

4.1.5. STUDY OF STRESS-DEFORMED STATE IN DENTS AREA ON THE WALL OF VERTICAL STEEL TANKS

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During design work strength and stability calculations of vertical steel tanks shall be performed using momentless theory of shells. Herewith the shape of tank wall is considered as an ideal cylinder.

As a result of inspection a considerable number of dents occurred during both erection and operation are found. It is evident that in dents area stressed-deformed state of the wall differs from stress-deformed state in ideal cylinder and can not be calculated using momentless theory of shells.

As a case study for calculation of stress-deformed state vertical steel tank with floating roof has been selected VSTFR-10000 having capacity of 10,000 m³. There are hundreds of such tanks available with various oil and gas producing and transporting companies. Therefore, stress-deformed state calculations of tank wall are crucial for assessment of resource to operate them safely.

Study of dependence of stressed-deformed state of tank wall from maximum dent tongue has been performed. During calculations the maximum dent tongue ($F_{\max}$) was set from 7.8 mm up to 273 mm with a step of 7.8 mm; all in all 35 dents have been created having equal width, height, shape, same location on the tank wall and different as far as dent tongues were concerned.

Calculation of stressed-deformed state of wall has been performed using finite element method by modeling VST wall with ANSYS. Maximum middle and surface stresses in tank wall in dent area and wall movement values in dent area during tank filling were determined.

Calculation example is given in fig. 1, the results of 35 calculations have been summarized on charts given in fig. 2 and 3.

Maximum allowable dent tongue value with specified parameters (width, height, shape, wall location etc.) during operation of VSTFR-10000 with design filling level as per criterion of ultimate stresses shall be 50.9 mm (fig. 2).

On the curve (fig. 3) one can emphasize 3 sections:

- 1st section – dent tongue value from 0 up to 117 mm – buckling in dent area does not occur;
- 2nd section – dent tongue value from 124.8 mm up to 241.8 mm – the dent “buckles”, i.e. local wall stability loss occurs in the dent area;

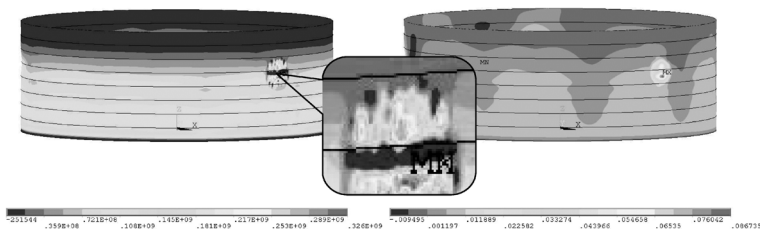


Fig. 1. Distribution of surface stresses (left) and movements (right) on the wall of vertical steel tank having dent

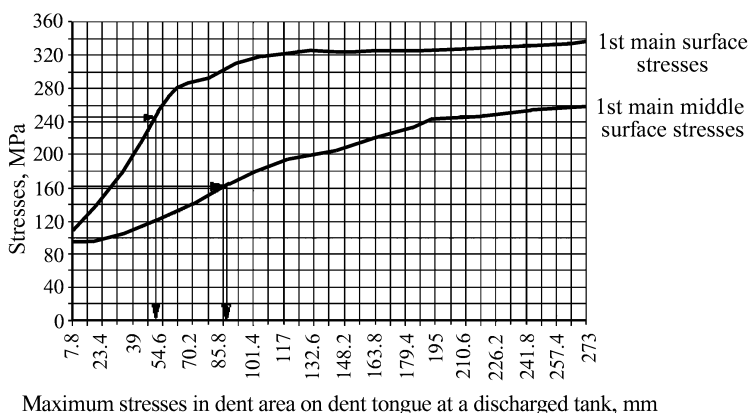


Fig. 2. Dependence of maximum stresses in dent area on dent tongue at a discharged tank

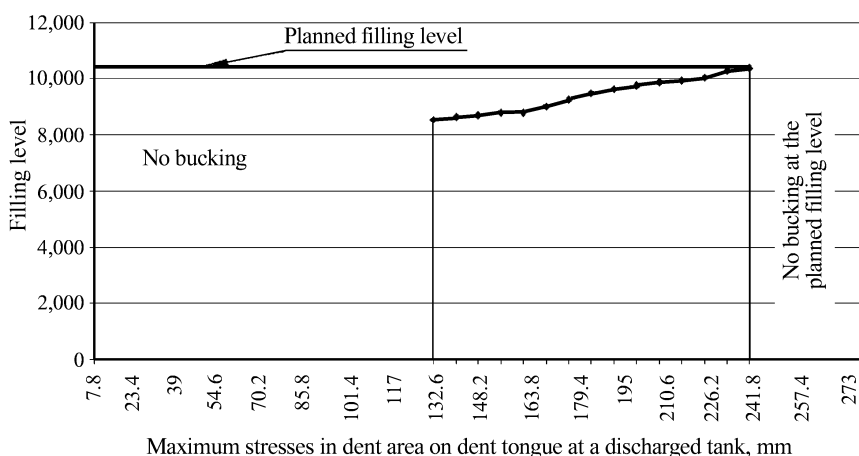


Fig. 3. Dependence of filling level, at which buckling occurs on maximum dent tongue

– 3rd section – dent tongue value 241.8 mm and more – bucking in the dent area does not occur at design filling level.

Therefore as a result of stressed-deformed state calculation influence of dent depth on tank wall stressed-deformed state variation and occurrence of local stability loss has been determined. In order to continue operation stresses on tank wall should not exceed ultimate ones and tank stability has to be ensured. Based on the calculations performed expert organization may extend operation of a tank having dent using design or reduced operation parameters.

