한국동력기계공학회지 제18권 제6호 pp. 180-185 2014년 12월 (ISSN 1226-7813)
Journal of the Korean Society for Power System Engineering http://dx.doi.org/10.9726/kspse.2014.18.6.180
Vol. 18, No. 6, pp. 180-185, December 2014

A Study on the Structural Characteristics and Shape of Outfitting Equipment Support in a 300K DWT Crude Oil Tanker

Kwang-Woon Jeong*, Han-Shik Chung**†, Hyo-Min Jeong***, Myoung-Kuk Ji*** and Jeong-Tae Kim***

(Received 30 October 2014, Revised 03 December 2014, Accepted 03 December 2014)

Abstract: Due to the larger and high-speed vessels recently constructed, output and speed of the engines for propulsion or power generation is increasing. These high-power and high-speed engine of the ship is becoming as a major contributor causing excessive noise and vibration. Other fittings as well as equipment installed on board, it makes equipment failure or other defect by resonance. This causes a lot of M/H(Man Hour) for repairs and the reliability of the company is invading even be negative because the clients give much comment. Thus, it's being studied for any fittings installed on board to maintain the safe operation and to prevent any problem during the performance in any operating conditions. In this study, it was investigated to solve these problems for the supports of the various fittings for easy installation-related support that each type of intensity and shape and manufacturing method using structural analysis program(DNV Nauticus Hull 3D Beam). Namely, it would be applied to the very large crude carriers in consideration of mechanics of materials of the support equipment by providing the fact that dynamics analysis of the structural characteristics of the equipment and the support of the production installation is easy and productivity can be high standards for geometry and thereby to simplify the analysis task to design changes at the same time and to minimize the reinforcement for the supports.

Key Words : Vessel, High-speed, Outfitting, Equipment, Support, Production

1. Introduction

A vessel has an average life of about 25.3 years, and the performance of its installed devices or equipment should also be continuously maintained and managed until the end of the life of the vessel. With the increase in the size and speed of recently built vessels, the output and speed of propulsion or generation engines have continuously increased and have become major causes of excessive vessel noise and vibration [1-2]. Accordingly, resonance occurs in the equipment and other outfitting equipment installed in vessels, and such equipment frequently malfunctions and fails. Therefore, in this study, to resolve this problem, the types, shapes, and structural characteristics of the supports that safely fix the outfitting equipment installed in vessels were investigated, and a standard was made for application to vessels [3-4].

**† Han-Shik Chung(corresponding author) : Department of Energy and Mechanical Engineering, Gyeongsang National University.
E-mail : hschung@gnu.ac.kr, Tel: 055-772-9115
*Kwang-Woon Jeong : Department of Energy and Mechanical Engineering, Gyeongsang National University, Daewoo Shipbuilding & Marine Engineering Corporation Ltd.
***Hyo-Min Jeong, : Department of Energy and Mechanical Engineering, Gyeongsang National University.
***Myoung-Kuk Ji : Dept. Solar E&S Corporation Ltd.
***Jeong-Tae Kim : Dept. Daewoo Shipbuilding & Marine Engineering Corporation Ltd.

2. Main Subject

A support is a device for attaching outfitting equipment, such as pipes, to a hull structure using various clamps and additional devices through extension, using angles, etc., to fix and support the outfitting equipment. Depending on the position and equipment for installation, the types of support can be classified into the deck mounting type, the wall mounting type, the ceiling mounting type, the vent duct type, and the cable tray type, as shown in Fig. 1 [5-7].

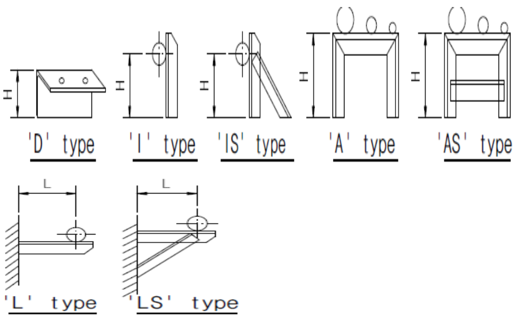

Fig. 1 Various types of support

3. Conditions for the structural analysis

The analysis was performed based on the shapes of the supports that are widely used in vessels Fig. 2, the types summarized in Table 2, and the conditions summarized in Table 1, using the DNV Nauticus Hull 3D Beam structural analysis program.

