Offshore & Dredging Engineering

Technische Universiteit Delft

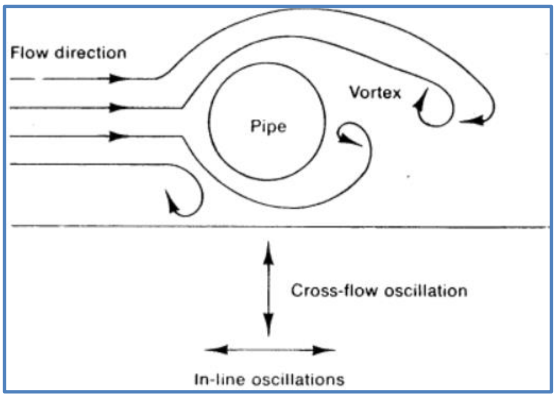
Technical feasibility assessment of hydrogen transport through existing offshore gas pipelines in the Dutch sector.

In the last century, the offshore industry has installed a network of offshore pipelines in the southern North Sea. Due to decreasing oil and gas extraction in the North Sea, many pipelines of this network are becoming redundant. A potential option for the reuse of these pipelines is the transport and storage of gaseous hydrogen, which is increasingly considered as an attractive energy carrier for a fossil fuel free economy. A Shell study has shown that offshore hydrogen production located at a renewable energy source, such as an offshore wind park, can economically compete with onshore hydrogen production that uses power cables to transport the energy to shore. The offshore hydrogen production case is based on newly built pipelines. If it is technically feasible to use existing pipelines, this can contribute to making the offshore hydrogen production case more attractive.

A transition from hydrocarbon transport to hydrogen transport through existing carbon steel gas pipelines changes the material behaviour of the pipeline, including a change in fatigue behaviour. Fatigue damage due to Vortex-induced vibrations (VIV) in offshore pipeline parts that are suspended above the seabed is a major challenge for oil and gas transportation in the southern North Sea. Therefore, it is of great importance to understand the change in fatigue behaviour due to the presence of gaseous hydrogen to assess the technical feasibility of hydrogen transport through the existing offshore pipelines.
A fatigue analysis for a specified existing gas pipeline of the NAM in the southern North Sea has been done according to DNV Free Spanning Assessment Methodology. For this analysis, the fatigue SN-curve for carbon steel material in a hydrogen environment is required. The SN-curve is approached based on available fatigue data for carbon steel material in hydrogen and severe sour environments. It shows that hydrogen has a significant influence on the fatigue behaviour of carbon steel material. The fatigue analysis outcomes show that adjustments to the pipeline are needed to avoid a significant increase in the risk of fatigue failure in critical pipeline sections. A remediation analysis has shown that rock dumping comes out as the cheapest option.

An existing time-domain numerical model that can determine the dynamic behaviour of a pipeline due to VIV is extended to perform fatigue damage calculations. The pipeline is modelled as a Euler-Bernoulli beam using the Finite Element Method. The model determines the VIV with a modal analysis in time-domain, which allows the model to include non-linear soil behaviour. The fatigue damage is determined for each pipeline element, which gives the fatigue damage distribution over the length of the pipeline. The time-domain numerical model is compared with the DNV Free Spanning Assessment Methodology and gives significantly higher fatigue lives. This suggests that the methodology that is used for the fatigue analysis is too conservative. However, there is still uncertainty about the influence of parameters predicting VIV. Further calibration of the model is required to ensure that the model outcomes correspond with target failure probabilities regarding industry standards.

The general conclusion of this research is that the specified existing offshore gas pipeline of the NAM is technically suitable for the transport of hydrogen if the adjustments are conducted. Compared to newly built pipelines, hydrogen transport through existing pipelines is an attractive option due to relatively low adjustments costs.



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