Master Thesis in Marine Technology - 2013
Pipeline Walking of High Pressure/Temperature Flowlines

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Objective

Short high pressure/temperature flowlines are exposed to frequent start-up and shut-downs during the design life. One of the phenomena related to this behaviour is that the flowline starts to move (i.e. walk) towards the cool end, thus being detrimental for the end connection design. The aim of the presented thesis is to get a clear understanding of the physical processes governing pipeline walking phenomena.

Introduction

Pipeline technology have a 150 year long history, whereas the offshore pipeline history started around 100 years ago [Guo et al., 2005]. Since then the industry have been in constant development. Today, as the offshore industry moves into more complex conditions, the industry faces several challenges. One of these challenges are connected to high temperature/high pressure pipelines that are subjected to frequent start-ups and shut-downs during its' life cycle. One of the phenomena related to this behaviour is that the pipeline moves axially towards the cold end. This global, axial displacement of the pipeline is called *pipeline walking*.

The aim of this thesis is to give an introduction to the offshore pipeline industry, with focus on the topics related to the concept of pipeline walking. Further, the phenomena of pipeline walking will be presented and described. To be able to obtain a clear understanding of this phenomena, a walking scenario will be defined. This case study will include relevant physical quantities, so that walking will occur.

This poster presents excerpts from the master thesis that are considered relevant for the exhibition. The extent of the theory, description of the analysis and result sections are limited due to lack of space and the aim for readability.

Pipeline Walking

As earlier stated, pipeline walking is the globally axial displacement of a pipeline. The pipeline walks cycle wise towards the cool end in correspondence with the start ups and shut downs during the design life. These movements are thus detrimental for the end connection design.

[Carr et al., 2008] gives a considerable insight into the pipeline walking phenomena. It is stated that pipeline walking is not a limit state itself, but it can lead to

- over-stressing spoolpieces/jumpers
- loss of tension in steel catenary risers
- increased loading within a lateral buckle
- need for restraint using anchors
- route-curve pullout of restrained system

Walking can occur in short high pressure/temperature pipelines. Here the expression *short* translates to pipelines that do not reach full constraint in the middle, but expand about a virtual anchor point located at the middle of the pipeline. When this requirement is fulfilled, pipeline walking occur when there

- is a tension at the end of the flowline, associated with an steel catenary riser (SCR)
- is a global seabed slope along the pipeline length
- are thermal gradients along the pipeline during changes in operating conditions

Unless the gradient of the thermal transient is extremely high, a fully constrained section will prevent walking.

References

[Carr et al., 2008] Carr, M., Sinclair, F., and Bruton, D. (2008). Pipeline Walking - Understanding the Field Layout Challenges and Analytical Solutions Developed for the SAFEBUCK JIP. *Society of Petroleum Engineers*, September:1–9.

[Guo et al., 2005] Guo, B., Song, S., Chacko, J., and Ghalambor, A. (2005). *Offshore Pipelines*. Elsevier Inc.

The number of references reflect the number of references used in the making of this poster, and not the references used in connection with the master thesis work.

Acknowledgements

This poster show a collection of excerpts from the master thesis relevant for The Master Thesis Poster Exhibition, in the running of winning the Department of Marine Technology Best Poster Award.

The master thesis have been written in the spring of 2013 as the final part of a MSc degree in Marine Technology at The Norwegian University of Science and Technology.

I would like to thank my supervisor at NTNU, Prof. Svein Sævik, for good guidance and academic support throughout the course of working with this thesis. I would also like to thank my supervisor at IKM Ocean Design, Pål Foss, for insight into the pipeline industry, as well as the necessary input data.

Analysis Model

The pipeline model used in the analyses can be seen in Figure 1.

