Advanced Finite Element Analysis for Qualification of Spiral Welded Pipe for Offshore Application

Ayman Eltaher¹, Syed Jafri¹, Paul Jukes¹ and Gustav Heiberg²

¹MCS Kenny, Inc
Houston, Texas, USA
²Det Norske Veritas, Inc. (DNV)
Houston, Texas, USA

ABSTRACT

Driven by cost, project characteristics and the need to use local technologies in offshore projects in developing countries, DNV and MCS Kenny have led a second phase of the Spiral Welded Pipe JIP, which aimed at qualifying spiral welded pipe for offshore shallow water applications. This paper focuses on the finite element (FE) study performed as part of the qualification program and aimed to investigate the response of spiral welded pipe to different loading combinations and particularly to S-lay conditions.

This paper provides benchmark and guidance to designers of spiral welded pipe for offshore applications regarding its points of strength and areas that require special attention. In that, an emphasis is placed on how spiral welded pipe compares to other types of pipe more commonly used in the industry.

In the paper, issues such as quality control, tolerances and loading conditions (e.g., load controlled vs. displacement controlled) and how they affect the pipe response are discussed. Detailed analysis and discussion are presented on limit states highlighted in DNVs standard for submarine pipelines (DNV OS F101), such as burst, collapse, axial tension, local buckling and combined loading. The analyses comprised nonlinear 3D FE simulations of spiral welded pipe, using Abaqus, and taking into account relevant tolerances that were likely to affect its limit states and response to loading and installation conditions. The paper touches on non-proprietary conclusions and findings of the FE study regarding the above limit states as well as spiral welded pipe fairs compared to other types of pipes commonly used in offshore applications, namely seamless and UOE pipes, as predicted by codes such as DNV OS F101.

The presented FE work, together with other studies of the Spiral Welded Pipe JIP, provides needed information that supports confidence in the analysis and design procedures of this type of pipe, which is less costly and more readily available in more areas of the world.

KEY WORDS: Offshore; Pipeline; linepipe, Spiral Welded Pipe; SAWH; Finite Element; Limit States; S-lay

NOMENCLATURE

3D Three-dimensional
API American Petroleum Institute
D Pipe Outer Diameter
DNV Det Norske Veritas
DSAW Double Submerged Arc Welded
DSAWH Helical DSAW (Spiral Welded)
DSAWL Longitudinal DSAW (Seam Welded)
FE Finite Element
FEA FE Analysis
t Pipe Wall Thickness
UOE Formed using “U”ing-“O”ing-Expansion Process

INTRODUCTION

Led by Det Norske Veritas (U.S.A.), Inc. (DNV) and MCS Kenny, a joint industry project (JIP) was initiated in 2009 to review the status of offshore applications for spiral welded pipes (sometimes known as SAWH pipes) and identify the most critical technology gaps using a technology qualification process per DNV RP A-203, as detailed in Heiberg et al., 2011. A second phase of the JIP has been carried out with focus on qualifying the spiral welded linepipes for offshore applications, using finite element analysis (FEA). At this stage, the aim of the JIP is limited to qualifying spiral welded pipes for shallow waters of only up to 240 m of depth and pipe dimensions that have been commonly manufactured as spiral welded pipe. Limiting the scope to shallow water also put an emphasis on the S-lay pipelay procedure and loads and conditions associated therewith.

The qualification process aimed at identifying the response of spiral welded linepipe to different loading conditions (e.g., axial tension and bending) as well as identifying its limit states and comparing of these limit states to those of the more commonly used seamless and UOE (SAWL) pipes, as defined in the industry codes such as DNV OS F101 and API RP 1111. This study was planned as a first step in a comprehensive program of analysis, testing and studies of special issues relevant to spiral welded pipe, such as fracture arrest.

It appears the industry has a general understanding that the performance