Applied Mechanics and Corrosion

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Fracture Control – Offshore Pipelines

Recent years have seen the introduction of a probabilistic approach to design of offshore pipelines. Most failure modes can be treated by means of calibrated safety factors. However, an established approach for probabilistic design against fracture in pipelines is lacking. This is the focus of the ongoing project "Fracture Control – Offshore Pipelines".

Pipelines will experience scatter in material properties, possible defect sizes, and applied loading. Thus, a deterministic approach for assessing the fracture behaviour can be of limited use in design. A better approach will be to account for the scatter in the input parameters and aim for a design that meets a defined probability of fracture, typically in the order 10^{-5}-10^{-3}, depending on the consequences of failure.

Figure 1. Large-scale testing of pipe.

In order to reach a format that allows for a probabilistic design it is necessary to derive partial safety factors for the different input parameters. In the Fracture Control – Offshore Pipelines Project the scatter to be expected in the different parameters are being defined. This again is used as input for probabilistic analyses from which the safety factors will be calibrated.

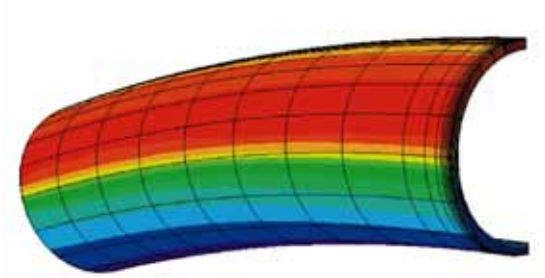


Figure 2. FE model of pipe loaded in bending.

Another important focus in the project is to derive improved assessment schemes applicable for strain-based design. The project aims at including the following features in the assessment:

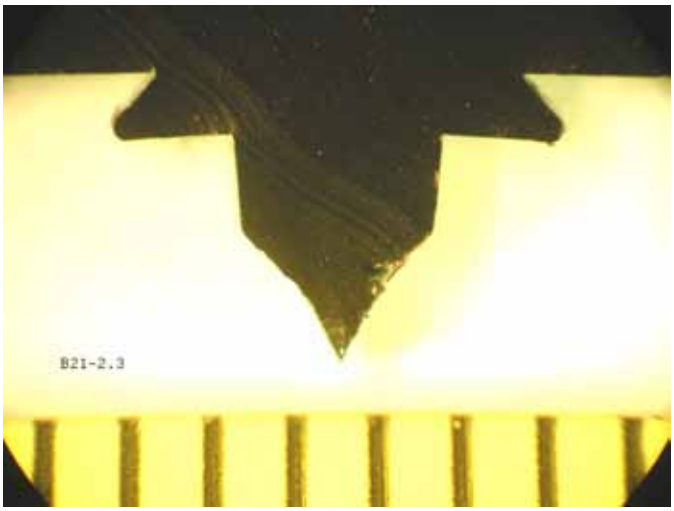
- Flaw size
- Ductile tearing resistance
- Biaxial loading/internal pressure level
- Materials mismatch
- Geometrical misalignment
- Surface vs. embedded defects

The effects above are studied through a combination of 3D FE analysis and small-/large-scale experimental testing.

As full 3D FE simulation of pipes with cracks is a rather time consuming task, its applicability for engineering calculations may be limited. An alternative approach for direct calculations, using a combination of shell and line spring elements, is developed through the software program LINKpipe. The LINKpipe program offers a combination of the accuracy from 3D calculations, and the computational efficiency of shell elements.

The main delivery from the project will be a project guideline that outlines the procedure for a probabilistic design against fracture in offshore pipelines, written by DNV. There is an aim that this will serve as a basis for later updates of international pipeline standard documents.

Phase I of the project ran from 2002 to 2006. The on-going Phase II is running from 2008 to 2010. The total budget of the project is 33 MNOK, and it is sponsored by a group of industry partners.



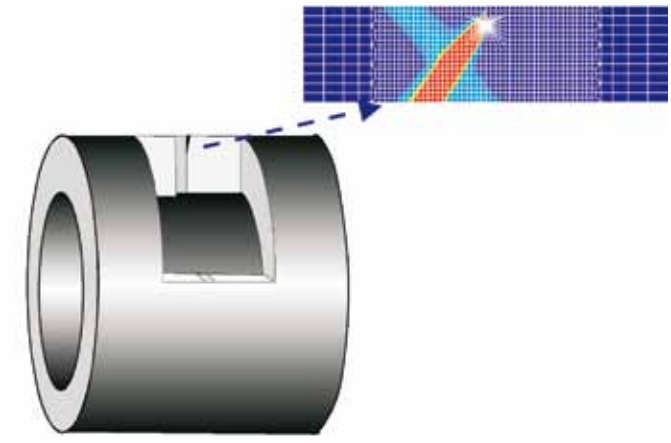


Figure 3. FE modeling of crack tip conditions in a mismatched weld.

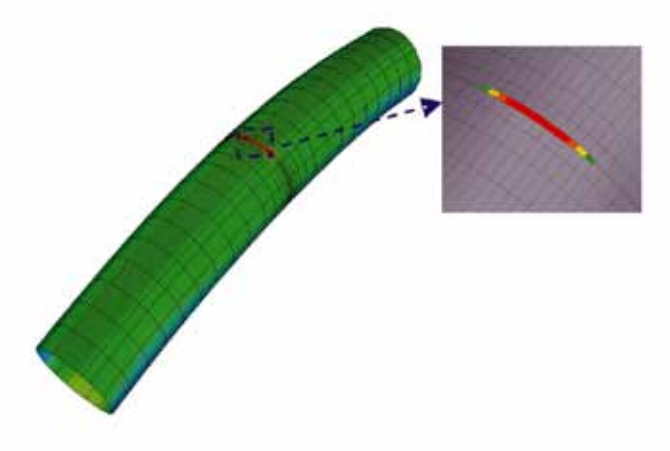


Figure 4. FE simulation of pipe with surface crack using the $LINK_{pipe}$ software.

Figure 5. (to the left) Silicone replica used to measure crack opening and ductile tearing.

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