Table 1 Model and conditions

Model	Figure 2
h	3.0 m
b	2.0 m
Members	200x8+200x12 (H)
Load(F)	500kN
For convenient calculation, only a lateral load as applied	

Table 2 Shape of the support

Ser.	Description(shape)
1	Basic support shape
2	Basic+horizontal lower support structure shape
3	Basic+horizontal middle support structure shape
4	Basic+diagonal support structure shape
5	Vertical+inclined support height structure shape
6	Vertical+inclined support base structure shape
7	Vertical+inclined support structure shape

Fig. 2 Model of the support

4. Analysis Results

4.1 basic support shape

As shown in Table 3, for Case 1 (the triangular shape), the maximum bending moment was 20 kN, the maximum bending stress was 37 N/mm^2, and the maximum deformation was 5.74 mm; for Case 2 (the trapezoidal shape), 179 kN, 339 N/mm^2, and 18.46 mm; and for Case 3 (the quadrilateral shape), 594 kN, 425 N/mm^2, and 68.99 mm. When the maximum deformation of Case 1 (5.74 mm) was assumed to have been 100%, those of Case 2 and Case 3 were 321% and 1,202%, respectively. Table 3 shows the changes in the conditions of Cases 1, 2, and 3. Therefore, the change in the results of Table 3 can be seen as shown of Fig 3.

Table 3 Analysis of basic support shape

	Case 1	Case 2	Case 3
Max. Bending Moment	20 kN	179 kN	594 kN
Max. Bending Stress	37 N/m^2	339 N/m^2	425 N/m^2
Max. Deformation	5.74 mm (100%)	18.46 mm (321%)	68.99 mm (1,202%)

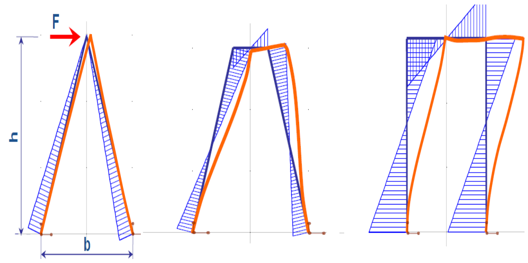

Fig. 3 Basic support shapes

4.2 basic + horizontal lower support structure shape

As shown in Table 4, for Case 1, the maximum bending moment was 19 kN, the maximum bending stress was 37 N/mm^2, and the maximum deformation was 5.74 mm; for Case 2, 178 kN, 338 N/mm^2, and 18.33 mm; and for Case 3, 402 kN, 760 N/mm^2, and 67.98 mm. When the maximum deformation of Case 1 in Table 3 (5.74 mm) was assumed to have been 100%, those of Case 1, Case 2, and Case 3 were 100%, 319%, and 1,184%, respectively. Table 4 shows the changes in the conditions of Cases 1, 2, and 3. Therefore, the change in the results of Table 4 can be seen as shown of Fig 4.

Table 4 Analysis of basic + horizontal lower support structure shape

	Case 1	Case 2	Case 3
Max. Bending Moment	19 kN	178 kN	402 kN
Max. Bending Stress	37 N/m^2	338 N/m^2	760 N/m^2
Max. Deformation	5.74 mm (100%)	18.33 mm (319%)	67.98 mm (1,184%)

