Analysis of Towing Scheme Based on Submerged Crude Oil Export Hose

Jiayi Zhang, Haiming Zhang*, Haijie Dong, Xiaotao Zheng, Shaowei Shang, Junfeng Wang, Kaidong Yang, Jinquan Zhu

CNOOC Energy Development Co., Ltd. Oil Production Service Branch, Tianjin 300452 China
*Corresponding author's email: zhmdyx@163.com

Abstract. Immersion crude oil export hoses are about to be applied in the South China Sea. Due to the fact that submerged export hoses have not been applied in Chinese waters before, in order to ensure that submerged export hoses do not sink during towing to designated locations, a finite element analysis model was established based on submerged export hoses and the sea conditions in the South China Sea to analyze the export hose string under different towing conditions. The results showed that there is a risk of sinking of export hoses under some operating conditions.

Keywords: towing scheme, crude oil export hose, analysis.

1 Introduction

Due to the distance between the production site and the service location of the export hose, it will be transported by towing to the service location. At present, most domestic operations use floating export hoses [1-3], and submerged export hoses are rarely used, so the research on towing conditions of export hoses is still blank. This article takes the towing of submerged export hoses[4] in the South China Sea as a prototype, analyzes the floatability and stress conditions of submerged export hoses during towing, and provides reference for future towing of submerged export hoses.

2 Establishment of Finite Element Model

The physical parameters related to the export hose are shown in Table 1.

Table 1. Internal structure division of export hose: Basic parameters of 16 inch submerged original export hose.

	First hose	Main hose	Tail hose
Hose Length(m)	12.2	12.2	12.2
Tensile stiffness(kN)	22650	22650	22650
Bending stiffness(kN·m^2)	35	35	35
Torsional stiff-	150	150	150

ness(kN·m^2)			
Permissible pressure(bar)	19	19	19
Allowable axial tension(kN)	1369	1369	1369
Inner diameter of hose(m)	0.387	0.387	0.387
Pipeline weight(kg)	2750	2550	2700

The floating model is a tugboat, and the parameters of the tugboat are shown in Table 2.

Table 2. Towing vessel parameters.

Total length of the ship	69.1m
Type width	15m
Depth Moulded	7.2m
Empty draft	3.031m
Total weight of the ship	2100t
Dry side	1m
Movement speed	5knot

According to the requirements of the classification society, wind protection measures should be taken when the wind speed exceeds Pu Shi 7 level (wind speed of 27 knots). The environmental parameters of this model are shown in Table 3.

Table 3. Model environment parameters.

Maximum wave height(m)	4
Wave period(s)	9.7
Surface velocity(m/s)	1.7
wind speed(m/s)	13.9

The towing method of the export hose string generally includes a "U"-shaped towing, where the first and last pipes of the export hose are fixed on the towing vessel[5].

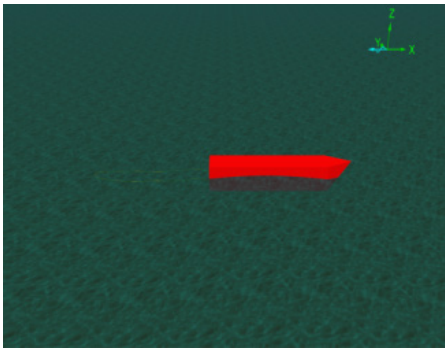


Fig. 1. Schematic diagram of towing model.

3 Model Calculation Results

The text is based on Orcaflex[6-8] to establish a finite element model, as shown in Figure 1.

Based on the above model, the calculation results are as follows.

