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Simulation of the Cargo Tank Cleaning Plant for an Oil Tanker

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Abstract: *In order to achieve the modeling of the sea water system through the freight tanks installation, the Ansys-Fluent v.14.5 programme was used. The help of the Design Modeler option offered by Ansys Fluent program has been performed by the geometry of a sealer from the tanning-washing plant. The discretization was initiated by the help of the "Mesh" interface of the Ansys Fluent program resulted 2586712 Cells and 886324 knots. It was followed: a) Determination of the parameters and boundary conditions; b) view results: local pressure and speed variations on certain seers, and on the entire installation. The results obtained from the simulation were: the static pressure max 3.9 · 108 Pa; dynamic max pressure 2.28 · 109 Pa; total pressure max 1.99 · 109 Pa. The ANSYS simulation program has been used to provide the best value of the parameters variation for the tank washing installation investigation.*

Keywords: *Simulation, flow, plant, cargo, tank, oil, pressure, parameter*

1. Introduction

Taking into account the large volume of oil transported worldwide and the variety of petroleum products, oil vessels must perform the following basic functions: a) the cargo space to ensure the required load capacity transport in economic conditions of crude oil and petroleum products with specific weight ranging from 0.7 g/cm^3 to 0.96 g/cm^3; b) to have a flexibility corresponding to the diversity of the products transported, that is, to be able to carry at least two freight sorts at the same time; c) the cargo-tanks are sealed between them and between the groups forming the sections, to avoid contamination of the freight transported simultaneously; d) cargo tanks have sufficient surplus space to ensure product expansion, when passing through high temperature areas; e) at the maximum transport capacity and at different loading states, ensure that a proper trim and proper weight distribution are maintained in order to avoid overstressing the vessel's body; f) the piping system allows for the easiest distribution of the different products, on the sections, both in loading and unloading.

2. Material and methods

The reference vessel is an oil/chemical tanker with a capacity of 40400 Tdw and double bridge (Figure 1, Figure 2) [1].

Fig. 1. Oil vessel-Histria Gemma [1]

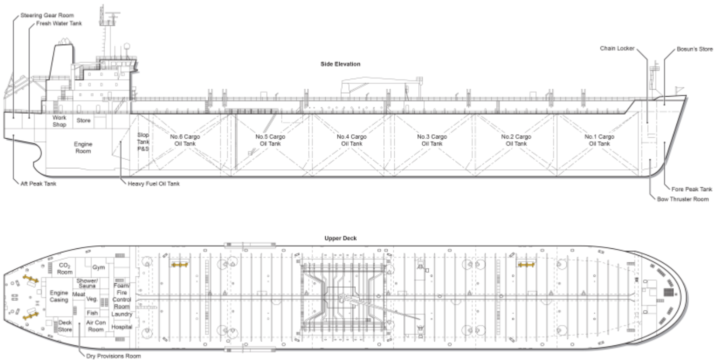

Fig. 2. Histria Gemma- Graphical representation of the ship [1]

2.1 Deadweight and capacities

 Gross tonnage: 25864;

 Net tonnage: 11369;

 Cargo Tanks: 10 tanks with a total volume of 47803 m^3.

 Tank filling is carried out by 10 pumps with total flow of 500 m^3/hour.

 The weight of the empty vessel shall comprise:

- Weight of body, machinery and electrical equipment; Inventory
- Spare parts.

The Deadweight will include:

- Heavy fuel, diesel, oil, water technique in systems and piping, drinking water in tanks;
- Freight
- Ballast
- Spare parts; Other than those required by the rules;
- Crew with luggage;
- Food.

2.2 The main dimensions of the vessel

 Maximum length L max = 179.96 m ;

 Length between perpendiculars LPP = 172 m ;

 Width B = 32.20 m ;

 Draught at the summer load line d = 11.00 m ;

 Construction Height D = 16.79 m ;

 Dead Weight DWT = 40400 TDW ;

 Speed: 18 knots.

2.3 The characteristics of the vessel body

 Builder: Constanţa, Romania ;

 Material: Steel ;

 Joint: Welding .

2.4 The transport features

- Transport capacity: 47803 m^3 ;
- Tank No.: 10 + 1 Slop ;
- Charging installation: 10 Framo SD-300 pumps of 500 m^3 (freight tanks) and 2 Framo SD-100 pumps of 200 m^3 (slop tank).