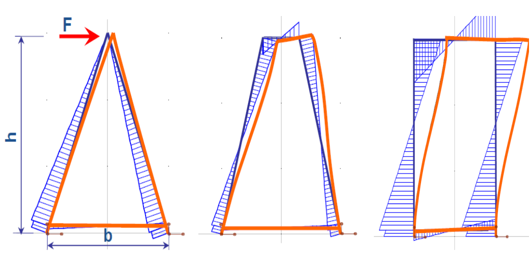

Fig. 4 Basic+horizontal lower support structure shapes

4.3 Basic + horizontal middle support structure shape

As shown in Table 5, for Case 1, the maximum bending moment was 25 kN, the maximum bending stress was 47 N/mm^2, and the maximum deformation was 5.65 mm; for Case 2, 137 kN, 259 N/mm^2, and 12.69 mm; and for Case 3, 275 kN, 519 N/mm^2, and 38.08 mm. When the maximum deformation of Case 1 in Table 3 (5.74 mm) was assumed to have been 100%, those of Case 1, Case 2, and Case 3 were 98%, 221%, and 675%, respectively. Table 5 shows the changes in the conditions of Cases 1, 2, and 3. Therefore the change in the results of Table 5 can be seen as shown of Fig 5.

Table 5 Analysis of basic + horizontal middle support structure shape

	Case 1	Case 2	Case 3
Max. Bending Moment	25 kN	137 kN	275 kN
Max. Bending Stress	47 N/m^2	259 N/m^2	519 N/m^2
Max. Deformation	5.66 mm (98%)	12.69 mm (221%)	38.08 mm (675%)

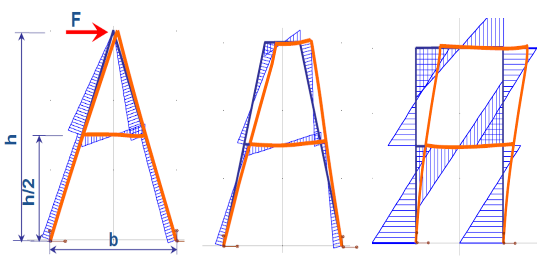

Fig. 5 Basic + horizontal middle support structure shapes

4.4 basic + diagonal support structure shape

As shown in Table. 6, for Case 1, the maximum bending moment was 37 kN, the maximum bending stress was 69 N/mm^2, and the maximum deformation was 5.59 mm; for Case 2, 187 kN, 345 N/mm^2, and 12.26 mm; and for Case 3, 308 kN, 581 N/mm^2, and 31.35 mm. When the maximum deformation of Case 1 in Table 3 (5.74 mm) was assumed to have been 100%, those of Case 1, Case 2, and Case 3 were 97%, 213%, and 541%, respectively. Table 6 shows the changes in the conditions of Cases 1, 2, and 3. Therefore the change in the results of Table 6 can be seen as shown of Fig 6.

Table 6 Analysis of basic + diagonal support structure shape

	Case 1	Case 2	Case 3
Max. Bending Moment	37 kN	183 kN	308 kN
Max. Bending Stress	69 N/m^2	345 N/m^2	308 N/m^2
Max. Deformation	5.59 mm (97%)	12.26 mm (213%)	31.35 mm (541%)

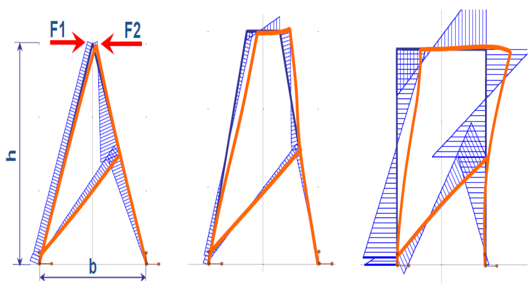

Fig. 6 Basic + diagonal support structure shapes

4.5 vertical + inclined support height structure shape

As shown in Table 7, for Case 1, the maximum bending moment was 1,000 kN, the maximum bending stress was 1,888 N/mm^2, and the maximum deformation was 162.5 mm; for Case 2, 750 kN, 1,416 N/mm^2, and 90.23 mm; for Case 3, 500 kN, 944 N/mm^2, and 47.61 mm; and for Case 4, 73 kN, 138 N/mm^2, and 20.45 mm. When the maximum deformation of Case 4, 20.45mm was assumed to have been 100%, those of Case 1, Case 2, and Case 3 were 795%, 441%, and 233%, respectively. Table 7 shows the changes in the conditions of Cases 1, 2, 3, and 4. Therefore the change in the results of Table 7 can be seen as shown of Fig 7.

