ANALYSIS OF THE NO. 6 METAL TANK IN PARK NO. 1 INDEPENDENȚA OF S.C. O.M.V. PETROM S.A. BY FINITE ELEMENT METHOD

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Abstract: In the month of February this year, in Park No. 1 Independența, situated in Schela village, Galați County, belonging to S.C. O.M.V. Petrom S.A., No. 6 metal tank for oil, of 117 m^3 capacity, was damaged. As a result of the damage, approximately 500 *l* remnant oil was spilled. The damage lied in the tank being turned over, its bottom fell out, the heating radiator and the related pipes were damaged. The damage was considered to have been caused by extreme climatic conditions of the period, or due to other factors. In order to be able to establish what caused the damage, a verification calculation of the strain on the tank had to be made, under the influence of wind, mechanical test on the samples taken from the tank material, as well as an analysis by finite element method.

The paper presents the tank analysis by finite element method.

Keywords: analysis, metal tank, finite element

1. INTRODUCTION

The analysis with finite element was made to determine the mechanical tensions in the body of the tank, under the effect of wind in the following cases: 5 mm plate tank, 2 mm plate tank, to determine mechanical tensions in the 5 mm tank body, in case of dynamic stress.

2. ANALYSIS BY FINITE ELEMENT METHOD

The metal structure was modeled in three-dimensional system according to

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figure 1.

The structure was made discreet with 5 mm width Shell 6 type plane elements, having 2473 elements with 1220 points, figure 2.

As restrictions, the bottom of the tank was applied to the earth, figure 3.

Fig. 1. Steel structure was modeled in three-dimensional system

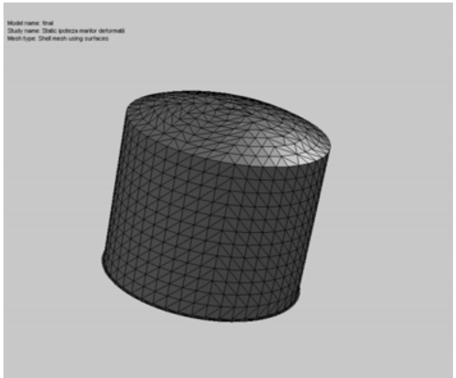

Fig. 2. The structure was discretized

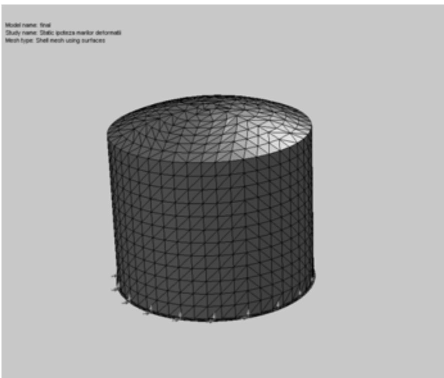

Fig. 3. Seating the tank bottom

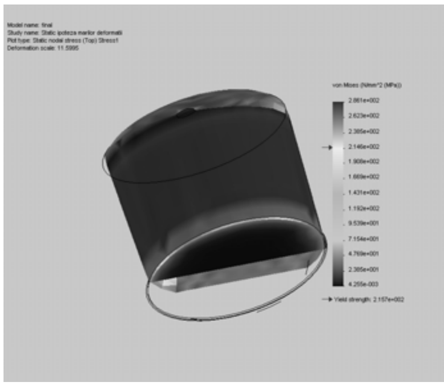

Fig. 4. Mechanical tensions

3. CALCULATION HYPOTHESES

An evenly distributed 0,6 bar load was applied on the inside walls of the tank. The load coming from the pressure produced by the explosion from inside the tank, 1,6 bar, out of which the atmospheric pressure of 1 bar is extracted from the exterior of the tank. With this value, a static calculation was made, in the hypothesis of great deformations with material linearity and a maximum tension of σ_{VM} = 286.1 MPa resulted, according to Von Mises resistance theory, figure 4.

The most strained areas were where the cylindrical part joined the bottom and of the tank, and the sphere, respectively, figure 5. In this case the flow limit, σ_{02} = 220 MPa, was greatly exceeded.

The maximum deformation occurs at the double bottom, subsequently attached, and is 50.87 mm, in the geometric center, Figure 6.

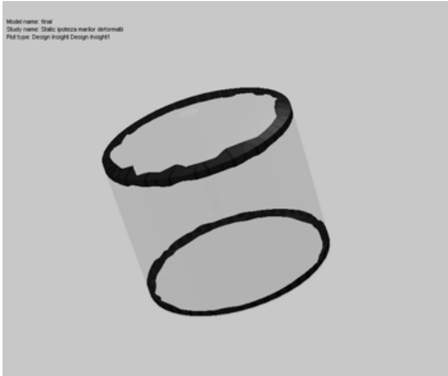

Fig. 5. Areas most requested

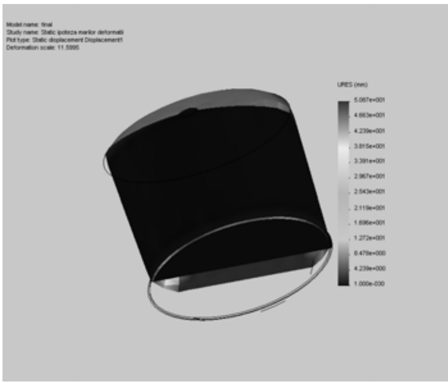

Fig. 6. Maximum deformation

From the analysis of the own frequency of the empty tank, only the first 15 frequencies of resonance were taken into consideration. These are shown in Table 1.

