Assessment of pipeline integrity after trawling impact by investigating dent with gouge

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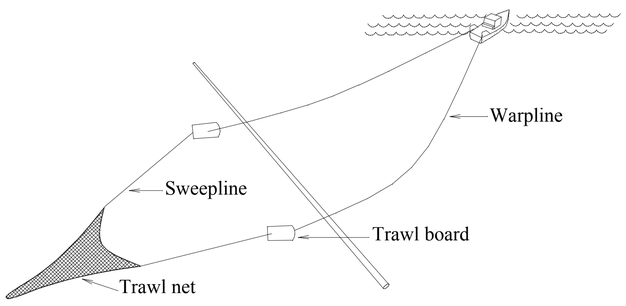
Background

Interference between subsea pipelines and trawling equipment is a relatively common occurrence. While pipelines and protection measures are designed for impact, damage may occur that compromises the long-term integrity of the pipe. For more than 30 years a significant amount of reasearch has been collected in an effort to understand the failure mechanism of pipelines associated with defects such as dents and gouges among others.

With regard to outside damage, current integrity assessment is based on the permanent dent depth as a percentage of the pipeline diameter. Scratches are not permitted, which is justified by the large fatigue life scatter in pipelines with both smooth dents and gouges. Consequently, a pipeline with a scratch must be repaired and this is a great cost for the operator.



Trawling gear inteference with pipeline [1]

Scope

This project will study the influence of dents and gouges on pipeline fatigue lives. The aim is to improve our understanding of the problem through numerical and experimental methods. Small-scale experiments will be conducted by applying cyclic internal pressure to damaged pipes, and finite element models will be applied to calibrate predictive models. Since the problem is quite involved, the scope of the project will have to be limited to what can be feasibly achieved within the time period:

1. Measurement of dent and gouge geometry by 3D acquisition methods
2. Instrumentation by strain gauges and verification of FEA.

Gouge is defined as a surface damage to a pipeline that has displaced or removed material from the pipe wall, resulting in a metal loss defect.

Acknowledgement

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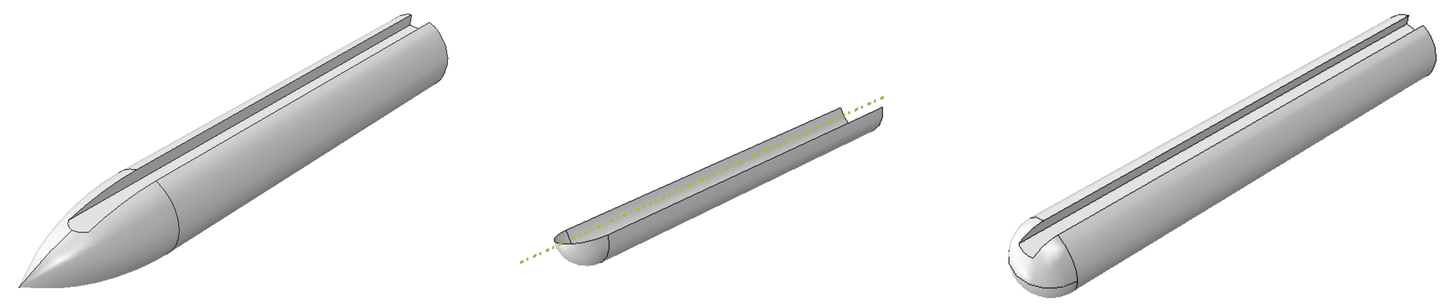
Method

The fatigue life of a material is strongly affected by holes, corners, notches etc. These are more commonly called stress concentrations. A stress concentration factor (SCF) allows the fatigue analysis to be executed by using nominal stress, and are defined by maximum hoop stress (σ_{max}) and nominal stress (σ_{nom}) as in the equation below

$$SCF = \frac{\sigma_{max}}{\sigma_{nom}} \tag{1}$$

In order to investigate different dent geometries and how the SCF varies when a gouge is introduced both numerical analysis and experiments are performed. The pipe segment investigated has a diameter of 102 millimetres and a thickness of 2 millimetres. Three different indenters are evaluated to predict the dent shape, illustrated below.