Table 7 Analysis of vertical + inclined support height structure shape

	Case1	Case2	Case3	Case4
Max. Bending Moment	1,000 kN	750 kN	500 kN	73 kN
Max. Bending Stress	1,888 N/m^2	1,416 N/m^2	944 N/m^2	138 N/m^2
Max. Deformation	162.5 mm (795%)	90.23 mm (441%)	47.61 mm (233%)	20.45 mm (100%)

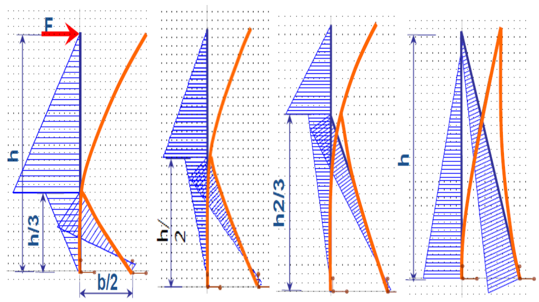

Fig. 7 Vertical+inclined support height structure shapes

4.6 vertical + inclined support base structure shape

As shown in Table 8, for Case 1, the maximum bending moment was 1,500 kN, the maximum bending stress was 2,832 N/mm^2, and the maximum deformation was 372 mm; for Case 2, 500 kN, 944 N/mm^2, and 79.71 mm; for Case 3, 500 kN, 944 N/mm^2, and 47.61 mm; and for Case 4, 891 kN, 1,684 N/mm^2, and 262.7 mm. When the maximum deformation of Case 2 (79.71 mm) was assumed to have been 100%, those of Case 1, Case 3, and Case 4 were 467%, 60%, and 329%, respectively. Table 8 shows the changes in the conditions of Cases 1, 2, 3, and 4. Therefore the change in the results of Table 8 can be seen as shown of Fig 8.

Table 8 Analysis of vertical + inclined support base structure shape

	Case1	Case2	Case3	Case4
Max. Bending Moment	1,500 kN	500 kN	500 kN	891 kN
Max. Bending Stress	2,832 N/m^2	944 N/m^2	944 N/m^2	1,684 N/m^2
Max. Deformation	372.75 mm (467%)	79.71 mm (100%)	47.61 mm (60%)	262.7 mm (329%)

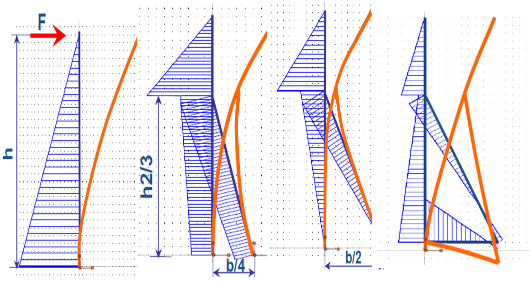

Fig. 8 Vertical+inclined support base structure shapes

4.7 vertical+inclined support structure shape

As shown in Table 9, for Case 1, the maximum bending moment was 500 kN, the maximum bending stress was 944 N/mm^2, and the maximum deformation was 47.61 mm; for Case 2, 500 kN, 944 N/mm^2, and 41.183 mm; and for Case 3, 500 kN, 944 N/mm^2, and 45.91 mm. When the maximum deformation of Case 1 (47.61 mm) was assumed to have been 100%, those of Case 2 and Case 3 were 86% and 96%, respectively. Table 9 shows the changes in the conditions of Cases 1, 2, and 3. Therefore the change in the results of Table 9 can be seen as shown of Fig 9.

