# EVALUATION OF STRESSES IN THE AIR CONDITIONING TOWER IN CEMENT INDUSTRY

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**Abstract.** The paper presents the simulation of air conditioning tower loading in order to determinate the stresses. The 3D model of air conditioning tower was done using Autodesk Inventor. The stresses were obtained using Ansys and Design Star software. The reason of this calculus was to propose a reconditioning/replacement solution for the air conditioning tower. In the final there are presented the upgrading measures.

**Keywords:** FEA, stress, simulation

## 1. Introduction

This paper is the second part of the study concerning the air conditioning tower used in cement industry presented in [1].

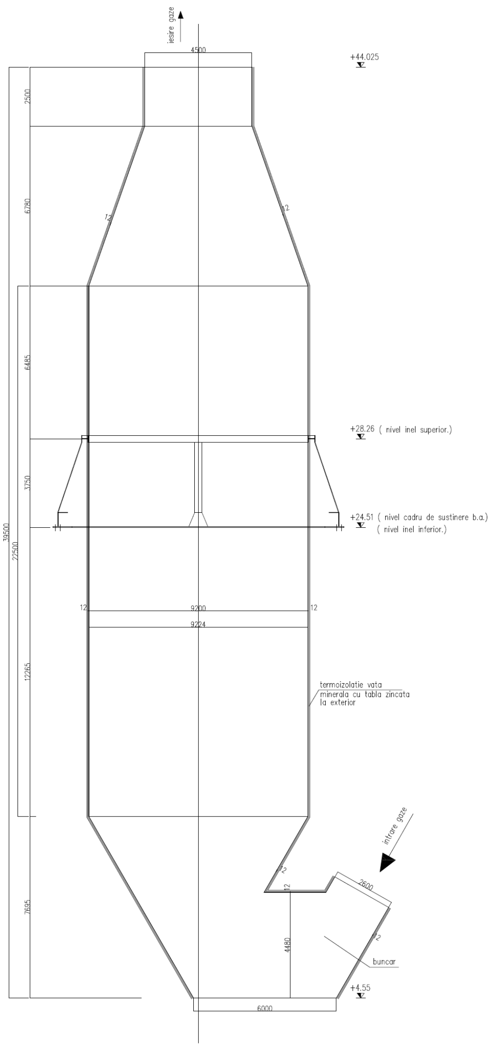


Figure 1. The drawing of the air conditioning tower

This study refers to a tower built 30 years ago, using the heat resistant steel OLK4 STAS 2883-62. The chemical composition of the OLK4 steel is presented in table 1 [1].

Table 1. The chemical composition of OLK4 steel

| Steel | C | Mn | Si | P | S | Cr |
|---|---|---|---|---|---|---|
| OLK4 | 0.12…0.20 | 0.45…0.70 | 0.15…0.35 | 0.045 | 0.045 | max. 0.30 |

The mechanical properties of the OLK4 steel are presented in table 2.

Table 2. The mechanical properties of OLK4 steel

| Steel | Rm [N/mm$^2$] | $Rp_{0.2}$ [N/mm$^2$] | A [%] | KCU [J] |
|---|---|---|---|---|
| OLK4 | 410…500 | 240…260 | 22 | 70 |

The AutoCAD drawing of the air conditioning tower is presented in figure 1. The total length is 39500 mm, the maximum inner diameter is 9200 mm and the original thickness of the wall was 12 mm.

Due to intense functioning in hot polluted gases, the wall suffered an intense corrosion and erosion [2, 3], the inner surface was covered by cement dust and there are severe distortions of the cylindrical surface between the fixation rings and above them (figure 2).

After the removing of the outer insulation layer and mechanical cleaning of the inner surface, the measured thickness was 1.4…11 mm, meaning an 8.3…88.3% thinning of the wall.

The reason of this study is to establish the possibility to use the air conditioning tower and the strengthening measures.

Figure 2. The damaged wall of the air conditioning tower between the fixation rings and above them

## 2. Tower modelling

The tower was 3D modelled using Autodesk Inventor software. The current dimensions after the wall thickness measuring were considered. The 3D model of the air conditioning tower is presented in figure 3.

