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NUMERICAL CALCULATION OF OVERPRESSURE AND UNDERPRESSURE OF RESERVOIR Z2

NUMERICKÝ VÝPOČET PŘETLAKU A PODTLAKU ZÁSOBNÍKU Z2

Abstract

Reservoir of oil-based liquid stored in iron-concrete foundation is solved using the finite element method. Foundation stiffness is in the calculation included variantly. Load cases are based on operating conditions.

Abstrakt

Zásobník kapaliny na bázi oleje uložený na železo-betonovém podloží řešený pomocí metody konečných prvků. Tuhost podloží je do výpočtu zahrnuta variantně. Zatěžovací stavy vycházejí z provozních podmínek.

Keywords

FEM, elastic foundation, reservoir, oil-based liquid, stress, deformation.

1 INTRODUCTION

CS CABOT, spol. s r.o. produces and sells carbon black for a production of tyres and mechanical rubber goods in its production plant in the city of Valašské Meziříčí, Czech Republic. The history of production of carbon black in the Czech Republic started in 1938 when channel black production was started in Ostrava.The production of carbon black was moved to Valašské Meziříčí in 1968 where the new production plant using furnace black process was built in 1971.

The turning point in further development of carbon black production in the Czech Republic was a creation of a joint venture between DEZA a.s. and CABOT CORPORATION in 1991. The building of a new plant with complete Cabot technology started in 1992 and the production on the two production lines was launched in May of 1994. The products are sold on the market under the registered CABOT trade marks.

Fig. 1 Reservoir Z2

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The production plant in the city of Valašské Meziříčí is one of the six European carbon black plants of CABOT CORPORATION. CS CABOT cooperates with other places of sale all over the Europe. CABOT headquarters is in Boston, USA and the main centre of research and development is situated in Billerica nearby Boston. CABOT has 36 plants in 21 countries, 24 of whom are carbon black plants.

2 SOLUTION

The main objective was to determine the maximum values of overpressure and underpressure of Z2 reservoir. On the basis of the overpressure and underpressure values are set the safety pressure fuses. The assessment criteria are the values of the displacements and stress distribution (main, radial, axial, reduced according to HMH).

The reservoir is produced from carbon steel. Each ring has different thickness – from 3.5 mm to 10 mm.

The subject of interest is a closed cylindrical reservoir, made by a thin wall welded steel strips of certain thicknesses, docked on iron-concrete foundation, see Fig. 1, 2 and 3. The reservoir is used for storing oil-based liquid, which evaporates and thus creates overpressure. The underpressure is generated by exhausting the fumes. The FEM simulations have put into account even with the temperature of the medium and also with temperature of reservoir's surroundings. Hereby, there are defined two load cases:

1. full reservoir, overpressure, temperature 110°C, see Fig. 2 left,
2. empty reservoir, underpressure, temperature -30°C, see Fig. 2 right.

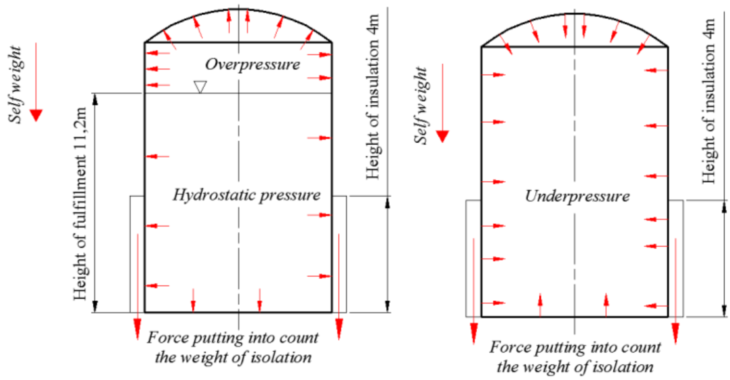

Fig. 2 Load cases: first load case left, second load case right

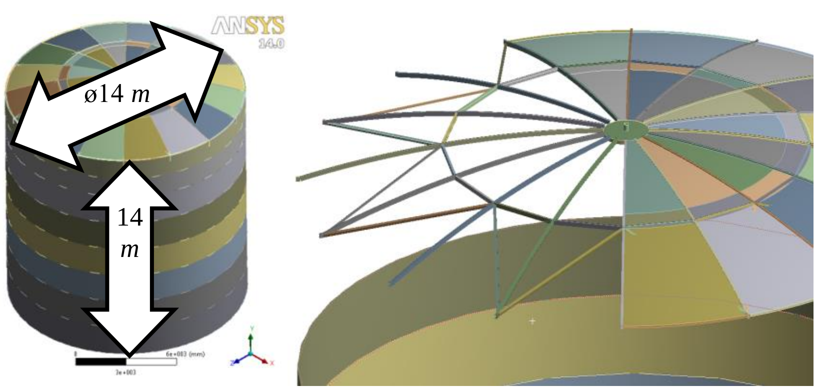

Fig. 3 Geometry model

The thickness of the plates is reduced by the effect aging and service. For this reason, there are periodically performed service checks, during which is also with aim of ultrasonic methods measured residual thickness of the plates. Such measurement has been used as an input for following FEM simulations.