2.5. Main propulsion engine characteristics (Figure 3)[2]

- Builder: MAN B & W ;
- Type: 6S50MC-C Mk7 ;
- Operating principle: diesel-reversible – 2 strokes ;
- Power (MCR): 9480 KW at 127 rpm ;
- Power (NCR): 8044 KW at 120.3 rpm ;
- Cylinders: 6 L ;
- Transmission: Direct ;
- Cylinder Diameter: 500 mm ;
- Piston Race: 2000 mm ;
- Actual consumption: 126 g/CPH.

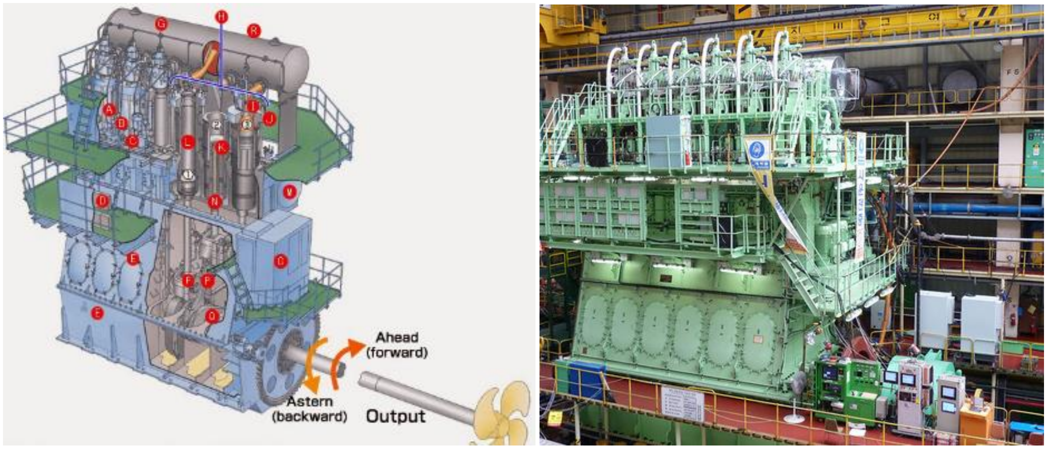

Fig. 3. Main propulsion engine [2]

2.6. Diesel characteristics of main generators

- Diesel Generators: 3 pcs (Figure 4) [3] ;
- Builder: Hyundai Himsen ;
- Type: 6h21/32 ;
- Diesel engine power: 960 kW ;
- Speed: 900 rpm ;
- Cylinders: 6L ;
- Cylinder Diameter: 210 mm ;
- Piston Race: 320 mm ;
- Engine power: 787 kW ;
- Generator Type: Himsen, HFC7 ;

 Power generator: 925 KVA ;

 Voltage generator: 450 V ;

 Intensity generator: 1186.8 A ;

 Generator frequency: 60 Hz.

Fig. 4. Diesel main generator [2]

3. Description of the structure of the fuel tank cleaning plant

The ship is equipped with 10 cargo tanks (5 on the starboard board and 5 on the port board), and 1 slop tank. In the tank washer plant, ballast pumps, fire pumps and slop tank pumps are used (Table 1).

Table 1: Cargo and Slop tank capacity

CARGO OIL AND SLOPS TANKS							
Compartment	Location Frame	Volume 100% m^3	98% m^3	98% (Barrel US)	VCG From BL m	LCG from Midship m	Max. Moment of Inertia m^4
No.1 Cargo Tank (P)	162 - 187	3,069.8	3,008.4	18,922.3	9.853	66.15	1,971
No.1 Cargo Tank (S)	162 - 187	3,069.8	3,008.4	18,922.3	9.853	66.15	1,971
No.2 Cargo Tank (P)	138 - 163	3,666.3	3,593.0	22,599.3	9.678	44.97	2,877
No.2 Cargo Tank (S)	138 - 163	3,666.3	3,593.0	22,599.3	9.678	44.97	2,877
No.3 Cargo Tank (P)	114 - 139	3,670.8	3,597.4	22,627.0	9.677	23.18	2,881
No.3 Cargo Tank (S)	114 - 139	3,670.8	3,597.4	22,627.0	9.677	23.18	2,881
No.4 Cargo Tank (P)	90 - 115	3,670.8	3,597.4	22,627.0	9.678	1.31	2,884
No.4 Cargo Tank (S)	90 - 115	3,670.8	3,597.4	22,627.0	9.678	1.31	2,884
No.5 Cargo Tank (P)	66 - 91	3,670.8	3,597.4	22,627.0	9.677	-20.50	2,881
No.5 Cargo Tank (S)	66 - 91	3,670.8	3,597.4	22,627.0	9.677	-20.50	2,881

3.1. Pumps used in the tank cleaning plant

Ballast Pump (2 pcs)-flow rate 750 m^3/ h, 242 l/min; Height of discharge-25 m; pressure-193 bar. Slop pump (2 pcs)-flow rate 150 m^3/ h, 173 l/min; Height of discharge-120 m; pressure-200 bar (Figure 5) [3].
Salt water Pump (3 pcs)- flow rate 380 m^3/ h, 173 l/min.