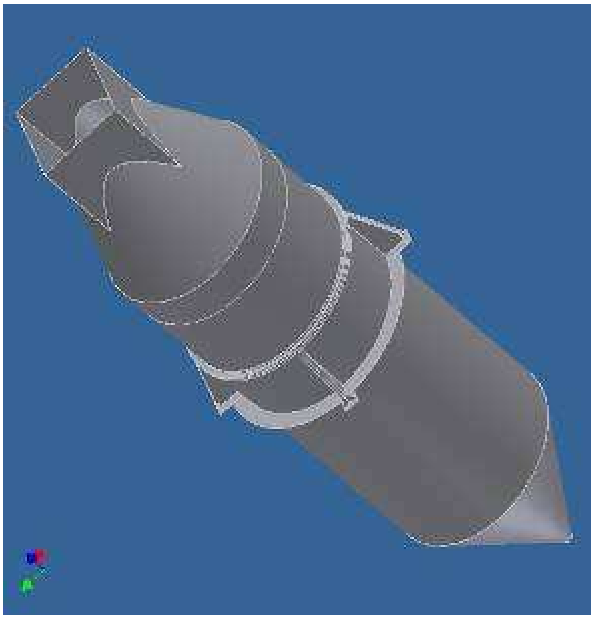

Figure 3. The 3D model of the air conditioning tower

Because the gas suction region and gas exhaust part are not relevant for the calculus, they are removed from the model. The support framework creates the fixation of the tower at 19960 mm altitude (figure 4).

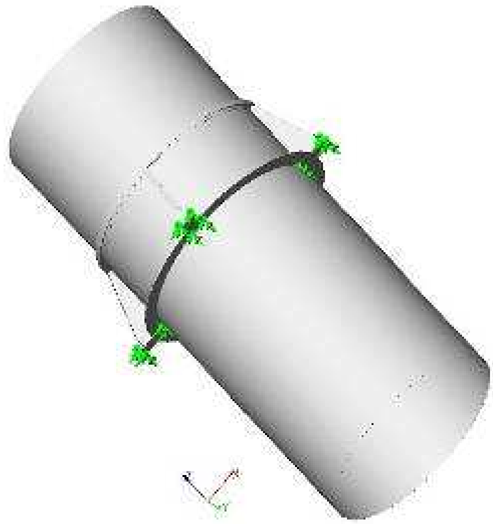

Figure 4. The simplified 3D model of the air conditioning tower with boundary conditions

## 3. Evaluation of stresses

In order to calculate the stresses in the air conditioning tower, the finite element method is applied [4, 5], using Ansys and Design Star software.

Five loading situations are analyzed, considering different loadings, forces and/or temperatures, on the air conditioning tower.

In the first case, the loading with p=4.006 $N/mm^2$ pressure on the lower ring and gravity is considered. The cement dust layer deposited on the inner surface of the tower causes this pressure.

The results obtained using Ansys software [6] are presented in figure 5. Maximum von Mises stress is 40.91 $N/mm^2$.

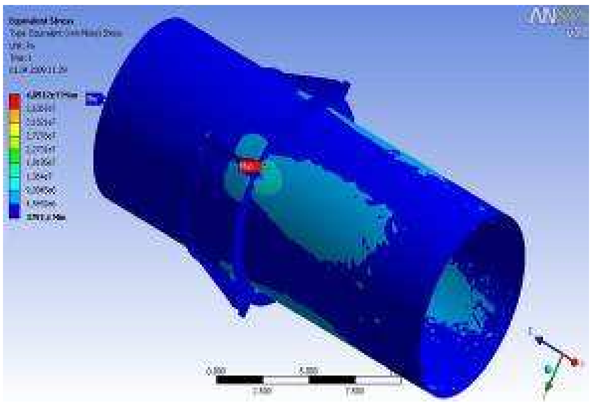

Figure 5. Von Mises stresses in the air conditioning tower, first loading case using Ansys software

For the same loading case, using Design Star software [7], the stresses obtained are presented in figure 6. Maximum von Mises stress is 35.17 $N/mm^2$.