3.1 Calculation Results of Maximum Effective Tension of Export Hose String

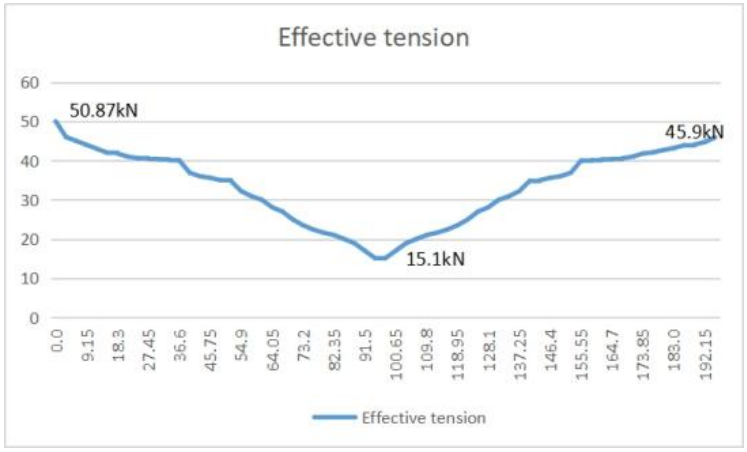


Fig. 2. Calculation results of maximum effective tension for "U" - shaped towing.

The distribution of the maximum tensile force along the direction of the submerged export hose string during the "U" - shaped towing is shown in Figure 2. According to the calculation results, the maximum effective tension occurs at the connection between the first pipe and the tail pipe, that is, the pipe string and the towing ship. The maximum effective tension is 50.87kN, which is much lower than the allowable axial tension of the first pipe of the submerged export hose, and there is no safety hazard.

3.2 Calculation Results of Floatability of Export Hose String

Figure 3shows the analysis results of the maximum sinking amplitude of the submerged export hose string. It can be seen from the figure that the maximum sinking position occurs at the water inlet of the hose, while the sinking amplitude of other parts of the string is relatively average. Based on the above analysis, time-domain analysis was conducted on the inlet, sixth, seventh, and eighth hoses of the external hose string. The calculation results are shown in Figure 4. The calculation results indicate that the export hose will not sink under the influence of wind and waves during the "U" - shaped towing process, and can always remain near the water surface.

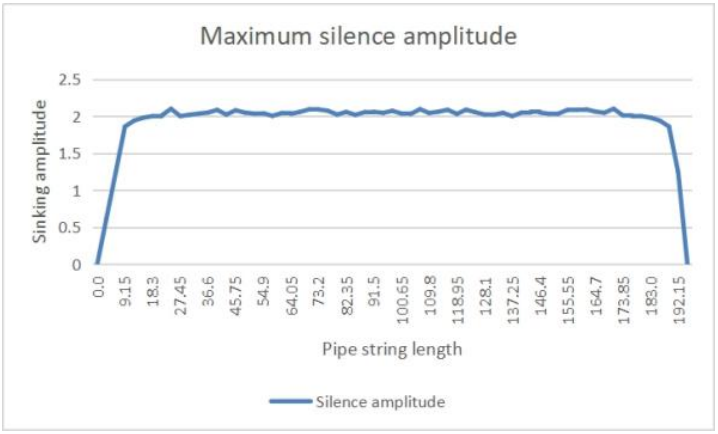
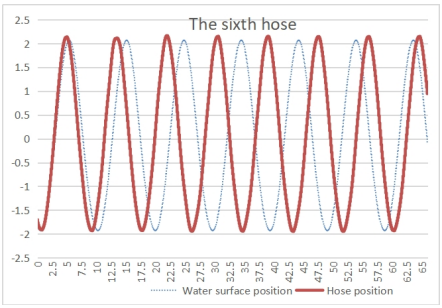
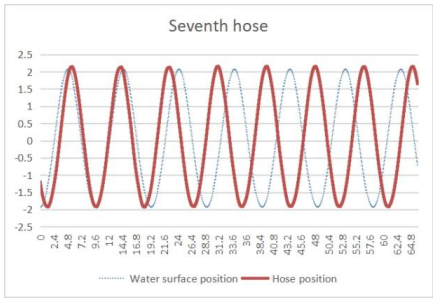


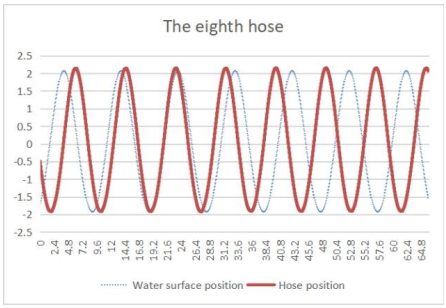
Fig. 3. Maximum sinking amplitude of pipe string during "U" - shaped towing.