Table 9 Analysis of vertical + inclined support structure shape

	Case 1	Case 2	Case 3
Max. Bending Moment	500 kN	500 kN	500 kN
Max. Bending Stress	944 N/m^2	944 N/m^2	944 N/m^2
Max. Deformation	47.61 mm (100%)	41.18 mm (86%)	45.91 mm (96%)

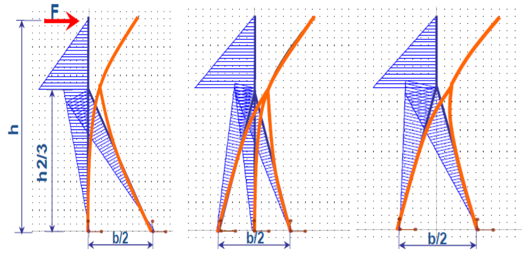

Fig. 9 Vertical + inclined support structure shapes

5. Conclusions

In this study, when a constant load was applied to outfitting equipment supports that are widely used in very large crude oil tankers, the structural characteristics of the shapes of the supports (i.e., the maximum bending moment, maximum bending stress, and maximum deformation) were examined and analyzed. As a result, the structural characteristics of the following seven typical types of support structure shapes were determined: the basic (triangular, trapezoidal, and quadrilateral) support shapes in Fig. 3 the basic (triangular, trapezoidal, and quadrilateral) + horizontal lower support structure shapes in Fig. 4 the basic (triangular, trapezoidal, and quadrilateral) + horizontal middle support structure shapes in Fig. 5 the basic (triangular, trapezoidal, and quadrilateral) + diagonal support structure shapes in Fig. 6 the vertical + inclined support height structure shapes in Fig. 7 the vertical + inclined support base structure shapes in Fig. 8 and the vertical + inclined support structure shapes in Fig. 9. The results of the experiment are as follows.

1) Among the seven types of shapes, the basic + horizontal middle support structure shapes in Fig. 5, which added a horizontal middle support to the basic (triangular, trapezoidal, and quadrilateral) support shapes in Fig. 3, and the vertical + inclined support base structure shapes in Fig. 8 showed the best performance.

2) In the case of a good support, the shape of the support determines the amount of the required material in terms of the production cost, and the work load and productivity in the manufacturing process should also be considered.

3) In the case of a good support, the shape of the support should be determined considering the structural characteristics (e.g., the strength and rigidity) in terms of mechanics.

4) In the case of a good support, the support should be designed to satisfy the required structural characteristics using the minimum amount of material and so that it can be easily manufactured in terms of the prime cost.

Acknowledgement

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by Ministry of Education, Science and Technology (NO. NRF-2011-0021376) and the Future Leading Project through the Small and Medium Business Administration (No.S2044441).

References

1. S. H. Choi, K. S. Kim, Y. Cho and B. G. Kim, in February 2002, "A Study on the Evaluation of Vibration Characteristics for Onboard Machinery with Resilient Mountings" Journal of the Society of Naval Architects of Korea Vol. 39, No. 1, pp.73-81
2. K. H. Lee, J. G. Bae and S. M. Lee, 2005, "Vibration Characteristics of Diesel Generator Set with Resilient Mount and Prevention of Vibration on the Design Stage" The Korean Society for Noise and Vibration Engineering (KSNVE) Spring Conference, pp.921-924
3. B. H. Kim, 2013, "Vibration Testing Requirements for Shipboard Equipments (ISO 10055:1996(E) & MIL-STD-167-1)" The Korean Society for Noise and Vibration Engineering (KSNVE) Spring Conference, pp.459-462
4. Y. H. Kim, K. H. Kim, T. M. Choi, and D. S. Cho, 2010, "Numerical Dynamic Stiffness Assessment of Ship Equipment Foundation with FEM"The Korean Society for Noise and Vibration Engineering (KSNVE) Anniversary of 2nd Period, Spring Conference, pp.212-213
5. Shipbuilding Technology (Making All Ships) Journal of the Society of Naval Architects of Korea, pp339-343,617-618
6. DSME Technology Standard DSE-D2H4087 Engine Room Pipe Support Design Standard, pp.4-10
7. DSME Technology Standard DSE-201006-038 Topside Pipe Support Design Standard (Flxed Platform, FPSO) pp.6-17
8. K. W. Jeong, 2013, "A Study of Structural Characteristic and Shape of Machinery Outfitting Support in Engine Room of the Very Large Crude Oil Tanker" The Korea Society for Power System Engineering, (KSPSE) Spring Conference, pp. 135-140