Table 1. **The first 15 frequencies of resonance of the empty tank**

Mode No.	Frequency (Radians/Seconds)	Frequency (Hertz)	Period (Seconds)
1	9.3314	1.4851	0.67334
2	19.365	3.082	0.32447
3	19.37	3.0829	0.32438
4	31.774	5.0569	0.19775
5	31.784	5.0585	0.19769
6	36.279	5.774	0.17319
7	46.433	7.39	0.13532
8	46.499	7.4006	0.13512
9	55.272	8.7969	0.11368
10	55.333	8.8065	0.11355
11	63.305	10.075	0.099253
12	63.424	10.094	0.099066
13	76.864	12.233	0.081744
14	76.908	12.24	0.081697
15	81.105	12.908	0.07747

4. MODAL ANALYSIS IN CASE OF DYNAMIC LOAD

An evenly distributed load of 0,6 bar was applied on the inside wall of eh tank, the width of which was considered to be 5 m. The load coming from the pressure produced by the dynamic strain from the inside of the tank, 1,6 bar, of which the atmospheric pressure of 1 bar from the outside of the tank is extracted. Time of load application $T = 1$ ms. Thus the modal analysis calculus was made, in the hypothesis of great deformations, considering the steel in linear field, taking to calculation the 15 own frequencies a maximum tension resulted, according to Von Mises theory of resistance, $\sigma_{VM} = 435$ MPa, figure 7.

The most strained areas are where the cylindrical part joins the bottom of the tank, figure 8. In this case, the limit of rupture was exceeded by far, $\sigma_r = 400$ MPa.

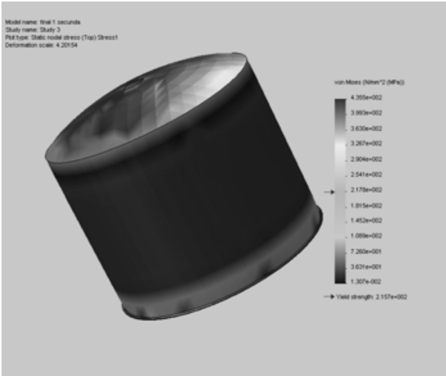

Fig. 7. Maximum mechanical tension after Von Mises stress theory

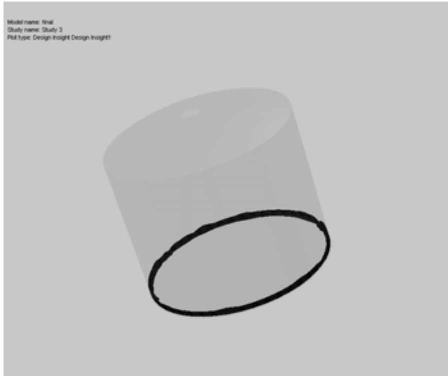

Fig. 8. Most requested areas

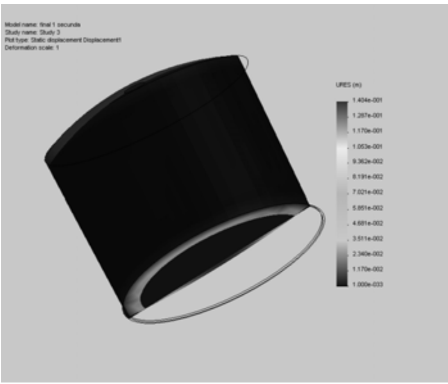

Fig. 9. Maximum deflection

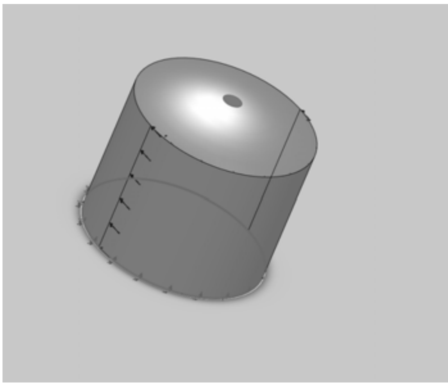

Fig. 10. Request wind

Maximum deformation occurs at double bottom, attached subsequently, and its value is 140 mm, in geometric center, figure 9.

5. THE STATIC ANALYSIS OF THE TANK ACTUATED BY WIND PRESSURE

5.1. 5 mm wall tank

The structure was made discreet with Shell type plane elements, with 2473 element of 1220 points. The width of the tank wall was established at 5 mm, the value also found in the sample receive from the beneficiary, figure 2. The wind strain, 32 m/s, was considered as a pressure distributed on half of the cylinder, P = 651 Pa.

