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STRUCTURAL STRESS EVALUATION AT CONNECTION AREA BETWEEN THE SUCTION ARM AND THE HULL FOR A TRAILING SUCTION HOPPER DREDGER

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ABSTRACT

The present paper presents the analysis of strees distribution over a dredge arm and its connection with the ship's hull during operation. The study aims to a better understanding of the hull loading since there are no empirical formulas to determine forces that appear in this connection area. The analysis was performed by means of finite element method using FEMAP

Keywords: *Trailing suction hopper dredger, dredge arm, forces on suction inlet, FEM*

1. INTRODUCTION

Strenght analysis based on the 3D finite elements method is a widely used methodology to determine displacement and stress distribution of the structural parts of the ship. The main concern while using FEM is to improve the hull shape and ship structure in terms of ship arrangement efficiency.

Trailing suction hopper dredger – TSHD (Fig.1.1) represents a new class of ships, being considered as part of special vessel type. This kind of dredger is the self-propelled version of suction dredger. Dredging is done hydraulically by "raking" the bottom and moving the draghead along with dragging. The draghead may or may not be provided with lashing or cutting devices depending on the nature of the soil. The dredged material is discharged into the hopper where the solid material is deposited and the excess water is discharged over board. Discharging the hopper is done either mechanically with buckets, etc., or hydraulically by injecting water into the hopper, creating spoils and pumping it to the shore, or gravitationally by opening the bottom gates.

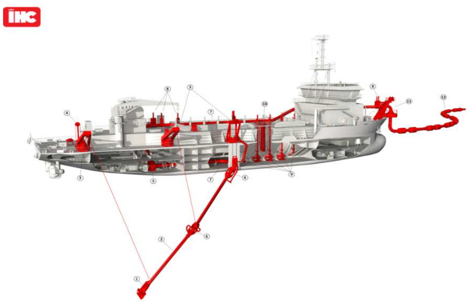


Fig.1.1 TSHD arrangement [1]

This analysis is performed in order to sudy the impact of dredging induced loads while ship advances in waves. Since there ar no empirical formulas provided by classification societies for this type of forces, only information from designer, an important further step would be a hydrodynamic numerical analysis.

2. SHIP HULL MODELING

The Trailig Suction Hopper Dredger (TSHD) is a self-propelled sea-going or inland waterway vessel with a hopper and a loading and unloading facility.

In Fig. 2.1 is given the lines plane of the TSHD vessel.

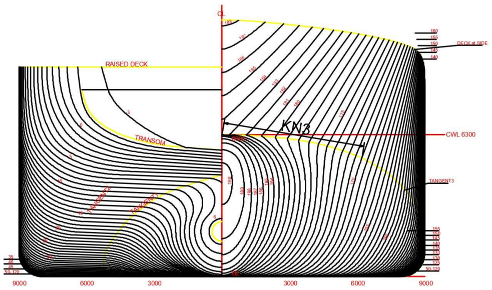


Fig.2.1 TSHD plane

The ship hull 3D model presented in Fig. 2.2, was generated by using Rhinoceros software with educational licence (Dunarea de Jos University of Galati).

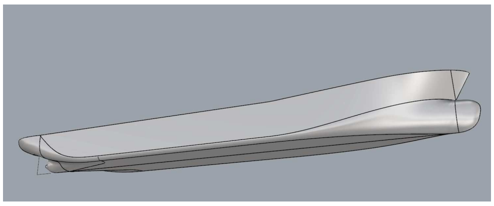


Fig.2.2 TSHD 3D hull model

In the standard version, such a dredger is equipped with the following dredging equipment: draghead, suction pipe, gantry, pumps, onboard dredge line, discharging system, floating dredge line, compensators of the ship's vertical motion with respect to the bottom of the sea to keep the draghead in contact with the bottom.

The dredging arm has (generally) the following components: sucction bend, complete with arms, sucction hose, intermediate pipe with arms, upper pipe section, universal joint, turning gland, lower pipe section, draghead, as can be seen in Fig.2.3.

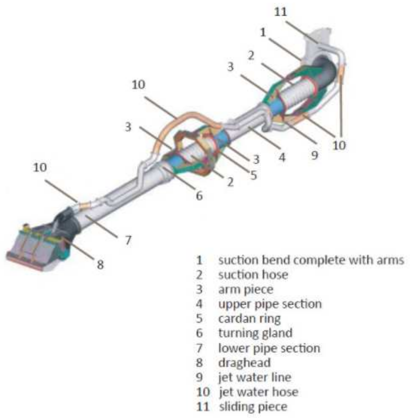


Fig.2.3 Dredging arm components [2]

Table 1 presents the main dimensions of the trailing suction hopper dredger.

Table 1. Main dimensions of the TSHD vessel.

Dimension	Symbol	Value
Length overall	LOA	116.8 m
Length between perpendiculars	LPP	110.0 m
Beam B	B	18.0 m
Depth D	D	8.3 m
Draft T	T	13.0 m
Hopper capacity	-	4000m^3
Maximum dredging depth	-	35 m^3
Suction pipe diameter	-	850 mm

3. NUMERICAL ANALYSIS USING FEM

The numerical analysis was performed using with FEMAP v11.2 with license.

The analized 3D model extends over a distance of 16 frames from the frame 104 to frame 120, representing the midship area of the TSHD vessel, with special attention on the connection area between the suction arm and the ship hull.