Indenter 1, 2 and 3 (from the left)

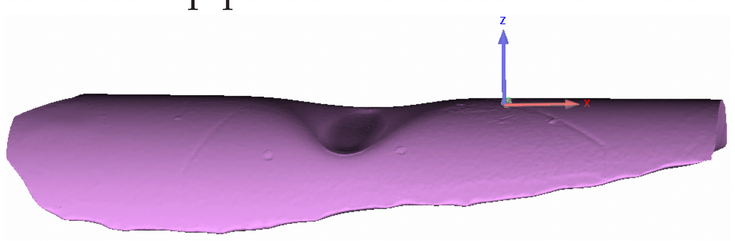
A numerical model is created to estimate SCF for the dent without the gouge, and experimental work is done to estimate SCF with a gouge. The purpose is to assess how the SCF is affected when a gouge is introduced.

Results

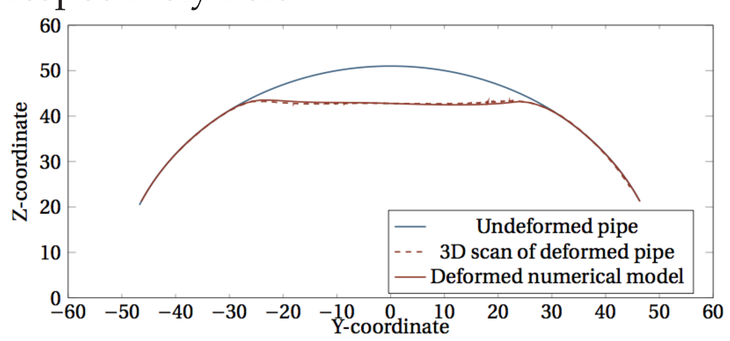
The experiment are being conducted at this moment, hence there is no result for SCF from dent with gouge is available. Therefore the work cannot reach a conclusion at this time. The expected results are that the SCF is significantly higher when the gouge is introduced. Early numerical analysis shows a small difference in SCF for the different dent geometries introduced by the three indenters applied for a plain dent.

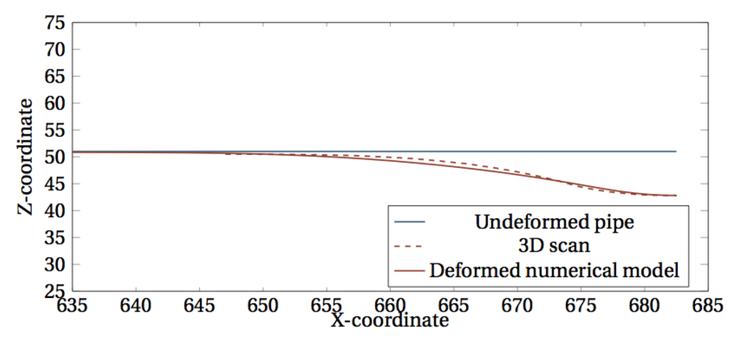
3D acquisition tool

To ensure the geometry was consistent from the experimental work to the finite element analysis 3D acquisition tool was utilised. An scanned pipeline is illustrated below.



The plot below showing the correlation between the results from the numerical analysis and 3D scan of the deformed pipe before internal pressure was applied showed good results. The YZ and XZ-plane is show respectively below.





Future Work

The research on the result of mechanical damage resulting in a combination of plain dent and gouge is sparse. Further work to investigate the effect can include:

- Measurements of residual stresses in damaged areas, before and after application of internal pressure.
- Fatigue life prediction based on geometrical parameters and/or finite element analysis stress solutions.
- Further investigation on the effect of the geometrical parameters of dent and gouges

References

[1] DNV (2014). Interference between trawl gear and pipelines. Oslo: DNV (DNV-RP-F111).