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Evaluation of material response subjected to high plastic deformation when forged into Saipem submarine repairing system

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ABSTRACT

An innovative pipeline repair system for deepwater applications has been recently developed by Saipem. Sealing is ensured by a forging process which plastically deforms the linepipe material at very high strain level. In order to evaluate the material response to high plastic deformation when forged into the system, a devoted testing programme has been performed coupled with FEM calculations so to assess the material response during the plastic straining process and in the after straining plus ageing conditions.

KEY WORDS: Deepwater; repair system; plastic deformation; speckle measurement; FEA.

INTRODUCTION

There is a well established trend towards the exploitation of deep water and ultradeep water offshore oil and gas fields. As a consequence subsea pipelines will be laid and hence operated down to greater water depth, where maintenance/repairing activities are very difficult to carry out and the use of highly specialised equipments remotely operated is mandatory.

On this respect Saipem and Sonsub on behalf of ENI have recently developed an innovative pipeline repair system, named SiRCoS (it stands for "Sistema Riparazione Condotte Sottomarine" i.e. Underwater Pipeline Repair System), which is especially suited for deepwater application and makes it possible to replace a damaged section of the pipeline with a telescopic spool piece inserted between two end-connectors of special design. These end-connectors are made up by swaging the pipe ends into them, achieving effective sealing and load carrying capability (Fig. 1). Since the sealing is ensured by a forging process, the level of plastic deformation introduced in the linepipe material is unusually high; line pipe steel material in fact undergoes a severe local plastic deformation during the forging process into the connector, locally reaching plastic strain values well beyond necking, as measured with traditional uniaxial tensile test.

Conventional mechanical characterization does not allow investigating the forged pipe material performances and its behaviour over time when subjected to so high plastic deformation. Though special provisions exist for high plastic deformations of pipelines, such as those implemented in the DNV OS-F101, they refer to a different kind of application (typically pipes exposed to plastic strain cycling as that produced by reel laying methods) and may result in unnecessary limitations for this case.

The paper presents the methodology adopted for evaluating the material response when subjected to high plastic deformation during the forging into the connector. A number of tests, including bend and tensile tests, have been performed on the undeformed pipe, as well as on the forged one, and then artificially aged pipe material. In addition special tensile testing has been carried out in which, due to special measurement and post processing analysis combined with Finite Element calculations, it was possible to follow the deformation after the necking onset, so as to allow comparison with pipe material strain during forging and assessment of the critical strain at failure of the material.

Figure 1 – Saipem Sonsub "SiRCoS" repair system – Spool piece