

# FINITE ELEMENT ANALYSIS OF STEMPIPE USED IN DEEPWATER PIPELINE INSTALLATION

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**Abstract** - The project deals with deep water pipeline installation by "J-Lay" method, for off shore oil and gas exploration which consists in laying submarine pipelines with a straight stinger at near vertical angles. Attention is focused on the detection of the Touch Down Point (TDP) (to vessel relative position) which is the principal point for following a prescribed laying route and having reliable installation. The determination of the maximum stress/strain, usually attained in the section at the maximum bending, which is at the PLET (pipe line end termination) or the beginning of the pipe, which leads to failure of the pipe at that point. To avoid such failure and damage due to high bending moment a stem pipe is designed to take high bending moment so that the pipe is safe during installation. This is achieved by analyzing global pipeline model and local 3D model of the stem pipe using FEM, which is used to lay at the initial point of PLET and stress analysis are done in the FEA (Finite Element Analysis).

## 1. INTRODUCTION

Deep water Pipelines are used for of the development of offshore hydrocarbon resources. These include (Transportation) export though pipelines. Flow lines to transfer a product from a platform to export lines

Pipelines are major components of the oil and gas production. Both technical and economical challenges should be taken into considerations for pipeline design installations in ultra-deep water.

Pipeline installation methods and selection of pipeline concept are important concerns and set limitations to how deep a pipeline can be laid. Not only limitations to laying vessel tension capacity but also to technical design solutions are important in order to make pipeline installations and operations feasible in deep water depths.

There are basically three methods of laying pipe in a marine environment

1. S-lay
2. Reel lay
3. J-lay

## 1.1 S-lay method

The most common method of pipeline installation in shallow water is the S-lay method. In the fig-1 shows S-lay method, the welded pipeline is supported on the rollers of the vessel and the stinger, forming the over-bend. Then it is suspended in the water all the way to the seabed, forming the sag-bend. The over-bend and sag-bend form the shape of an "S."

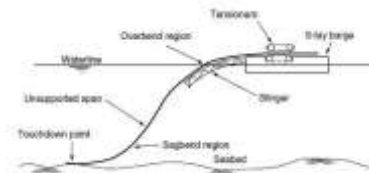


Fig-1 S-lay configuration

In the S-lay method, tensioners on the vessel/barge pull on the pipeline, keeping the whole section to the seabed in tension. The reaction of this pull is taken up by anchors installed ahead of the barge or, in the case of a dynamically positioned (DP) vessel, by thrusters.

## 1.2 Reel lay method

Reel pipe lay is a method of installing pipelines in the ocean from a giant reel mounted on an offshore vessel. In this fig-2 the reel lay method Pipelines are assembled at an onshore spool-base facility and spooled onto a reel which is mounted on the deck of a pipe lay barge.

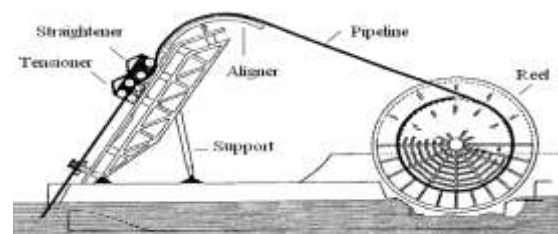


Fig-2:-Reel lay configuration

### 1.3 J-lay method

In areas where the water is very deep, the S-lay system may not be appropriate because the pipeline leaves the stinger to go almost straight down. To avoid sharp bending at the end of it and to mitigate excessive sag bending, the tension in the pipeline would have to be high. Doing so would interfere with the vessel's positioning, and the tensioner could damage the pipeline. A particularly long stinger could be used, but this is also objectionable since that structure would be adversely affected by winds and currents. The J-lay system, one of the latest generations of lay-barge, is better suited for deep water environments. In this system, the pipeline leaves the vessel on a nearly vertical ramp (or tower). There is no overbend only a sagbend of centenary nature (hence the *J* notation), such that the tension can be reduced. The pipeline is also less exposed to wave action as it enters the water. However, unlike for the S-lay system, where pipe welding can be done simultaneously at several locations along

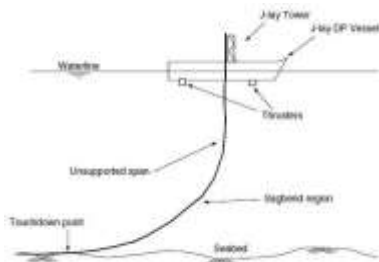


Fig-3:- J-lay method

The vessel deck's length, the J-lay system can only accommodate one welding station. Advanced methods of automatic welding are used to compensate for this drawback.