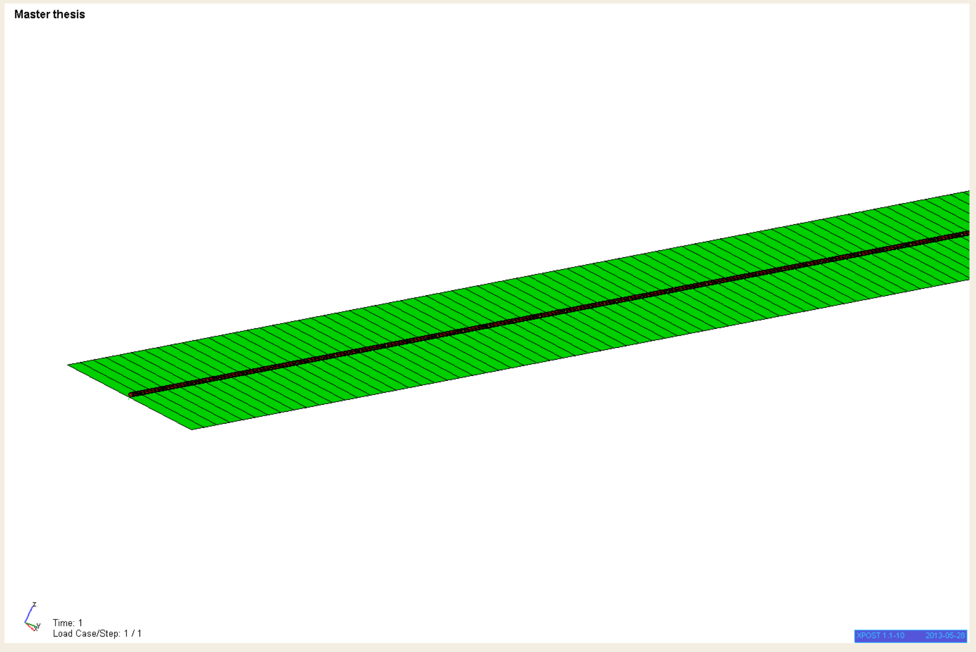


Figure 1: The Pipeline Model shown in Xpost

The model is 3000 [m] long, have an outer diameter of 42.29 [cm], and consists of 900 elements.

The analysis tool used is the MARINTEK program SIMLA, with the accompanying programs FlexEdit and Xpost. The programming language Python have been used when running the simulations, while MATLAB have, among others, been used to post process and plot results.

The analysis have consisted, and consists, of varying relevant parameters influencing the walking behaviour. The parameters making up this sensitivity matrix are

- effective axial friction coefficient in the axial direction
- global seabed slope along the pipeline length
- radius when globally curving the pipeline

The modelling of an SCR will also be performed. The temperature transients are not varied throughout the analyses, thus the same transients are applied in each case. This is done to keep the transients as authentic as possible, since the input temperatures are adopted from one of IKM's previous projects. The temperature transients are illustrated in Figure 2.

