Saba Metallurgical & Plant Engineering Services, LLC

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Materials Projects

<u>Projects Brief Details</u>: Saba Metallurgical provides services assisting in material selection and troubleshooting. The below list details some very brief information on a select few of these projects.

1. A metal dusting study, and additional degradation mechanisms was evaluated for a plant in the design. Reference data from a sister plant was used. Due to the extreme metal dusting environment in a particular heat exchanger, a coating was recommended and proved to be highly successful. As predicted in the study and provided report, the sister plant was experiencing accelerated metal dusting after only a few months of service. Use of an aluminum oxide coating on both ID and OD surfaces of the tubes in this infinite carbon activity service has proven to be successful for several years now. Plant personnel indicate that the tubes still look as they looked when they were installed.

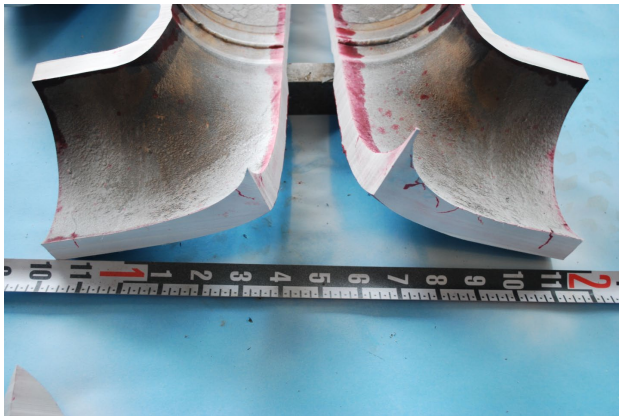
2. A chemical process had a pump that started leaking after only 8 hours of service. The seals were replaced over 50X per year, allowing leakage for several days at a time. Investigation of the process showed that Nickel Cadmium catalyst was being used and that it was rapidly attacking the Kalrez o-ring. A specialty (hybrid) seal was designed that replaced the inlet side of an API plan 54 double seal with a grafoil bellows seal. This seal operated for years without issues.

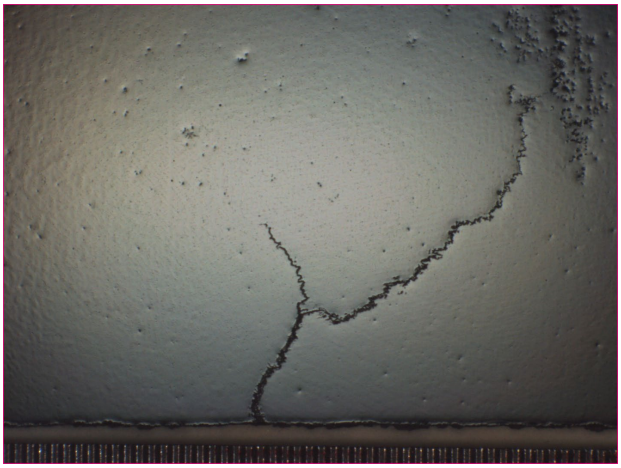
3. Discovered that laser etching on medical titanium devices was causing surface brittleness. This created micro-craze-cracking, which then greatly reduced fatigue life. Solution was to move the laser etching to location of FEA-indicated low stress on the device.

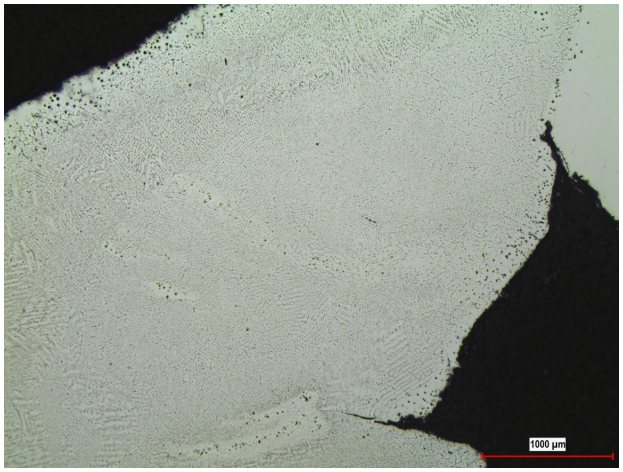
4. Client had been advised from another engineering firm that their equipment was damage and needed to be replaced due to loss of strength. This recommendation was based on surface hardness readings and in-situ metallography, both indicating a pure ferritic (not pearlitic) structure. It was simply advised to client that this is a typical surface decarburizarion and that all they need to do was lightly grind the surface and retake the hardness readings and in-situ metallography. Following this recommendation, it was discovered quickly that the underlying metal was the original pearlitic microstructure and that the thin decarburization layer was well less than the allowable corrosion allowance. The equipment did not require expensive replacement.

5. Discovery of arcing in pipeline system at impressed current split isolation. Rapid pit damage. Added coating to ID which resolved the damage mechanism. Further applied to other clients with the same issue.

6. Reformer furnace review produced prediction that first bends would be experiencing ID cracking due to thermal shock/impact from the cool-down nitrogen purge. Upon removal of u-bends for inspection, up to 90% through wall cracking was observed. Identification of this damage from this requested inspection helped prevent a destructive furnace fire and then led to a revision of the operating procedure.







7. A multi-million-dollar heat exchanger was deemed to be scraped due to highly excessive thinning (6-8 mils remaining thickness) of the tubes. Eddy current was used to make this determination. It was advised to the client that part of the tube bundle operated where the microstructure changed to several other types of phases (Laves, Chi, Sigma etc.) and carbide precipitation. This microstructure change caused the electromagnetic properties to change for the tube material. As calibration was performed on new material, the eddy current was not calibrated properly, leading to the grossly under-identifying of the actual tube wall thickness.