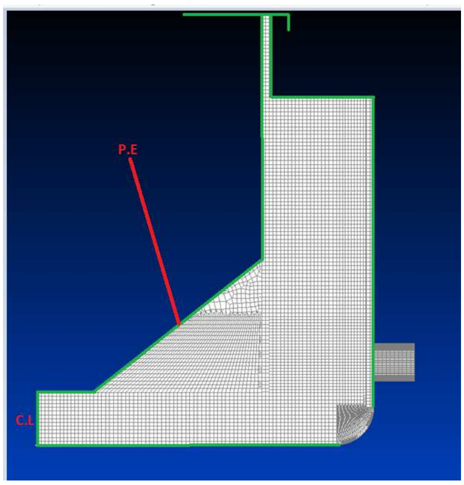
There were considered two dredging cases. The first one was for a dredging depth of 25 meters with a pipe angle of 25 degrees and second case respectively, for a dredging depth of 35 meters at a pipe angle of 45 degrees. The second case represents also the maximum dredging case of the considered TSHD vessel.

The TSHD structure is made of standard steel grade type A, having yield stress R_{eH}=235 (σ_{adm}=175 N/mm^2, τ_{adm}=110 N/mm^2). The considered material characteristics are mass density 7,86x10^{-6}, Young's Modulus 206000 and Poisson's ratio 0,3. The 3D-FEM model was developed usig quad PLATE elements [3]. The area around dredging pump has a discretization with an element size of 50 x 50 milimeters.

As boundary condition, due to the fact that the 3D-FEM model induced loads were considerd from quasi-static equivalent waves, the model has symmetry boundary conditions with respect to the ship's center line (CL) and for the aft and fore part of the model, the master-slave constraints were considered. Thus, the 3D-FEM model will be extended from the coupling area of the dredging arm with 3 frames both in the aft and in the bow directions.

In Fig.3.1. are given the boundary conditions applied for CL (*center line*), respectively PE1, PE2, (*watertight bulkheads*).

The considered loads applied to the analized structure were the dredging induced ones. The values of the applied forces were given by the designer since there are no empirical formulas given by classification societies.



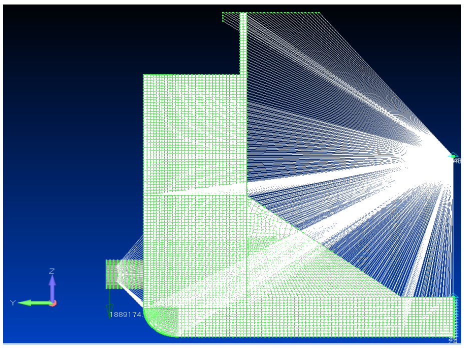


Fig. 3.1 Boundary conditions

The model was analyzed for two dredging cases by considering equivalent forces on X, respectively Y directions, with the values given by designer, presented in Table 2.

Table 2. Forces on suction inlet – IHC [1]

Sucction pipe angle 25^o	Sucction pipe angle 45^o
A = 506 kn - pull. force	A = 936 kn - pull. force
B= 1543 kn - pull. force	B = 1641 kn - pull. force
C = 2049 kn - press. force	C= 2577 kn - press. force

Though, a more expensive method to have accurate information on the induced loads while dredging operation at a certained ship speed consists in measuring the instantaneous value of specific parameters.

To determine the stress distribution of the sliding components area, these components were considered as a rigid (Fig.3.2). So, the force was applied to the rigid master node, the rigid being RB2 type. This type was chosen because the forces are equally applied to all the nodes of the elements describeing the sliding zone of the dredging pipe.

The numerical results obtained for the two dredging cases are given in Fig. 3.2-3.3.

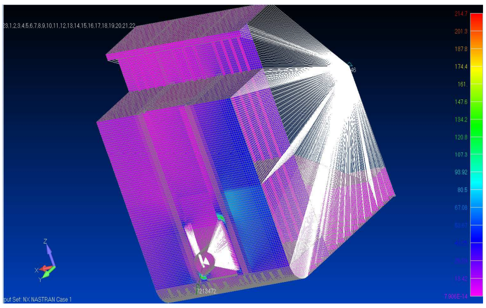


Fig.3.2 Stress distribution, $\beta=25^{o}$

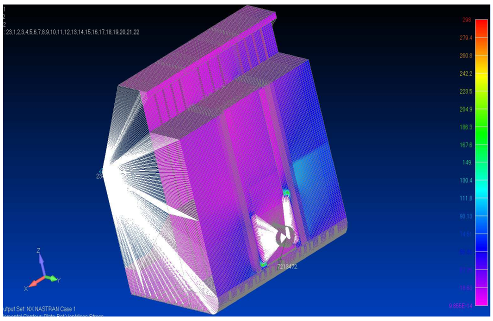


Fig.3.3 Stress distribution, $\beta=45^{o}$

4. CONCLUSIONS

The analyzed structural model is described by of a number of 75823 nodes and 77381 elements.

The main object of this study was to determine the stress distribution in the coupling zone of the sucction pipe with the ship's hull.

The structural analysis was performed by using the finite element method with FEMap 11.2 program. The boundary conditions applied are specific to this type of analysis.

The results revealed the VonMisses stress distribution, with maximum values of 241.7 MPa for the average dredging case (25 °) and 298 MPa for the maximum dredging (45 °). The displacements for the first case are 1.597 [mm] and 2.22 [mm] for the maximum dredging case.

Further studies are to be extended in terms of a hydrodymic numerical computation, in order to obtain the hydrodynamic loads over the ship'hull in operation.

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