As restrictions, the tank bottom was seated on earth, figure 3. With this value a static calculus was made, in the hypothesis of small deformations with material linearity, and a maximum tension resulted, according to Von Mises resistance theory, σ_{VM} = 1,4 MPa, figure 11.

The most strained areas are where the cylindrical part joins the tank bottom, figure 12. In this case the maximum tension is under the flow limit by far, σ_{02} = 220 MPa.

The maximum deformation occurs at the middle of the tank, and its value is 0,0819 mm, Fig. 13.

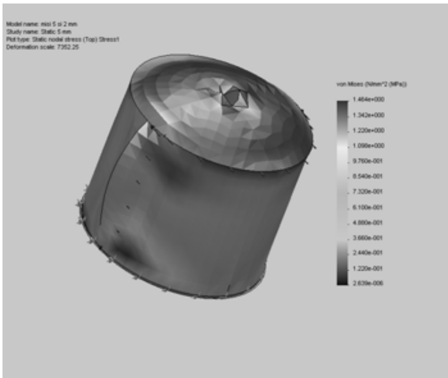

Fig. 11. Maximum mechanical tension after Von Mises stress theory

Fig. 12. Most requested areas

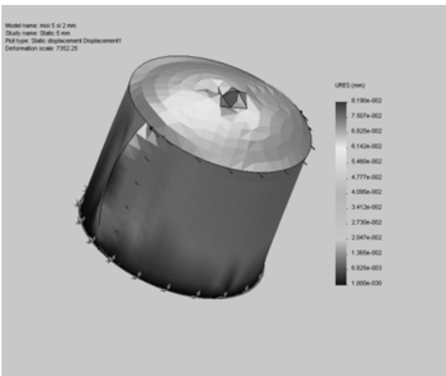

Fig. 13. Maximum deformation occurs in the middle of the tank

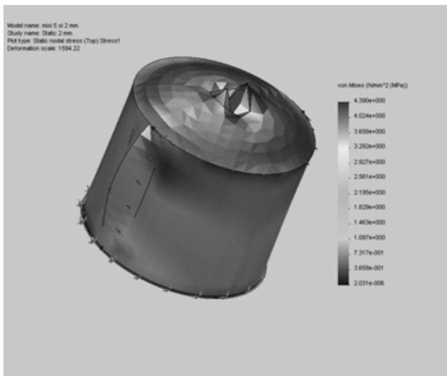

Fig. 14. Maximum stress after Von Mises stress theory

5.2. 2 mm wall tank

The discretion and loading conditions are identical with 5.1. The width of the tank wall was established at 2mm. With these values, static calculation was made, with small deformation hypothesis, with material linearity and a maximum tension resulted, according to Von Mises resistance theory, σ_{VM} = 4,39 MPa, figure 14.

The most strained parts are where the cylindrical part joins the tank bottom, figure 15. In this case, the maximum strain is under the flow limit, σ_{02} = 220 MPa, by far.

Maximum deformation occurs at the middle of the tank and its value is 0,377 mm, figure 16.

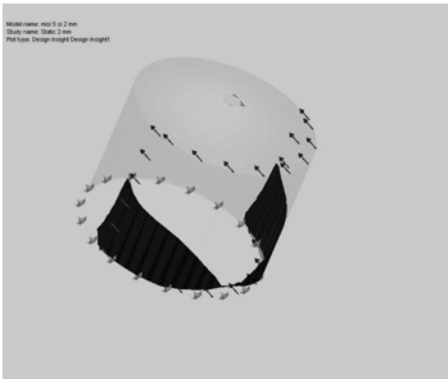

Fig. 15. Most requested areas

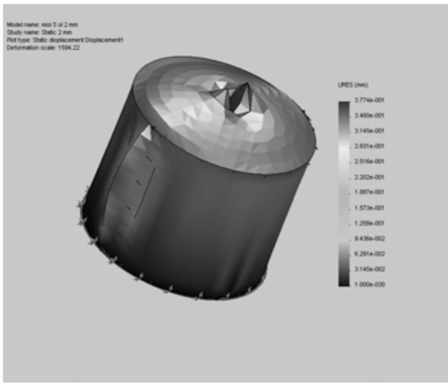

Fig. 16. Maximum deformation

6. CONCLUSIONS

Finite element analysis. As a result of calculations made regarding the strain on the tank, with 5 mm wall, under a 1,6 bar pressure application, that is a 0,6 bar overpressure, the following resulted:

- In static regime, σ_{VM} = 286.1 MPa maximum tension resulted, according to Von Mises resistance theory. In this case the flow limit, σ_{02} = 220 MPa, was exceeded by far.
- In dynamic regime, considering the increase of overpressure in 1 second, a maximum tension resulted of σ_{VM} = 435 MPa, according to Von Mises resistance theory, in this case the rupture limit, σ_r = 400 MPa, was exceeded by far. The maximum tension occurs where the bottom joins the tank wall.

REFERENCES

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[3] ***, *Cosmos DesignStar Software v.4,* License S.C. INICAD DESIGN S.R.L: Bucureşti.