### 2. Problem Statement

To design and analyse a pipe that would prevent the failure of the pipe used in J-lay deepwater pipeline installation.

### 3. Purpose & Scope

The purpose of this document is to verify that the FTA stem pipes with their respective stiffeners, forgings and pipelines designed to meet the allowable stress (ASD) criteria in accordance with DNV-OS-F101. The stem pipes covered in this report include the following:

- 10.75"/14" FTA Production Stem Pipe

The functional loadings of the stem pipe imposed on the FTA and ITA structures are also included in this report.

### 4. METHODOLOGY

To avoid the fracture and damages occurred in the pipe used for the initial installation of the deep water pipeline system. Stem pipe is recommended to use during the installation of deep water pipeline which may sustain the pressure and loads occurred during installations. This stem pipe is modeled in solid works software. Stem pipe is similar to normal pipe used in deep water installation which consists of tapered fins to sustain such loads. This 3D model of Stem pipe is imported to ANSYS (finite Element Analysis). To the stress analysis for the bending loads (installation loads). The load include external pressure pipeline and PLET weight acting axially (vertically) bending moment.

#### 4.1. Designing of Stem Pipe

The modeling of stem pipe is carried out in Solidworks software, where Solidworks software is used to create engineering models. Building a model in solidworks usually starts with a 2D sketch, the parts of stem pipe were initially drawn in the 2D sketch then they are converted into 3D parts. Similarly each and every parts of the stem pipe is created with respective geometry(dimensions) and they are assembled to form a 3D model of stem pipe.

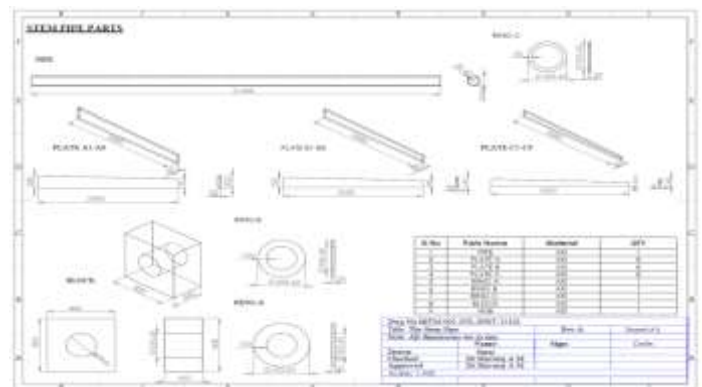


Fig-4:-Design of stem pipe

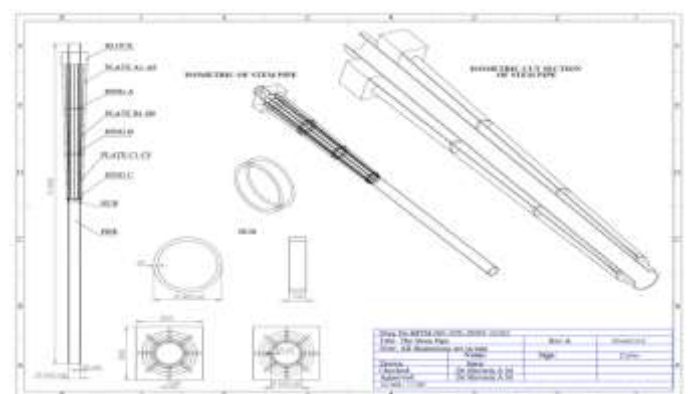


Fig-5:-Design of stem pipe



Fig-6:-simple pipe with block



Fig-7:-stempipe with stiffeners

Tab 1:- Stempipe size & material

Item	Value	Units
<b>Pipe without stiffeners</b>		
Outside Diamter	355.6	mm
Wall Thickness	20.6	mm
Material	DNV SML 485 U	-
Total Pipe Length	31000	mm

Tab 2:-Stiffener Details

Item	Value	Units
<b>Pipe with stiffeners</b>		
Outside Diamter	355.6	mm
Wall Thickness	20.6	mm
Material	DNV SML 485 U	-
Total Pipe Length	31000	mm
Stiffener section Length	10800	mm
Pipe section Length	20200	mm

Description	Value	Units
Material	Strutural Steel	-
Young's Modulus	207	MPa
Poisson's Ratio	0.3	-
Density	7850	Kg/m <sup>3</sup>
Tensile Yield Strength	250	MPa
Tensile Ultimate Strength	460	MPa

#### 4.2. Installation of Loads

The stem pipes are welded onshore to FTA and ITA prior to the transportation to the installation site. Installation analyses of the FTA with stem pipe were carried out and the installation loads experienced by the production and service flow line stem pipes on the FTA structure are obtained from installation contractor.

