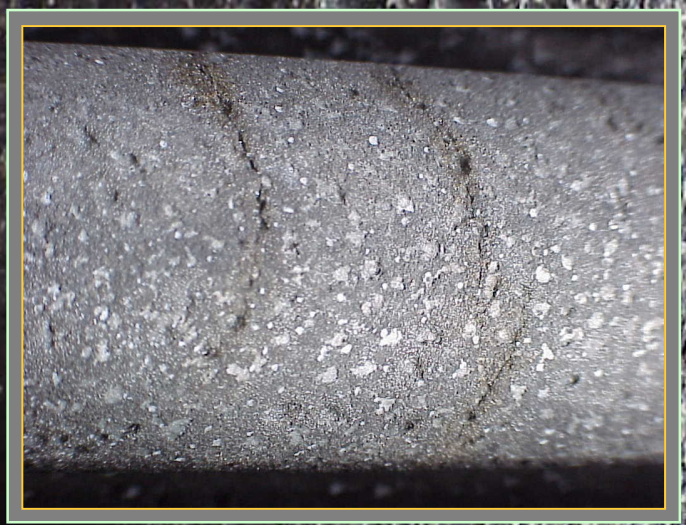

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Single crack pit initiation site

Note axial crack propagation from circ. crack

For more info on eddy current, go to:

http://www.magnetec-inspection.com/2EddyCurrent.html

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