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Root Cause Analysis of Cracking in MDEA Regenerator

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Purified gas is considered an important source of energy in the world. Mellitah Gas Complex consists of a Gas Treatment Plant composed of a Sulphur Recovery Unit. This system was commissioned in 2004. The effluent gases from the Claus plant are directed to a tail gas treatment system and incinerated to oxidize any residual sulfur to sulfur dioxide. Air regulations prohibit the discharge of large amounts of sulfur to the atmosphere.
The Sulfur Recovery Unit Comprises a Methyldiethanolamine (MDEA) Regenerator to concentrate acid gas (H2S & CO2) before thermal reactor and Catalytic converter in Claus Unit. In 2019 the regenerator was inspected and found that it was suffering from several cracks or crack-like flaws on internal weld seams, and further investigation and inspection have shown an aggravated situation of the cracks specifically in CW-7 welded joint that have progressed to reach 11mm in depth on some spots on a 27mm plate.
This case study will identify the Root Causes Analysis (RCA) of the cracks and contributing factors that lead to the cracking phenomenon in the Regenerator. Course of action have been taken to achieve this target; A sample of metal was extracted from multiple locations around the regenerator and the welded joint CW-7, which is the most affected by the crack. Metallurgical study was conducted to address the RCA. The study was entirely based on experimental data and actual operations conditions (gas and liquid samples from different areas of the complex have been collected and analyzed). Process Parameters such as P, V, T data and flow rate were collected, and chemical treatment conditions including Amine Quality (Heat Stable Salts using Ion Chromatography (IC), Acid Gas load, MDEA Concentration, Chloride/Oxygen content, MDEA filtration) were examined. In addition, Corrosion Damage Mechanism that included metallurgical using Scanning Electron Microscopy (SEM) /Energy Dispersive X-ray Spectroscopy (EDS) analysis) and corrosion investigation using Non-Destructive Test (NDT) techniques such as magnetic particle examination (MT) and phased array UT (PAUT) were applied to show the behavior of cracks in the damaged area.
As results of the study: Metallurgical study showed that the crack propagating was mainly along the grain boundaries (intergranular) and was filled with deposits. There are many factors that could contribute to Amine Stress Corrosion Cracking, the inborn fabrication and welding defects are the most probable damage mechanism for the crack in the MDEA regenerator. Lean MDEA concentration is verry low (~30% wt.), however, the design philosophy advises keeping concentration at a minimum of 45–50 weight percent. Additionally, the chloride content in lean MDEA was very high content ~ 941 ppm(w) which can lead to future potential corrosion problems. To maintain lower chloride content (< 500 ppm), it should be ensured that a partial continuous blowdown is implemented to keep the feed of lean MDEA in the circuit along with monitoring the continuous injection of antifoam and corrosion inhibitor in the system. On the other hand, more contaminants were found in the lean MDEA solution which indicated the problem in the filtration unit, and it is suggested to install reclaiming skid to reduce the contamination and keep the fresh amine within the desire limit. The other side of problem is the makeup water quality due to presence of oxygen in the system, the analysis confirmed that there was about ~100 ppb of oxygen in the system and it seems that the main source is the demineralized water which having an oxygen concentration of 180 ppm, suggesting that water deaeration shall be provided in the demineralized water production process to strip-off all dissolved oxygen in parallel of this action it's recommended to install an O2 and pH online analyzer around the amine and water makeup circuit. A secondary source of Oxygen might be the fresh amine itself. Furthermore, it is advised to apply suitable coating compatible with fluid media.

Authors: Dr BELASHEHR, Turia (Mellitah oil and gas company); Dr ALABOUB, AlSiddiek (Mellitah oil and gas company)

Co-author: Mr HAWASS, Ahmed (Mellitah oil and gas company)

Presenters: Dr BELASHEHR, Turia (Mellitah oil and gas company); Dr ALABOUB, AlSiddiek (Mellitah oil and gas company)

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