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Corrosion Analysis of a 3-1/2” Production Tubing of an Offshore Oil and Gas Well

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Abstract : During the exploratory testing phase of an offshore oil and gas well, when the tubing string was pulled out after production testing, it was observed that there was visible corrosion/pitting in a few of the 3-1/2” API 5 CT L-80 Grade tubing. The area of corrosion was at the same location in all the tubing, i.e., just above the pin end. Since the corrosion was observed in the tubing within two months of their installation, it was a matter of concern, as it could lead to premature failures resulting in leakages and production loss and thus affecting the integrity of the asset. Therefore, the tubing was analysed to ascertain the mechanism of the corrosion occurring on its surface. During the visual inspection, it was observed that the corrosion was totally external, which was near the pin end, and no significant internal corrosion was observed. The chemical compositional analysis and mechanical properties (tensile and impact) show that the pipeline material was conforming to API 5 CT L-80 specifications. The metallographic analysis of the tubing revealed tempered martensitic microstructure. The grain size was observed to be different at the pin end as compared to the microstructure at base metal. The microstructures of the corroded area near threads reveal an oriented microstructure. The clearly oriented microstructure of the cold-worked zone near threads and the difference in microstructure represents inappropriate heat treatment after cold work. This was substantiated by hardness test results as well, which show higher hardness at the pin end in comparison to hardness at base metal. Scanning Electron Microscope (SEM) analysis revealed the presence of round and deep pits and cracks on the corroded surface of the tubing. The cracks were stress corrosion cracks in a corrosive environment arising out of the residual stress, which was not relieved after cold working, as mentioned above. Energy Dispersive Spectroscopy (EDS) analysis indicates the presence of mainly Fe_2O_3, Chlorides, Sulphides, and Silica in the corroded part indicating the interaction of the tubing with the well completion fluid and well bore environment. Thus it was concluded that residual stress after the cold working of male pins during threading and the corrosive environment acted in synergy to cause this pitting corrosion attack on the highly stressed zone along the circumference of the tubing just below the threaded area. Accordingly, the following suitable recommendations were given to avoid the recurrence of such corrosion problems in the wells. (i) After any kind of hot work/cold work, tubing should be normalized at full length to achieve uniform microstructure throughout its length. (ii) Heat treatment requirements (as per API 5 CT) should be part of technical specifications while at the procurement stage.

Keywords : pin end, microstructure, grain size, stress corrosion cracks
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