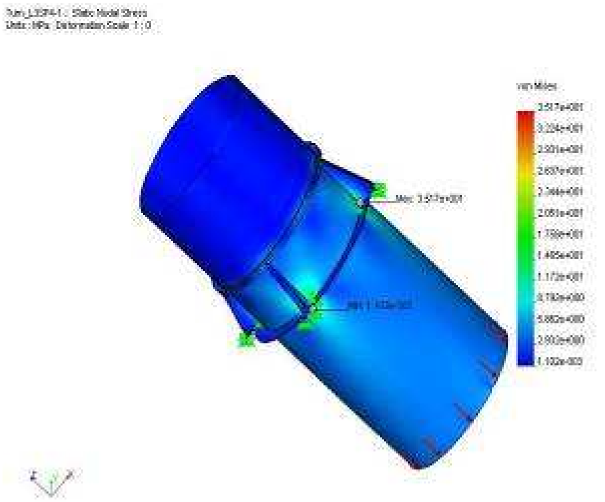

Figure 6. Von Mises stresses in the air conditioning tower, first loading case using Design Star software

There is a small difference between the results of these two analyses, but the maximum stresses are located in the same point, near the lower fixation ring, where the minimum thickness is 7.6 mm.

The obtained values do not exceed the admissible strength of the OLK4 steel, being 6 times lower than the $Rp_{0.2}$ limit.

In the second case, the tower was considered to be exposed to extreme temperature conditions: T=385 ˚C on the lower ring and T=140 ˚C on the upper ring.

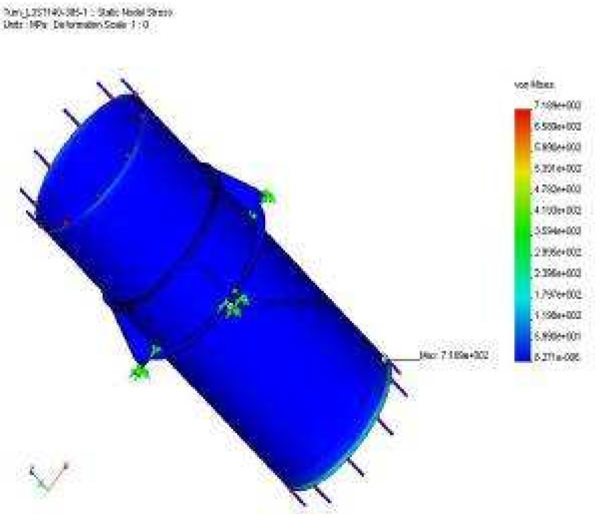

Figure 7. Von Mises stresses in the air conditioning tower, second loading case

The hot polluted gases that must be cleaned by the tower can produce these temperatures. This temperature gradient is considered to be the extreme functioning condition.

The results, obtained using Design Star software, are presented in figure 7. Maximum von Mises stress is 718.9 N/mm$^2$. This is the worst analyzed loading case because the greatest values of the stresses are obtained.

The obtained values exceed strongly the admissible strength of the OLK4 steel, the cause being the 36.7% reduction of the wall thickness. The maximum stressed point is located on the lower part of the tower.

In the third case, the tower is considered to be exposed to extreme temperature conditions: T=385 ˚C on the lower ring and T=140 ˚C on the upper ring, p=4.006 N/mm$^2$ pressure on the lower ring and gravity.

The results, obtained using Design Star software, are presented in figure 8. Maximum von Mises stress is 717.1 N/mm$^2$.

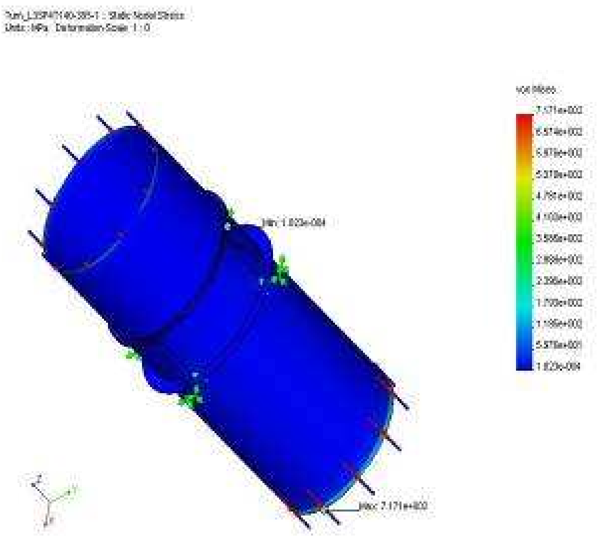

Figure 8. Von Mises stresses in the air conditioning tower, third loading case

The obtained values are very close to the previous case, exceeding strongly the admissible strength of the OLK4 steel.

