Lined Pipe Testing and Finite Element Modelling for Reel-Lay Application

Minh Le, Mamadou Ahmed-Kogri, Richard Stableford, Eric Giry
Offshore Subsea Engineering, Saipem SA
Montigny Le Bretonneux, France

ABSTRACT

In this paper a numerical model is proposed for Mechanically Lined pipe (MLP). LASER based scanning techniques were used to capture local straining of the liner and Digital Imaging Correlation (DIC) of the backing steel outer during simulated reeling trials. This included wrinkling generated by an unexpected anomaly near the transition area of one test string. Data was collected pre-reeling, during reeling and post-reeling. The numerical model developed to simulate the bending trial corresponds well with test data, proving the method useful for further MLP modelling studies.

KEY WORDS

Mechanically Lined Pipe; Abaqus; Python; LASER scanning; Eigenvalue Analysis, Liner Wrinkling.

NOMENCLATURE

CRA Corrosion Resistant Alloy
DIC Digital Imaging Correlation
DNV Det Norse Veritas
ERW Electrical Resistance Welding
FE (A), (M) Finite Element (Analysis), (Modelling)
ID Inner Diameter
MLP Mechanically Lined Pipe
OD Outer Diameter of pipe
SMLS Seamless (pipes)
SVD Singular Value Decomposition
WT Wall Thickness
2-D 2 Dimensional
3-D 3 Dimensional

INTRODUCTION

Mechanically lined pipe (MLP) is a cost-effective solution to transmit corrosive hydrocarbon fluids. A carbon steel host pipe shelters a thin tubing layer made of Corrosion Resistant Alloy (CRA). The thin tubing is inserted and expanded to fit the inner surface of the host pipe. A specific failure mode can occur based on delamination and collapse of the liner, known as “wrinkling”, when installed by reel-laying (Vasilikis and Karamanos, 2012), or under repeated large bending (Bartolini et al., 2017). Several works were performed to address specifically the conditions that may trigger a wrinkle, from a numerical perspective (previous references), or combining experimental and numerical studies (Toguyeni and Banse, 2012). Some proposed criteria to anticipate the situation where liner wrinkling may occur e.g.: JIP for lined and clad pipelines (2018), Tkaczyk et al. (2020), Le et al; (2021). Test campaigns were reported in recent years with dedicated instrumentation based on laser scanning to quantify the liner response and calibrate finite element model, e.g. Focke et al., (2007). High resolution measurements generate a large amount of data that requires a specific processing in order to get valuable interpretation such as the one described by Harrison et al. (2016). Some test programmes focused on local feature that could initiate a wrinkle such as a weld (Jones et al., 2021) or a liner imperfection (Pepin et al., 2019). However, to the authors knowledge, there is no MLP bending test involving an anomaly that specifically triggers a wrinkle that is measured with high resolution instrumentation and simulated through Finite Element Analysis. This paper proposes a comparison between experimental and numerical experience for such a case.

As part of an extensive test programme to validate finite element models for reel-laying application (Fig. 1), various full-scale reeling trial test strings have been fabricated for MLP reeling trials. Some have plain lined bodies, some incorporating deliberate delaminations between the liner and backing steel and some with girth welds concentrating on the performance of the liner transition (triple point).

6 pressurised reeling simulation trials were conducted on test strings with girth welds. A 7th test string was constructed to test at ambient pressure during reeling and installation. During post-assembly (pre-reeling) inspections, this test string was found to have an unexpected “anomaly” back from one triple point, further into the lined section of the test string. This resulted in a test string which coincidentally had one representative anomaly.