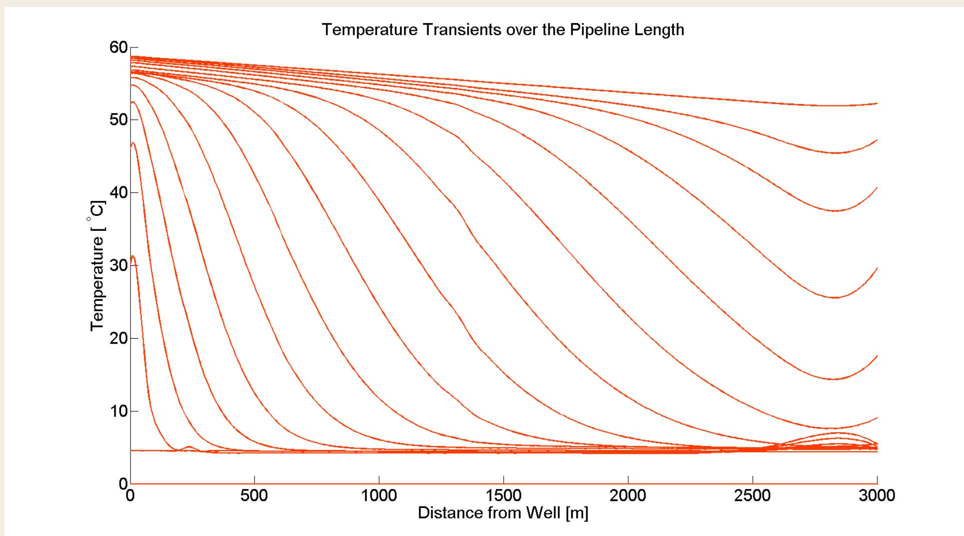
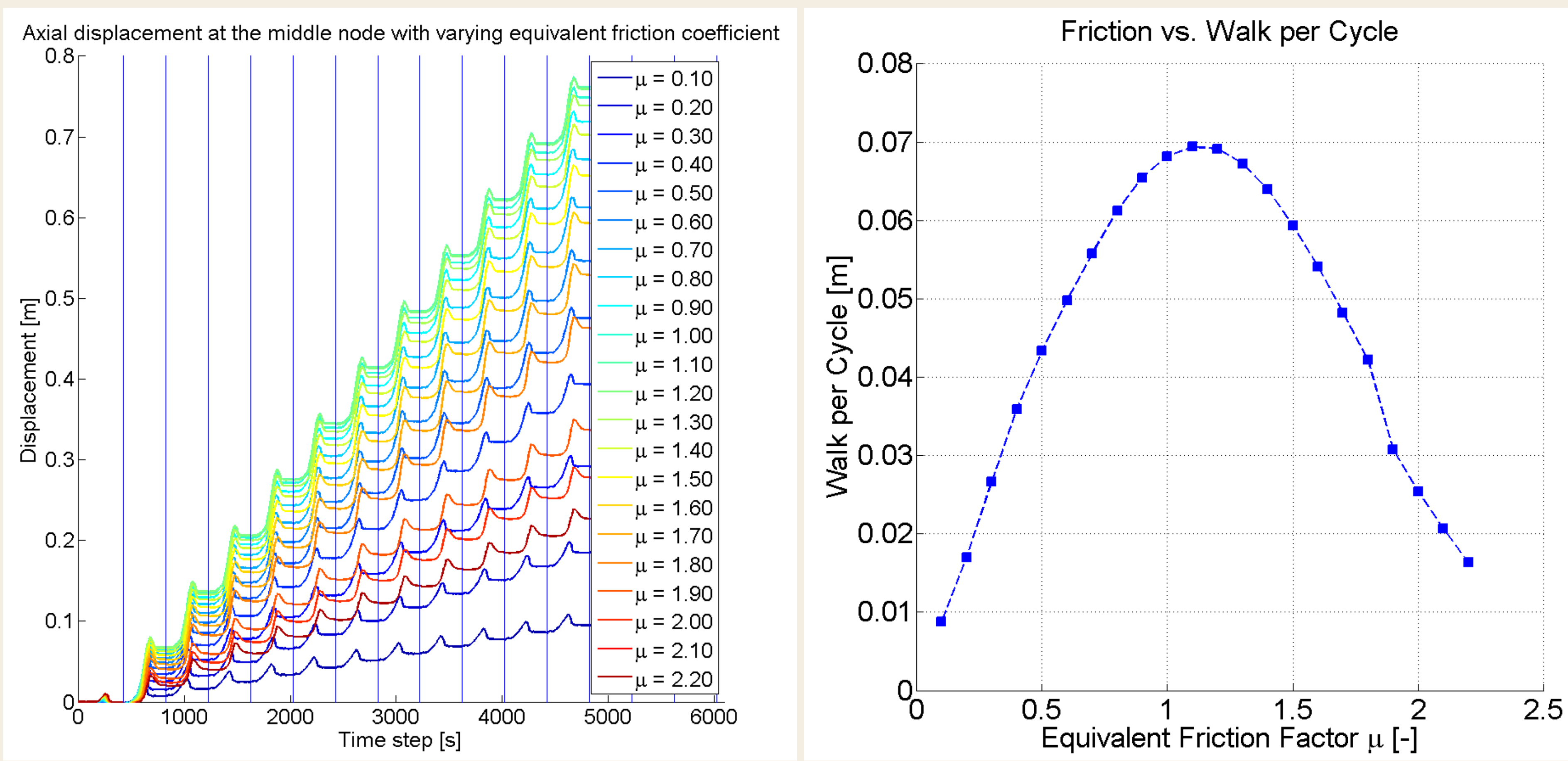


Figure 2: Distribution of the Temperatures over the Pipeline Length

Each line in Figure 2 above is the collection of the temperatures at one specific time step. In total, 322 time steps, with their corresponding temperatures, are included.

Preliminary Results

The results from the sensitivity analysis of the seabed conditions can be seen in Figure 3. Here, the effective axial friction coefficient was varied between $\mu = 0.1$ and $\mu = 2.2$.



(a) Axial Displ. for the Middle Node with Varying Friction Coeff.

(b) Friction plotted against Walk per Cycle

Figure 3: Results from Sensitivity Analysis of the Seabed Conditions Case

From Figure 3 one can see that the walk per cycle increase as the effective friction in axial direction increase, up to a certain point. Then the walk per cycle start to decrease, while the effective friction coefficient still increase. The blue vertical lines in Figure 3a show the time steps where each cycle start.