Value of the modulus of foundation compressibility was not precisely known, therefore it was decided to realize the variant solution. Initial FEM simulation has been performed with the standard boundary condition, which is defined by removing displacements of all nodes in the lower area of the bottom of the reservoir in the vertical direction. Two values of modulus of compressibility were chosen: $K = 1{,}6 \cdot 10^{10}\ [Nm^{-3}]$ and $K = 1{,}0 \cdot 10^{10}\ [Nm^{-3}]$. The third value of modulus of compressibility $K = 7{,}0 \cdot 10^{9}\ [Nm^{-3}]$ represents damage of foundation (due to age).

3 RESULTS

A critical point in terms of the highest stress values is situated in the connection between the cylindrical part and the roof of the reservoir (see Fig. 4 – zone A). In table 1 and table 2 are shown specified values of modulus of compressibility of the foundation with corresponding results of displacement and stress in zone A for the first and second load case.

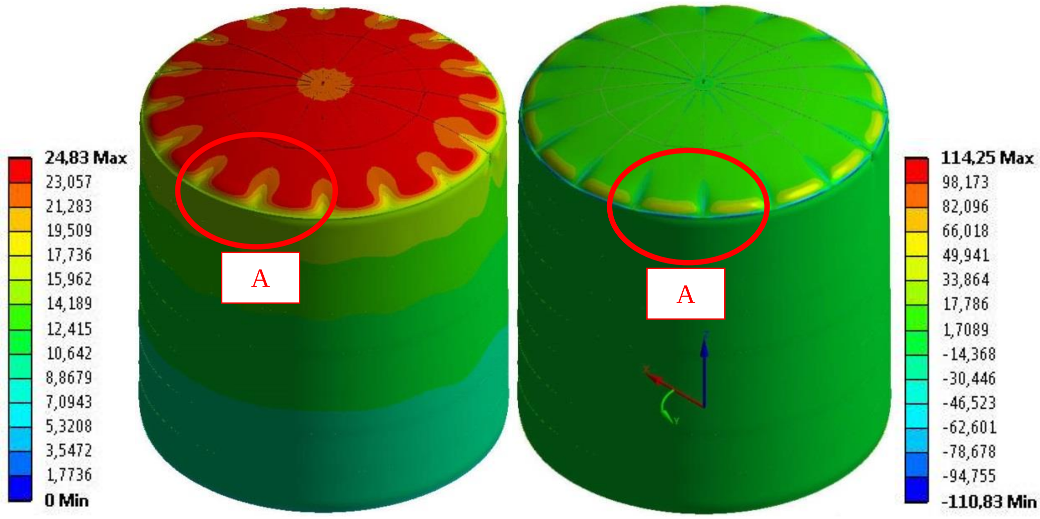

Fig. 4 Total displacement (left) $[mm]$ and distribution of the radial stress (right) $[MPa]$ for the first load case, without inclusion of elastic foundation

Tab. 1 Overview of the results for the first load case

Compressibility modulus of foundation $K\ [Nm^{-3}]$	**Total displacement** $[mm]$	**Radial stress** $[MPa]$	**Reduced stress according to HMH** $[MPa]$	**Loss coefficient shape stability** $[-]$
Rigid foundation	24.83	114.25	179.98	3.57
$1{,}6 \cdot 10^{10}$	24.72	114.14	179.83	3.57
$1{,}0 \cdot 10^{10}$	24.70	114.14	179.83	3.57
$7{,}0 \cdot 10^{9}$	24.68	114.14	179.83	2.68

Tab. 2 Overview of the results for the second load case

Compressibility modulus of foundation $K\ [Nm^{-3}]$	**Total displacement** $[mm]$	**Radial stress** $[MPa]$	**Reduced stress according to HMH** $[MPa]$	**Loss coefficient shape stability** $[-]$
Rigid foundation	18.93	110.32	179.87	1.95
$1{,}6 \cdot 10^{10}$	18.96	110.22	179.74	1.95
$1{,}0 \cdot 10^{10}$	18.97	110.22	179.74	1.95
$7{,}0 \cdot 10^{9}$	18.99	110.22	179.74	1.97

4 CONCLUSIONS

The results are showing us the minor decrease in terms of the stress critical value in zone A by using elastic foundation. However, the decrease is in our case almost negligible. It is worth to mention, that the shape factor of stability loss for the first load case for (especially for $K = 7{,}0 \cdot 10^{9}\ [Nm^{-3}]$) has decreased from $3{,}57\ [-]$ to $2{,}68\ [-]$.

Solved problem has reported approximately 3,025,000 equations.

Specific values of pressures and other details can not be publish due to the protection of confidential information.

ACKNOWLEDGEMENT

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