ReliabilityOf Subsea Pipeline API X70 In Different Water Depth

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Paper History

Received:10-October-2015
Received in revised form: 20-November-2015
Accepted: 23-Nevember-2015

ABSTRACT

Subsea pipeline is a medium of crude oil transportation which is operated in deep sea with variation of water depth such as shallow water, deep water and ultra deep water. Each of water level influence the mechanical properties of subsea pipeline. This paper describes the alteration of subsea pipeline properties such as stress and strain along with the alteration of water depth. To ensure the subsea pipeline integrity, the subsea pipeline is simulated with different water depth by using Finite element software ANSY Workbench. The results show that the equivalent stress and strain tend to decrease by increasing of water depth.

KEY WORDS: *Subsea Pipeline, Water Depth, Equivalent Stress, Equivalent Strain.*

NOMENCLATURE

API American Petroleum Institute

1.0 INTRODUCTION

Subsea pipeline is a medium to transport oil and gas in the deep water region which requires high level of safety during installation and operation. The design of subsea pipelines are not same to each level of water depth.The variation water depth result variation of external pressure and at a certain depth may result the same pressure between internal and external and it will be concerned in the design of subsea pipeline. In general, if a pipeline is subjected to internal pressure, then the pipeline will be exposed to burst pressure loading. In addition, when the pipeline is subjected to external pressure, so the pipeline will be exposed to collapse pressure loading.These combinationof loading influence to mechanical properties of subsea pipeline.

2.0 API RP 1111 REQUIREMENTS

Material selection is crucial process in design stage of subsea pipeline. However, there are several factors should be considered to select the pipeline material which will be applied in subsea pipeline. The Recommended Practice (RP) of API sets criteria for design subsea pipeline by considering operation and installation. According to the API Recommended Practice, the subsea pipeline is designed to withstand the maximum differential internal and external pressure where this condition will effect to the strength of material.

For subsea pipeline in deep water, the design consideration may be governed by external pressure because the installation process, the condition of subsea pipeline is empty. In order to avoid the collapse failure, the selection of wall thickness should be based on external pressure consideration.

Operating pressure in subsea pipeline should be under the design pressure because in the Recommended Practice provides safety factor by considering several parameter such as welding factor, design factor, incidental pressure factor and so on.

3.0 MEDGAZPROJECT FIELD DATA

The sea level of water depths are classified into three type of water depth starting from shallow water (0m – 400m), deep water

(400m-1500m) and ultra deep water (1500m – 3000m). This study, based on Medgaz Gas Transmission Project by completion of subsea pipeline linking Algeria and Spain across the Mediterranean Sea as shown in figure 1, The pipelines are made of X70 API Grade Steel. The Medgaz subsea pipeline route traverses various contours of sea bottom as shown in figure 2. The route has some area with sandy sediments and a clayey section between the shore approach and the outer shelf. the subsea pipeline route is going to down to the seabed with the maximum water depth of 2150 m.

Figure 1: Subsea Pipeline Route

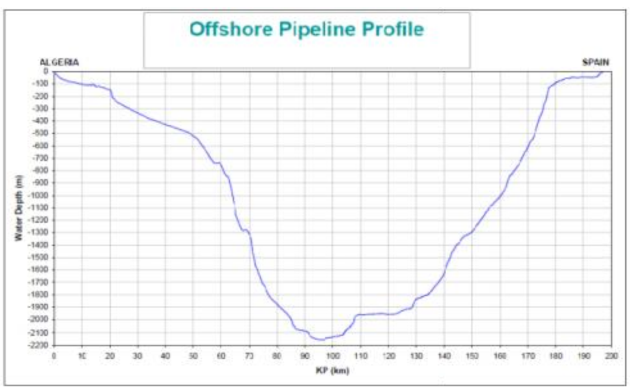

Figure 2: Contour of Seabed

The subsea pipelines have a constant internal diameter of 564.2 mm and consist of three section of wall thickness such as 22.9 mm, 28.5 mm and 29.9 mm. the wall thicknesses are conformed according to the water depth and installation process. Design pressure is 220 bar (22 MPa) and operating temperature is 60 ^{0}C.