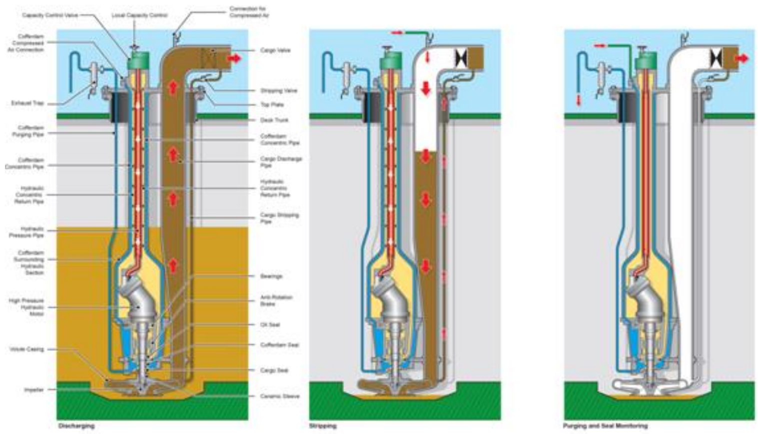

Fig. 5. Slop pumps [3]

3.2. Description of the calculation route

The buses of the ballast water tubing, sea water from the fire plant and the piping of the slop pump are connected to the cargo tanks washing buses. The circulation of water is carried out through a wide variety of pipelines. Also, depending on the pressure is chosen the pipe type, respectively the material. Due to the high corrosivity of seawater, the pipes are made of galvanised steel (Table 2).

Table 2: Diameters nominal piping installation of cargo tanks

Mainline	Nominal diameter
Salt water, freshwater and crude oil wash line	200 mm ; length 120 m
Salt water, freshwater and crude oil wash line	250 mm ; length 70 m
Salt water, freshwater and crude oil wash line	300 mm ; length 130 m
Salt water, freshwater and crude oil wash line	350 mm ; length 30 m

For hydraulic calculation We will consider as seawater washing agent. The analysis of the flow of seawater is intended, the determination of variable pressures, to understand the dimensioning of the pipes and the correct choice of water flow. Establishing the components of the plant and calculating the linear and local load losses, i.e. pressure losses, we can determine the total losses, but also carry out a study on fluid flow through the installation. Developing the calculation for each sector of the cooling plant, depending on the speed of the water resulted the following values, presented to the Table 3.

Table 3: Local load and pressure losses

Speed Flow	Reinforcement	Number of Fittings	Coefficient of friction	Local load loss	Local pressure loss
[m/s]				[m]	105 [Pa]
			ξ	$h_{f\,loc} = \xi \frac{v^2}{2g}$	$\Delta_p = h_{f\,l,oc} * \rho * g$
6,62	Elbows at 90°	4	1.3	5.81	57826.30
	Filter with Sieve	2	1.10	4.91	48929.94
	T-Connections	2	1.20	5.36	53378.12

	Coolers	2	1.40	6.25	62274.47
	One-way throttle valves	2	1.80	8.04	80067.18
	Reduction	2	1.90	8.49	84515.36
4,24	Elbows at 90°	5	1.30	5.96	59303.61
	Filter with Sieve	2	1.10	2.02	20071.99
	T-Connections	6	1.20	6.60	65690.15
	Coolers	3	1.40	3.85	38319.25
	One-way throttle valves	4	1.80	6.60	65690.15
	Reduction	4	1.90	6.96	69339.60
2,94	Elbows at 90°	2	1.30	1.15	11405.23
	Filter with Sieve	4	1.10	1.94	19301.16
	T-Connections	4	1.20	2.11	21055.81
	Coolers	4	1.40	2.47	24565.11
	One-way throttle valves	4	1.80	3.17	31583.71
	Reduction	4	1.90	3.35	33338.37
2,16	Elbows at 90°	5	1.30	1.55	15390.65
	Filter with Sieve	4	1.10	1.05	10418.28
	T-Connections	8	1.20	2.28	22730.80
	Coolers	8	1.40	2.66	26519.27
	One-way throttle valves	4	1.80	1.71	17048.10
	Reduction	8	1.90	3.61	35990.44
TOTAL				97.89	974753.06

4. Simulation of the cargo tank cleaning plant

The ANSYS simulation program has been used to provide the best value of the parameters variation for the tank washing installation investigation [4].

