Stress Analysis of Submarine Pipeline Laying by J Type

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Abstract: J type pipe laying method is the main laying pattern for deep-water pipeline. The exploitation of offshore oil and gas in China has stride forward into deep sea. However, domestic pipe laying technology in deep sea has yet to mature. This article adopts the stress analysis software CAESARII to do stress analysis of the process of submarine pipeline laying by J type, to study pipe's deformation in the flowing water. It provides the corresponding theoretical basis for the submarine pipeline laying by J type, as well as the corresponding engineering value and guiding significance.
Keywords: Submarine pipe; J type; Stress analysis

1 INTRODUCTION (Heading 1)

Submarine pipeline is the main media of exploitation and transportation of offshore oil and gas. At present the submarine pipeline laying methods mainly include lay barge, traction method, and reel-type lay barge, in which lay barge is the most common way of laying. The exploitation of offshore oil and gas in China has stride forward into deep sea. Pipeline laying by J type is considered to be the optimal practice in the situation of deep and ultra-deep water. J type laying method is good for the ship dynamic positioning. The stress that J-type laying method produces is smaller than S-shaped laying method, but its construction technology is complex and difficult and it requires longer construction period [1-2].

Due to the complicated underwater environment, pipeline is prone to pipeline failure under the effect of various load caused by many factors. So it is necessary to do pipe stress analysis which can provides a basis for the safety in the laying of submarine pipeline construction [3-5].

2 MARINE GAS PIPELINE INSTALLATION STRESSES AND CHECKING

In the process of pipeline laying, the external loads are mainly bending moment, axial force and the external pressure.

Hoop stress:

$$\sigma=\frac{(P_{\mathrm{i}}-P_{\mathrm{e}})D}{2t} \tag{1}$$

Equivalent stress:

$$\sigma=\sqrt{\sigma_x^2+\sigma_y^2-\sigma_x\sigma_y+3\tau_{xy}^2} \tag{2}$$

According to DNV81 specification requirements, the stress checking should be satisfied with the following equation 3:

$$\sqrt{\left(\frac{N}{A}+\frac{0.85M}{W}\right)^2+\sigma_y^2}-\left(\frac{N}{A}+\frac{0.85M}{W}\right)\sigma_y\le\eta\sigma_F$$

ISSN: 2222-7059(print), ISSN: 2222-7067(online), http://www.aspbs.com/aiem/
DOI: 10.7508/AIEM-V3-N3-49-52

Where N represents Axial force; A represents The pipe sectional area.

3 CASE STUDY OF J TYPE PIPE LAYING METHOD

CAESARII is applied to conduct stress analysis of pipeline laying by J type method (as shown in Figure 1), in which the laying angle is 90°. The modeling steps are as follows [6].

3.1 Piping input

It includes inputting pipe parameters (see Table 1), the trend of the pipeline (cosine of X, Y, Z), constraint condition, etc. In this case, due to the top is tower and the end is the workstation, then the constraint conditions can be simplified as two fixed constraint.

3.2 Environment modeling

It includes the input of marine environment (wind load above sea level and current load below, see Table 2) and seabed environment, such as the seabed soil specific weight.

Table 1. Environment parameters

Density, kg/m^3	Elastic Modulus, Pa	Poisson's ratio	Pipe diameter, mm	Wall thickness, mm	Coating thickness, mm	Coating density, kg/m^3	minimum yield strength, MPa
7850	2.1×10^{11}	0.3	1016.0	31.8	2.5	940	358

Table 2. Environment parameters

Sea-water density, kg/m^3	Wind velocity, m/s	Depth of the sea, m	Significant wave height, m	Significant wave height, s	Sea surface current velocity m, s	Central flow velocity m, s	Bottom of the flow velocity m, s
1030	38	2939.1	8	7.4	1.93	1.42	0.26

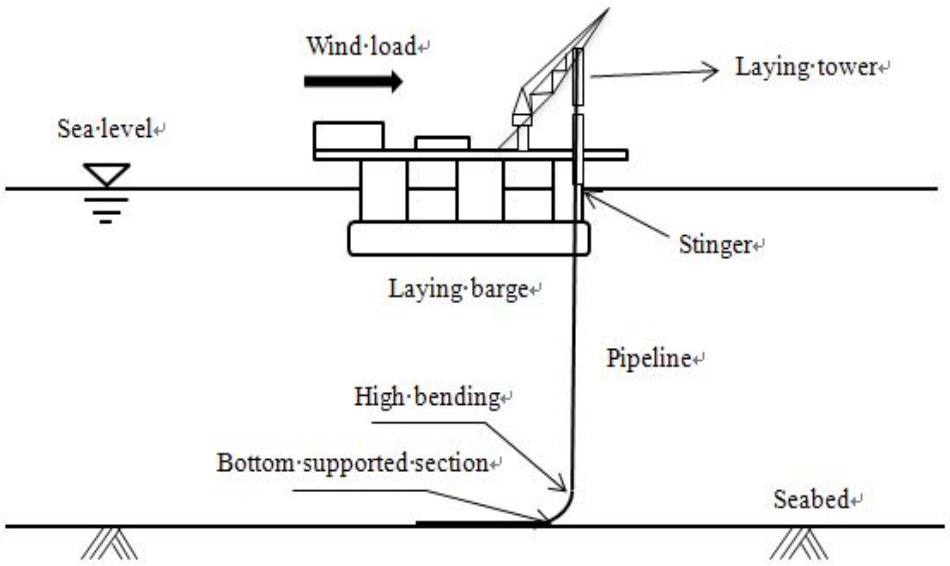
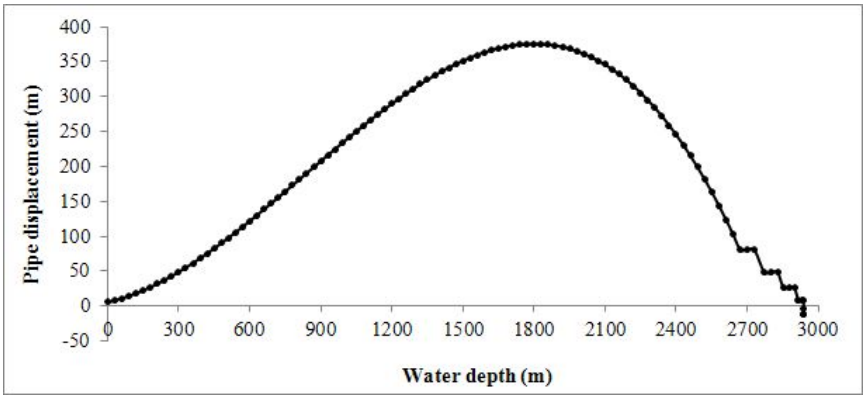


Fig. 1. Diagram of the pipe laying by J type method



Note: Displacement for "-" means that it is in the opposite direction

Fig. 2. Diagram of the pipe laying by J type method

3.3 Result analysis

By analyzing the working condition of submarine pipeline under the effect of flowing water, it is obtained the stress distribution and displacement of the pipeline, and the pipe stress concentration point can be clearly located.

3 CONCLUSIONS

This article studies the stress in the process of pipe laying barge doing its job with J type laying method, from which the maximal displacement location and its value of 375.7 m can be got, that is the middle position of vertical pipe. The Marine gas pipeline laying temporarily does not widely employ J type pipe laying method. It is suggested that detailed marine pipeline laying stress analysis and comprehensive consideration of factors such as the marine environment and the construction efficiency should be considered, in order to ensure the safety of the pipeline laying.

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