4.0 PIPELINE MODEL

4.1 Geometry and Meshing Type

The pipeline model was built in Ansys design modeler where the finite element analysis is conducted in 3D model in order to obtain the whole integrity of subsea pipeline structures. The Ansysmeshing tool is a strategy to build a mesh type that is appropriate with tubular geometry. For subsea pipeline, the free mesh is applied because of the element shape of pipelines are not complicated model. A free mesh has no requirement and restriction to generate element mesh and there is no specified patern as well.

The geometrical shape of the pipeline is a tubular element which is created and modeled using ANSYS structure design modeler. Element model is defined to provide the proper degree of freedom to simulate models in different water depth level. The Element consists of nodes which are connected to each other. A node in each element has coordinate location where degrees of freedom and physical problem takes place. In each element are arranged by element numbers and node numbers.

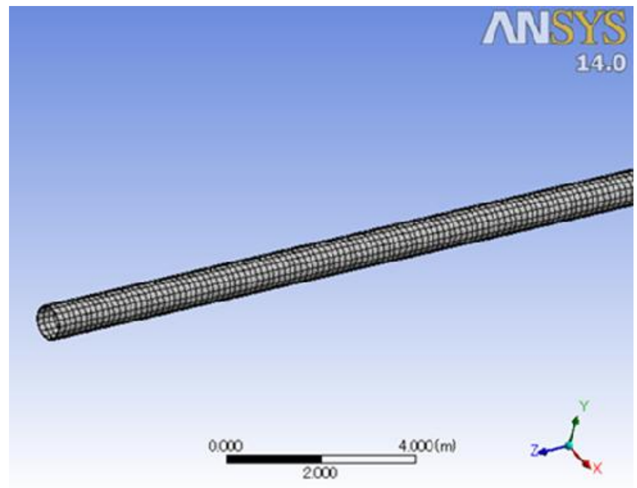

Figure 3: Mesh Type of Pipeline

4.2 Boundary Condition

The boundary conditions are important in Finite Element. In this section, the boundary conditions are presented in structural problem which becomes the part of stress interface with concrete coating , both ends of the pipeline were fixed and the internal and external pressure as load are applied to the pipeline. Internal pressure sets into load steps to describe load pressure and load distribution along the pipeline. The results are obtained by means of setting a load and solve process.

The applied boundary conditions are set up by applying internal pressure of 22 MPa and external pressures consist of three different water depth such as at shallow water 350 m, deep water 1000 m and ultra-deep water 2150 m.

5.0 RESULT AND DISCUSSION

5.1 Equivalent Stress Without Concrete Coating

In the figure 4, figure 5 and figure 6 illustrate the equivalent stress without concrete coating in the different water depth. As seen in figure 4, the equivalent stress distribution along the pipeline are uneven when it is compared to figure 5 and figure 6. However, the maximum equivalent stress decreases with increasing of water depth.