4.1. Realization of the installation plan

The help of the Design Modeler option offered by Ansys Fluent program has been performed by the geometry of a sealer from the tanning-washing plant (Figure 6).

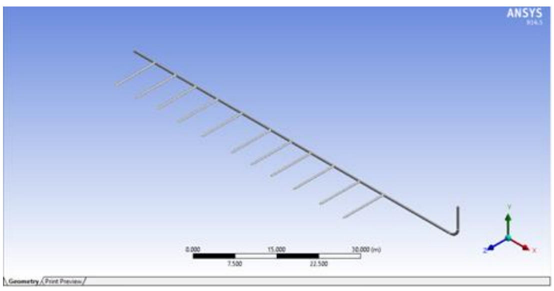

Fig. 6. Tank Washing Plant Plan

The cut-off from the diameter of 250 mm to 200 mm was made using a truncated cone, with the bases of diameters for two dimensions of tubing (Figure 7, Figure 8).

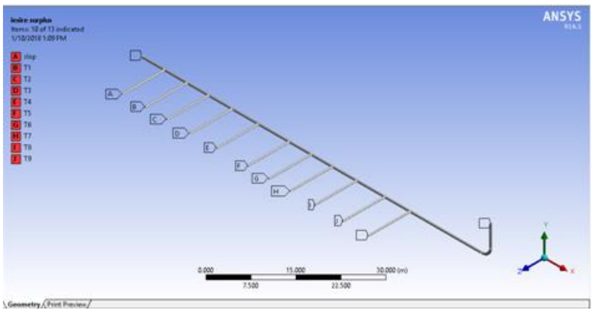

Fig. 7. Installation inputs and outputs

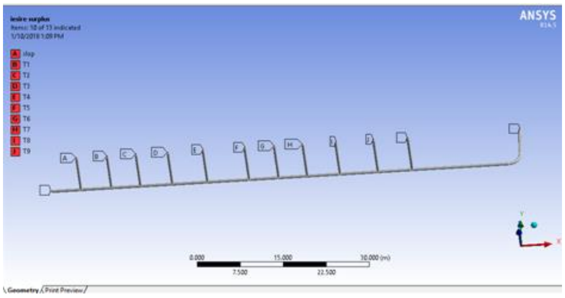

Fig. 8. Cargo tank cleaning plant

The elbow 90° was assembled by combining two perpendicular cylinders one against the other and the laying of a sphere in the jointing of the joint.
In order to achieve ramification in the "T", it was necessary to introduce a cylinder on the "X" axis, which has been intersected with the previous one (Figure 9).

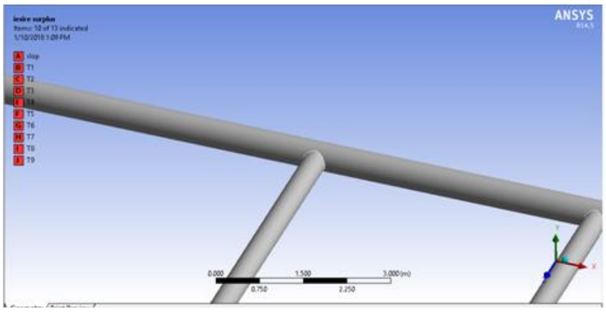

Fig. 9. T -connections

4.2. The discretization of the domain

The discretization of domain was initiated by the help of the "Mesh" interface of the Ansys Fluent. Following the structural analysis 2586712 Cells and 886324 knots resulted (Figure 10).

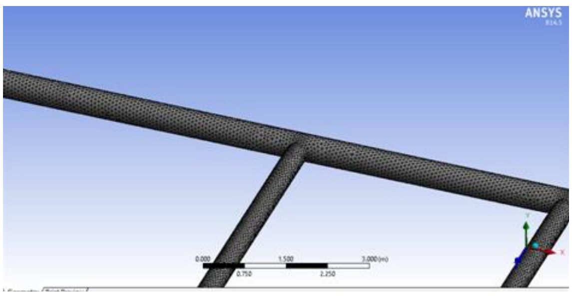

Fig. 10. The discretization of the plant’s domain

4.3. Determination of the parameters and boundary conditions

In the first stage, the input and output bags of the fluid were established. Thus, 1 entry and 11 exits were noted (Figure 11).