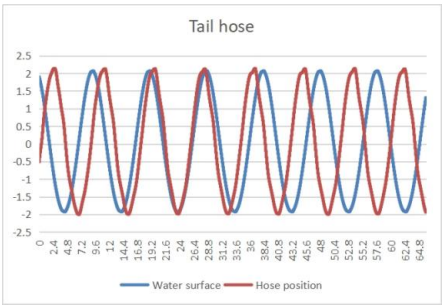
(a)The floating condition of the sixth hose



(b)Floating condition of the seventh hose



(c)Floating condition of the eighth hose



(d)Tail pipe floating condition

Fig. 4. Time domain analysis of floating situation at key positions of submerged export hose string during "U" - shaped towing.

3.3 Calculation Results of Curvature of Export Hose String

According to the "Guide to Purchasing and Manufacturing Hoses for Offshore Moorings" published by the International Maritime Forum of Oil Companies in 2009[9-11], the minimum bending radius of export hoses should be 6 times the inner diameter of the hose. To verify whether the maximum bending of the pipe string meets the specification requirements, the bending situation of the pipe string was calculated, and the calculation results are shown in Figure 5. The calculation results show that the maximum curvature of the pipe string during the "U" - shaped towing process is 0.3281rad/m, and the minimum allowable bending radius for the 16 inch submerged export hose is 2.322m, which is within the allowable range of curvature.

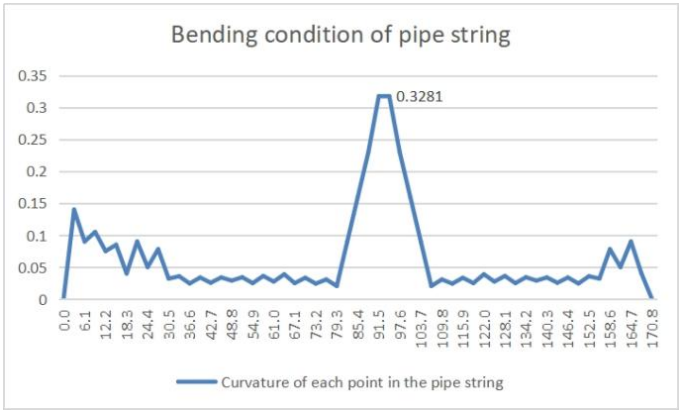


Fig. 5. Calculation results of bending of U-shaped towing hose.

4 Conclusion

Due to the distance between the production site and the service location of the export hose, it is necessary to transport the export hose to the service location by towing. Due to its limited buoyancy reserve, submerged export hoses pose a risk of sinking during towing. However, due to the limited application of submerged export hoses in China, the towing analysis of submerged export hoses is still blank. This article is based on the hydrodynamic software Orcaflex, and analyzes the bending, effective tension, and floating of submerged export hoses under different towing schemes. The conclusions are as follows:

(1) During the towing process, the minimum bending radius of the submerged export hose is greater than the allowable minimum bending radius of the hose, and the hose will not be damaged due to excessive bending, so there is no need to install a bending limit device;

(2) The maximum effective tension experienced by the submerged export hose during towing is much lower than the allowable axial tension of the hose;

(3) During the towing process of submerged export hoses in the port area, the sinking amplitude of the middle section of the pipe string is relatively large (the sixth, seventh, and eighth hoses). Therefore, buoyancy blocks should be added to the middle section of the pipe string and the tail pipe during towing to ensure towing safety.

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