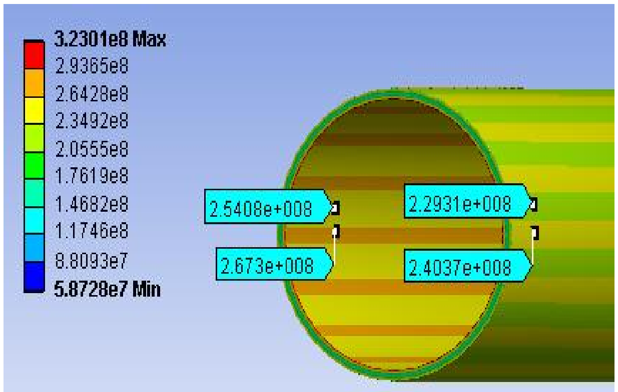

Figure 4: Water Depth 350 m

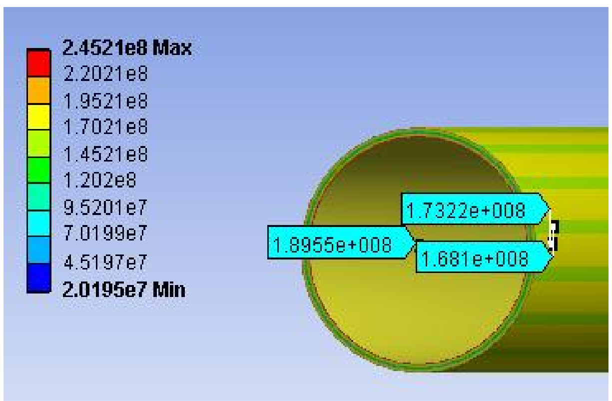

Figure 5: Water Depth 1000 m

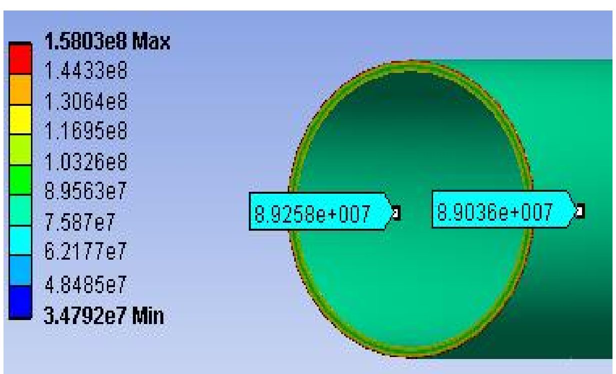

Figure 6: Water Depth 2155 m

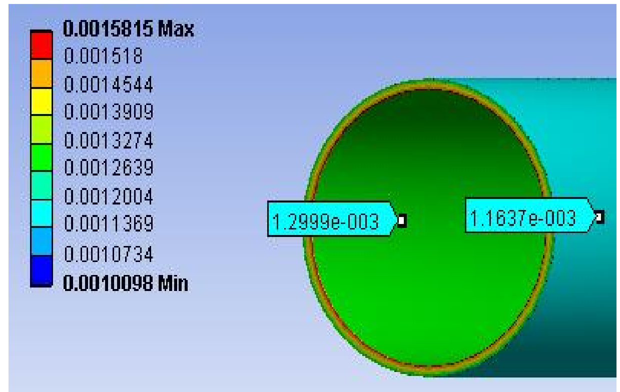

Figure 7: Water Depth 350 m

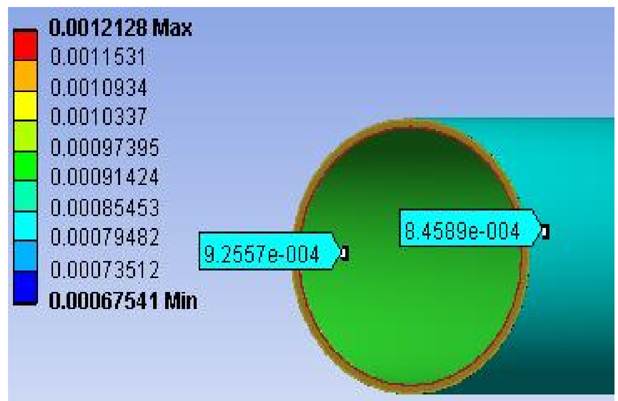

Figure 8: Water Depth 1000 m

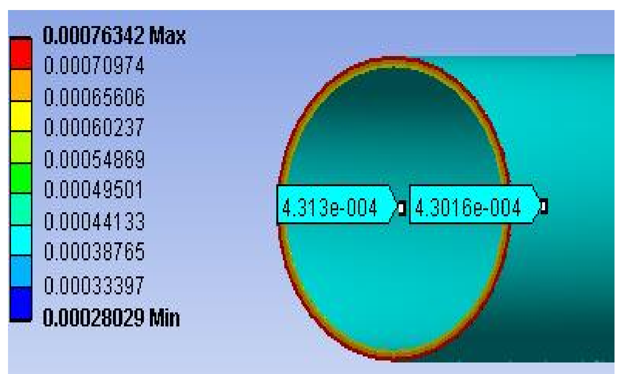

Figure 9: Water Depth 2155 m

5.2 Equivalent Strain without Concrete Coating

In the figure 7, figure 8 and figure 9 illustrate the equivalent strain of pipeline without concrete coating in different water depth. With increasing of water depth, the equivalent stress decreases and at the same time, the equivalent strain decreases. In the figures show the equivalent strain performance where the distributions of equivalent strain are uniformly along the pipeline.

5.3 Equivalent Stress With Concrete Coating

In the figure 10, figure 11 and figure 12 display the equivalent stress with concrete coating thickness 45 mm in different water depth of 350 m, 1000 m and 2155 m. The concrete coating influences to the proportion of pipeline stiffness, consequently the pipeline experiences constraint resulted in increasing stress in the pipeline. As seen in figures illustrate the performance of equivalent stress and describing interaction between pipeline and concrete coating. The distributions of equivalent stresses are uniformly along the pipeline. By using of concrete coating, the pipeline subjected to restrain condition when we compare to non coating of pipeline.