Fig6 shows the direction of the force and moments defined in the FTA installation analysis.



Fig 8:-Installation Loads on Typical FTA

Present the forces and moments on the FTA stempipe obtained from installation contractor to be used in the stem pipe modelling. The worse case between the 1<sup>st</sup> and 2<sup>nd</sup> end FTA obtained from installation contractor is presented here. These installation loads are applied to the stem pipe model to determine if the stem pipe is within the DNV OS F101 ASD obtained from installation contractor during installation. The installation load obtained from installation contractor had considered a dynamic amplification factor (DAF) of 1.2. Both these loads have been considered in the modelling to determine the stress range for fatigue analysis due to dynamic installation loads.

In the ANSYS 18.1 the structural analysis was done with the above loads on the normal pipe and stempipe, where results are calculated and compared.

**Note:-**The sign convention of the force and moments shown in this table refers to the load directions shown in fig.

Tab 3:- FTA Loading Conditions for Production Flowlines during Installation

Flowline	Case	Descript ion	Vertical Moment on Stem pipe, M <sub>z</sub> [kNm]	Tension, T [kN]
10.75"/1 4"	Installati on Static	DAF=1.0	-1415	578
10.75"/1 4"	Installati on Dynamic	DAF=1.2	-1698	693.6

To ensure that all the stem pipes are adequately designed to prevent stresses and fatigue over the allowable limit for all conditions, the following cases listed in Table 3 are analyzed for the installation and operating conditions respectively.

### 5. RESULTS

Tab 3 presents the loading from the production flowline FTA and ITA stem pipes. The force and moment are obtained from the ANSYS model and are used in the localized ANSYS Workbench local stem pipe model and also used for further FTA structural analysis.

It is not possible to exactly reproduce the operating loads of the global pipeline model in the stem pipe local model. It is assumed that the bending loads are more important to the design of the stem pipes than the shear load at the stem pipe/structure interface and for this reason, the moment distribution along the stem pipe is modelled accurately whilst shear force is not.

#### Results of the pipe without stiffeners

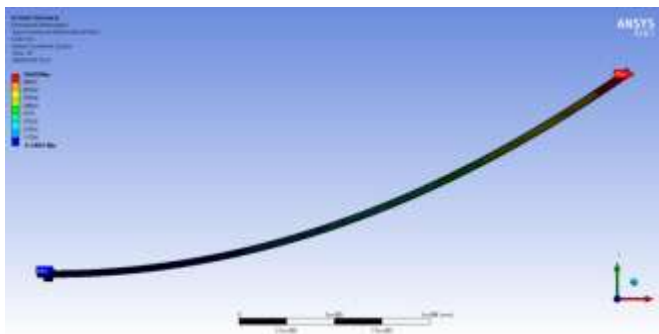


Fig 9:-Directional deformation of pipe without stiffeners in Y-direction

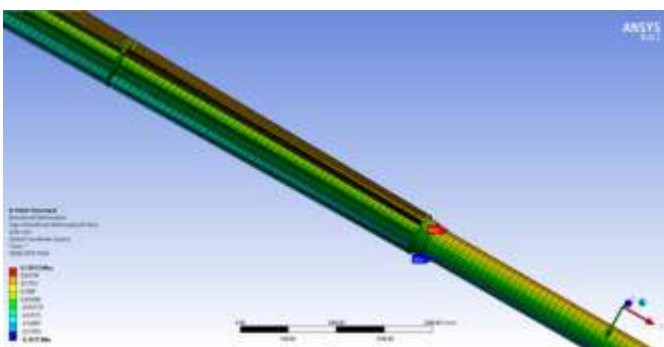


Fig 10:-Directional deformation of pipe with stiffeners in Y-direction

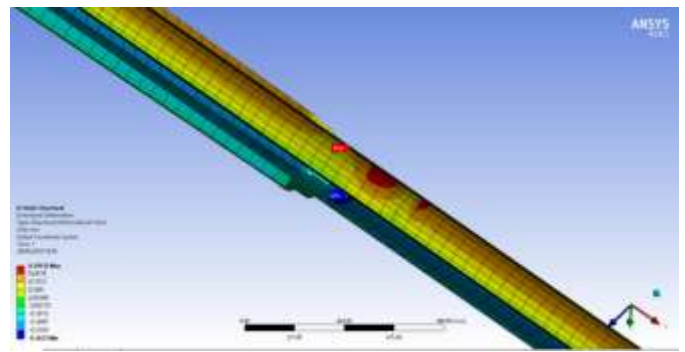


Fig 11:-The cut section view of Directional Deformation, normal stress, Von Moses stress & Elastic strain.

