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CRITICAL CONCERNS AND CHALLENGES IN FRACTURE AND FATIGUE ASSESSMENTS OF CORROSION RESISTANT ALLOY (CRA) PIPES WITH DISSIMILAR WELDMENTS: SUBSEA APPLICATIONS AND BEYOND

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Abstract

Despite the increased concern over the effects of climate change on essentially every aspect of human life, the rising world demand for energy is expected to increase rather sharply, with fossil fuels still remaining the dominant source over the next years, particularly in developing nations. As the more easily accessible oil and gas resources are becoming depleted and, at the same time, the technology has significantly improved, the oil and gas industry is expanding its exploration and production activities into more hostile environments, including very deep water offshore hydrocarbon reservoirs. To comply with the current stringent environment-based regulations, economic development of such resources has emphasized the need of fail-safe infrastructure for reliable production and transportation of oil and natural gas. In particular, the assurance of the structural integrity of subsea pipelines and flow lines conducting larger volumes of corrosive fluids containing carbon dioxide (CO_2) and hydrogen sulphide (H_2S) is essential in fail-safe operations of subsea pipelines. A key approach to address this issue is by the use of API grade steel pipes either clad or mechanically lined with corrosion resistant alloy (CRA) materials, such as Ni-based alloys, commercially known as Inconel 625 alloy, for the transport of oil and gas containing corrosive environment.

Fracture mechanics based approaches, also referred to as Engineering Critical Assessment (ECA) procedures, provide highly effective, albeit conservative, acceptance criteria for cracked structural components which relates the operating conditions with a critical applied load or critical crack size in terms of the *J*-integral or CTOD. While these methodologies have proven sufficiently effective in assessing the significance of structural defects in homogeneous materials, they do not necessarily provide reliable and accurate defect acceptance limits for welded components with weld metal strength mismatch. Here, mismatch in the flow properties between the weld metal and the base plate material alters the plastic deformation pattern of crack-like flaws that often occur in the weld metal thereby affecting the coupling relationship between remote loading and crack-tip fields (as characterized by *J* or CTOD).These features have important implications on structural integrity assessments of undermatched welds as, for a given remote loading, crack-tip driving forces are higher when compared with the corresponding quantities evaluated for homogeneous materials. Because of the increased use of higher strength pipeline steels, unintended undermatching between the weld metal and baseplate material may likely occur thereby adding potential difficulties in integrity assessments of field girth welds having circumferential flaws. This picture is further complicated in the case of a clad pipe girth weld made of corrosion resistant alloys (CRAs) since the the clad layer coupled with the rather strong dissimilar character between the weld metal and the baseplate material may affect the fracture and fatigue behavior.

Motivated by these arguments, the presentation will provide an overview of recent progress and challenges in fracture and fatigue assessments of corrosion resistant alloy (CRA) pipes having dissimilar weldments, with a particular focus on marine risers and subsea infrastructure. Despite advances in existing technology, there are still restrictions imposed by the use of new materials, more hostile environment and extreme loading conditions to obtain lighter and more cost-effective structures without compromising operation safety and environment protection. Clearly, there is a need of developing improved technological capabilities in connection with innovative and advanced procedures for fracture and fatigue assessments of critical components for subsea applications to ensure more reliable and fail-safe operations of the infrastructure for production and transportation of oil and gas in deep water offshore hydrocarbon reservoirs.