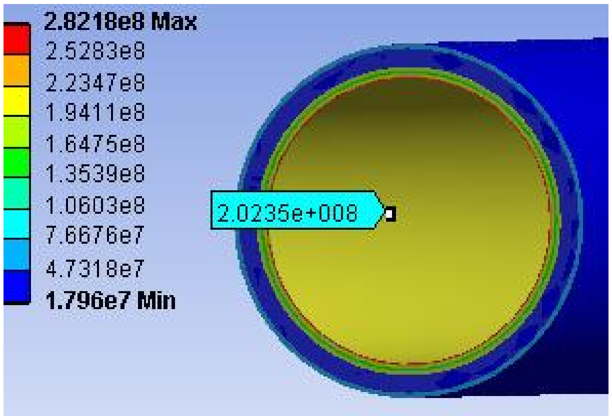

Figure 10: Water Depth of 350 m

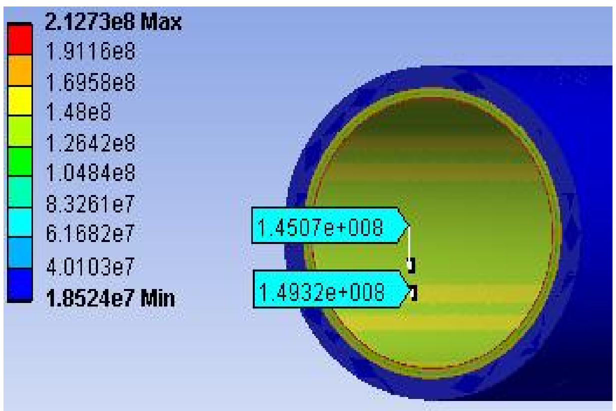

Figure 11: Water Depth of 1000 m

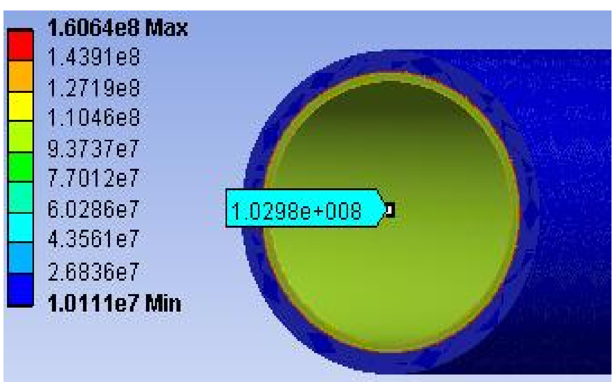

Figure 12: Water Depth of 2155 m

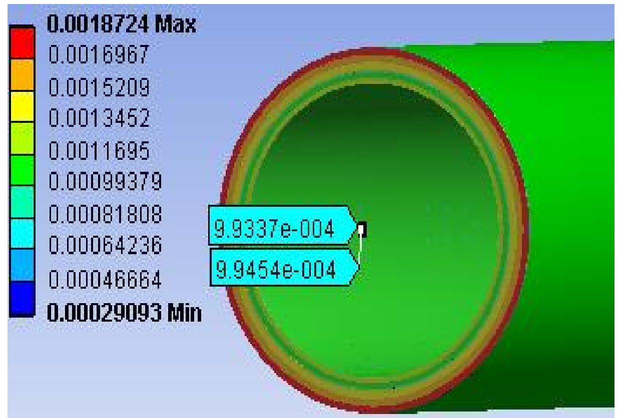

Figure 13: Water depth of 350 m

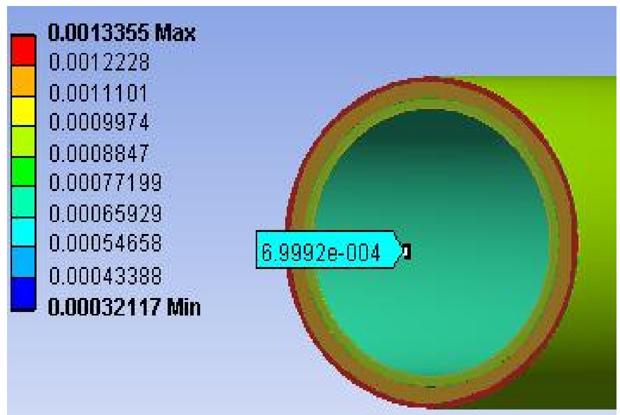

Figure 14: Water depth of 1000 m

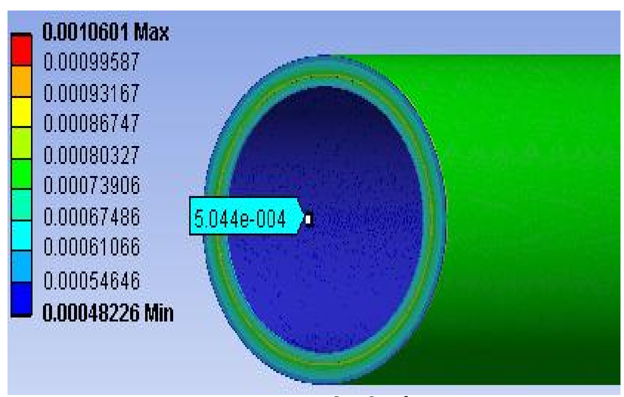

Figure 15: Water depth of 2155

5.4 Equivalent Strain with Concrete Coating

The equivalent strain with coating thickness 45 mm as shown in figure 13, figure 14 and figure 15 experience a constraint in different water depth. With increasing of water depth the equivalent strain decreases. In finite element ANSYS simulation shows the behavior equivalent strain at water depth 2155. It is the lowest when it is compared to deep water and shallow water at the same coating thickness**.**

6.0 CONCLUSION

The behaviors of pipeline stress have been described with different water depths consist of shallow water, deep water and ultra-deep water by performing ANSYS Static Structure simulation to observe mechanical properties of subsea pipeline such as equivalent stress and strain distribution. Increasing of water depth could reduce the stresses on subsea pipeline because of differences of internal and external pressure to become smaller.

Use of concrete coating will contribute to restraint condition where this condition effect to the flexibility of pipeline and cause to increase the pipeline stresses.The concrete coating of subsea pipelines were modeled in ANSYS Finite Element software to analyze the characteristic of pipeline interfaced with coating.

ACKNOWLEDGEMENTS

The authors would like to convey a great appreciation to Ocean and Aerospace Engineering Research Institute, Indonesia for supporting this research, Also Departement of Aeronautic, Automotive and Ocean Engineering, Faculty of Mechanical Engineering Universiti Teknologi Malaysia (UTM) and Mechanical Engineering, Universitas Riau, Indonesia.

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