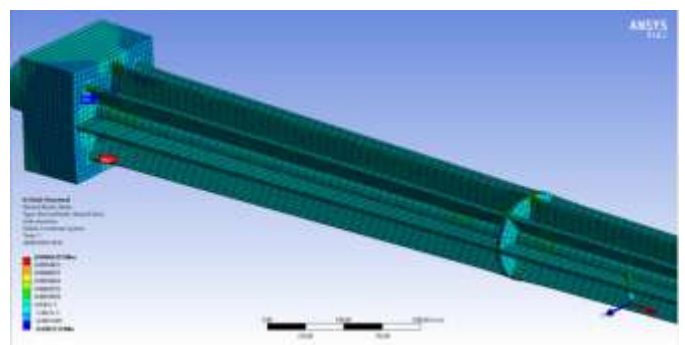


Fig 12:-Elastic Strain

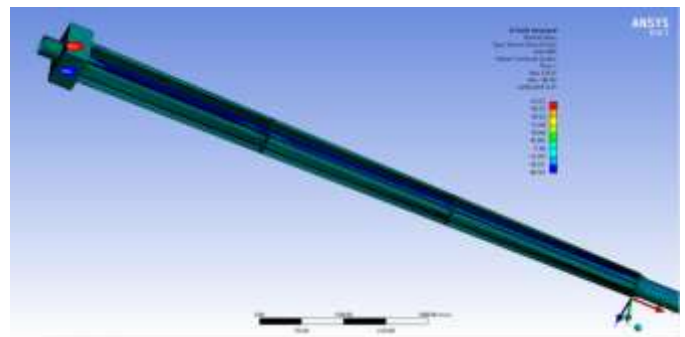


Fig 13:-Normal Stress

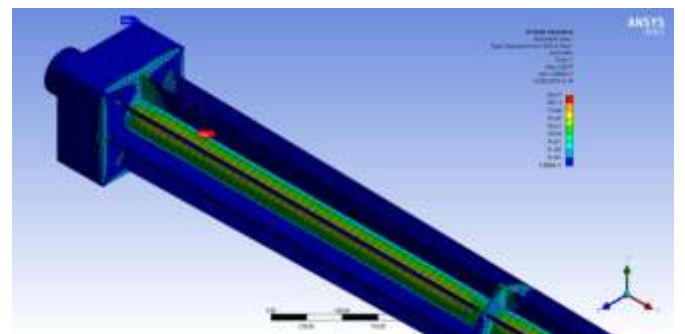


Fig 14:- Von Moses stress



Tab:-4 Represent the comparison results of both pipes

Results	single pipe without stiffener	Pipe with stiffeners	Units
Deformation in -y plane	10618	0.31035	Mm
Normal stress	1237.7	110.18	MPa
Von Moses stress	1572.9	241.81	MPa
Elastic strain	0.0070131	0.0005645	MPa

Table presents the results of Von Moses stress, Normal stress, and Elastic strain for the 10.75"/14" stem pipe during Installation Case 1 condition.

Tab:-5 Case 2 results for pipe with stiffeners

Results	Pipe with stiffeners	Units
Deformation in -y plane	0.29627	mm
Normal stress	215.31	MPa
Von Moses stress	230.77	MPa
Elastic strain	0.0010018	MPa

Table presents the results of Von Moses stress, Normal stress, and Elastic strain for the 10.75"/14" stem pipe during Installation Case 2 condition.

## 6. CONCLUSIONS

From the analysis of the stem pipe design for installation and operating cases (as shown in Table 2-3 to Table 2-5), the following conclusion can be made:

1. The design of stiffeners and stem pipe configuration of 10.75"/14" production flowline FTA stem pipe is acceptable in operating condition.
2. " 10.75"/14" production flowline ITA stem pipe configuration with the stiffeners are acceptable for both installation and operating conditions although a small spot of high stress occurs in the installation case
3. The design of stiffeners and stem pipe configuration of 10.75" and service flowline FTA stem pipe is acceptable for operating condition although small spot of high stress occurs.

## 7. REFERENCE

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