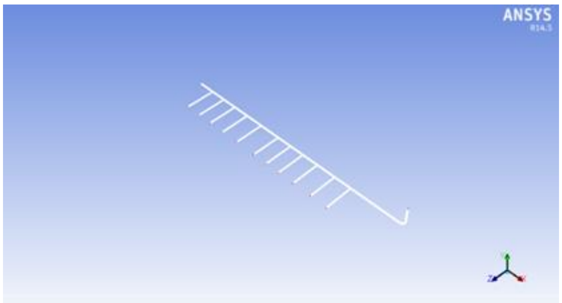

Fig. 11. Running simulation

4.4. Results and interpretations

As a result of the use of ANSYS Fluent numeric programme there are presented the local pressure and speed variations on certain spheres, as well as the entire installation (Figure 12, Figure 13, Figure 14, Figure 15, Figure 16).

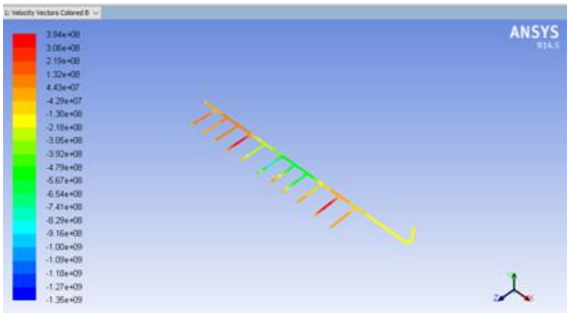

Fig. 12. Static pressure [Pa]

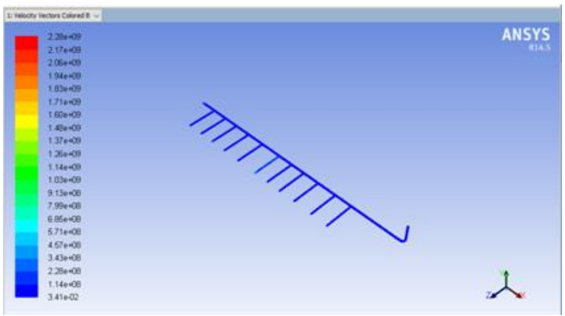

Fig. 13. Dynamic pressure [Pa]

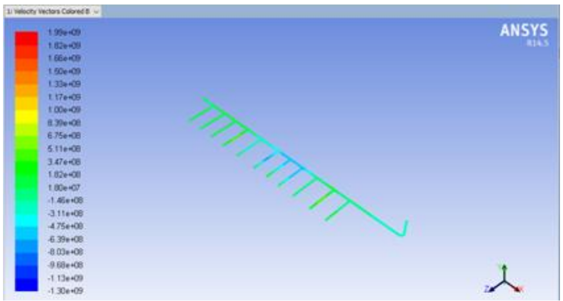

Fig. 14. Total pressure [Pa]

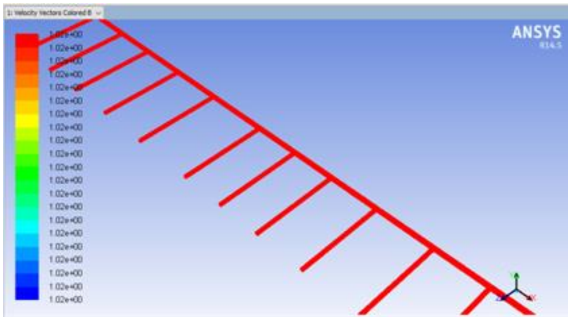

Fig. 15. Velocity vectors coloured by Density [kg.m^3]

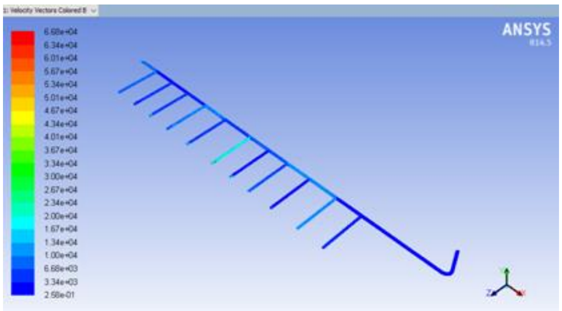

Fig. 16. Velocity vectors coloured by Velocity magnitude [m/s]

5. Conclusions

The results obtained from the simulation were:

- The static pressure maximum 3.9 · 108 Pa;

- Dynamic pressure maximum 2.28 · 109 Pa;

-Total pressure maximum 1.99 · 109 Pa.

The Ansys Fluent module v. 14.5, which has been taken to resolve the proposed theme, consists of 6 individual programs that help us to solve the problem of water collection. The programs are interconnected.

Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

In order to achieve the modeling of the sea water system through the washing facility, the Ansys-Fluent part is applied to the study of liquids, as this program offers a wide range of solutions for the simulation, engineering sets with access to almost the field of engineering simulation. For this simulation a design calculation process was required beforehand.

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