In the fourth case, the tower is considered to be exposed to the upper T=206 ˚C inner temperature and T=62 ˚C outer temperature.

The results obtained using Design Star software are presented in figure 9. Maximum von Mises stress is 531 N/mm$^2$.

The maximum stressed point is located above the upper fixation ring, where the wall reduction is maximum, due to the extreme corrosion caused by the water spray inside the tower.

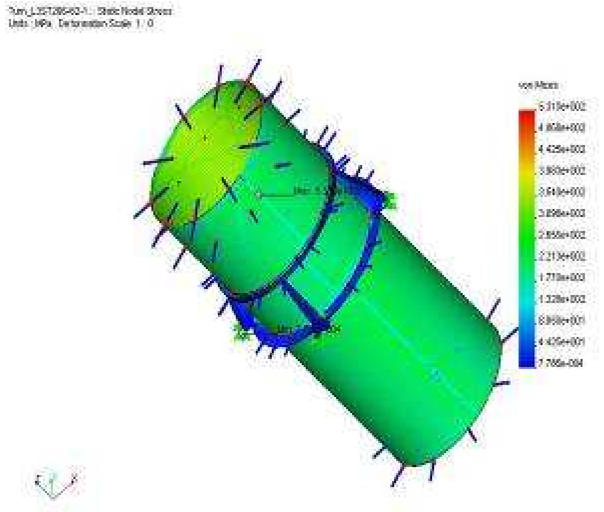

Figure 9. Von Mises stresses in the air conditioning tower, fourth loading case

In the fifth case, the tower is considered to be exposed to the upper T=206 ˚C inner temperature, T=62 ˚C outer temperature, p=4.006 $N/mm^2$ pressure on the lower ring and gravity.

The results, obtained using Design Star software, are presented in figure 10. Maximum von Mises stress is 531.5 $N/mm^2$.

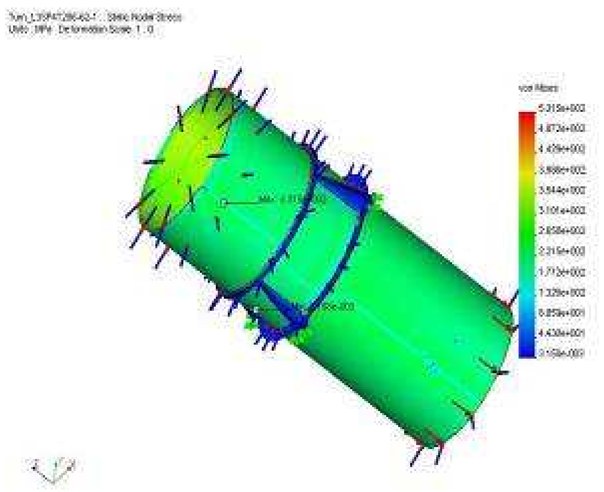

Figure 10. Von Mises stresses in the air conditioning tower, fifth loading case

The maximum stressed point is located in the same position like in the fourth case. Both fourth and fifth loading cases determine a high level of stresses, exceeding more than two times the $Rp_{0.2}$ limit.

## 4. Conclusion

Analyzing the results of the finite element simulations, one can observe that thermal effect is primary, mechanical tension being negligible.

Excepting the first loading case, all the others generate strong stresses, greater than the $Rp_{0.2}$ limit of OLK4 steel.

In the actual situation is very dangerous to use the air conditioning tower without an upgrade, necessary to fix the material thinning and deterioration.

To reduce the stress level it is necessary to apply a 5mm inner armour of P 295 GH (1.0481) steel, SR EN 10028- 2:1996, over 28.26 m high and to the upper cone of the tower.

This fix extends the service life of five years thereafter being necessary to replace the tower.

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