Evaluation of the Shutdown Time of Subsea Pipeline for Oil Transportation

D. Maciel[1], N. Bouchonneau[1]

[1]Universidade Federal de Pernambuco, Recife, Pernambuco, Brazil

Abstract

Introduction: The maintenance plan or rush-to-repair of a subsea pipeline for oil transport may result in the shutdown of the line, in other words, may stop the flow of fluid. During the shutdown, the temperature of the oil tends to decrease continuously, and the heavy molecules tend to crystallize and suspend in the oil, which increase the viscosity of the oil, and even form a paraffinic compound or freeze the production line.
Once the line is frozen during the shutdown, it is necessary to use complex time consuming procedures and expensive methods to unlock it and restart the production. Therefore it is important to conduct experimental and computational studies to analyze and better understand the behavior of lines submitted to a shutdown of the production and the evaluation of the time required to reach critical freezing temperatures (shutdown time), in order to present a safe, effective and economic proposal for the restart of the production.

COMSOL Multiphysics® use: In this work, the thermomechanical behavior of an immersed industrial pipeline with a multilayer insulation system subjected to high hydrostatic pressure (up to 300 bar) and high temperature gradient is simulated by using the Finite Element Method (FEM) in COMSOL Multiphysics® software. The objective is to study the thermal performance of the multilayer structure under ultra-deep service conditions, and thus determine the critical shutdown time according to the operation field. A model with 2D axisymmetric geometry will be conducted using both the Structural Mechanics Module and Heat Transfer Module, to study the coupled thermo-mechanical behavior of the structure (Figure 1). Thermal convection will be applied on external interface coating/water and internal conduction will be applied on the inner surface of the pipe (application of a heat flux on the internal surface of the pipe). Hydrostatic pressure will be applied to all external surfaces of the structure. The mechanical and thermal properties of the materials will be implemented as a function of temperature.

Expected Results: Once the steady state will be obtained, the internal heat flow condition will be withdrawn, and then, the behavior of the structure will be evaluated during a shutdown of the pipeline (Figure 2). From these results, the critical time of shutdown will be determined, considering that the formation of paraffinic compounds in the line begins from 40ºC, and the freezing of the same begins from 25°C. The results will be presented and discussed, in order to contribute to the characterization of the properties and thermal performance of the multilayer insulated pipe.

Conclusion: The study aims to develop a satisfactory multiphysical model which can predict the thermomechanical behavior of coated pipe subjected to ultra-deep service conditions and determine the critical time of shutdown, thus determining if the system coating is well suited to the field. We conclude that the expected results will contribute to the advancement and development of new technologies for extracting oil at great depths, from the study of the behavior and performance of the thermal insulation of subsea pipelines consisting of multiple layers currently employed.

Reference

1. BOUCHONNEAU, N., SAUVANT-MOYNOT, V., CHOQUEUSE, D., GROSJEAN, F., PONCET, E., PERREUX, D. Experimental testing and modelling of an industrial insulated pipeline for deep sea application. Journal of Petroleum Science and Engineering 73, p. 1–12 (2010).

2. COMSOL, COMSOL Multiphysics, Multiphysics Modeling Guide (2008).

3. TORRES, C. A., TREINT, F. e et al. Asphaltenes Pipeline Cleanout: A Horizontal Challenge for Coiled Tubing. SPE/ICoTA (Coiled Tubing Conference and Exhibition), The Woodlands, Texas (2005).

4. WANG, R.L. Smart Choice after the Accident. Oil and Gas Pipelines, Nº 2 (2010).

Figures used in the abstract

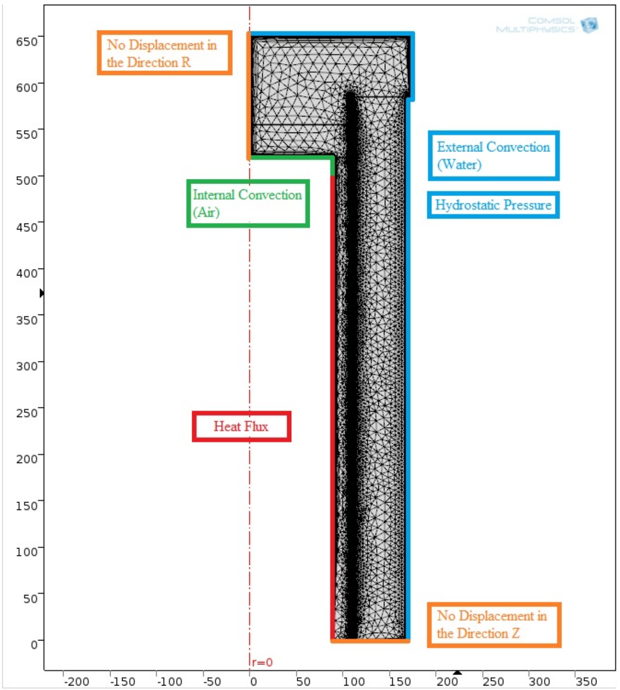

Figure 1: Finite Element Model with boundary conditions of the coated pipe performed with COMSOL Multiphysics.

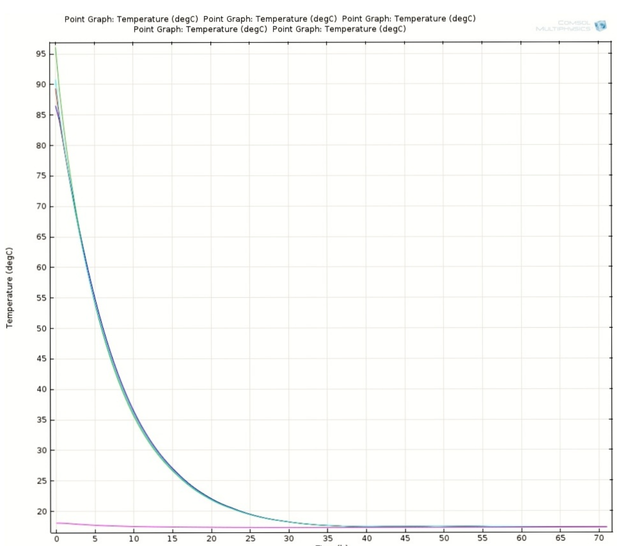

Figure 2: Simulation of the temperature evaluated at different points of the submarine pipeline during a shutdown obtained with COMSOL Multiphysics.