Structural Analysis and Design of a Sectored Cylindrical Vertical Tank

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Abstract

This paper describes the conceptual design and the structural analysis of a vertical cylindrical partitioned tank for an international chemical Company. Vertical cylindrical tanks are commonly used in the chemical industry around the world as vessels to contain liquids. Usually, they are grouped forming tank farms inside the plant in an Industrial Estate. The chemical industry manufactures coatings for vehicles, canned drinks, and construction materials. Currently, the business of the chemical coatings deals more than 30 billion of Euros worldwide. Most of these plants, because of the size of its plan view, have reduced area for the installation of the container tanks. Many of them have the need to renew their manufacturing process according to the new technologies and requirements. Also, in some cases, the preparation of mixtures is devoted to small areas. The stated conditions led to the idea of designing a partitioned vertical tank.

The main features of the tank designed are: i.-four vertical sectors; ii.- cylinder tank with 18 m height, 4,6 m diameter; iii.- conical self-supported covering; iv.- conical stiffened bottom base ; v.- concrete flat foundation with anchoring bolt system; vi.-the tank is manufactured with stainless steel sheets and components. Conventional vertical steel tanks are designed by means of well-known specifications, such as API-650 i.e.. These standards incorporate simplified methods based on, the cylindrical vessel as tensioned membranes being loaded by the hydrostatic pressures.

In this case, for the sectored tank, alternative hydrostatic pressure cases may lead to eccentrically loads on above the surfaces. Therefore, bending stresses will occur, together with compression and tension stresses as per its specific tank deformation. Thus, the traditional calculation approach is not advisable and efforts should be carried out to choose and develop an appropriate calculation criterion. On the other hand, in terms of installation and operation, the resins contained in these tanks may be dangerous and hazardous. Thus, partitioned tanks are classified as Class 3 according to EN 1993-4.2. Taking into account all the above-mentioned, a Finite Element Method calculation should be performed in order to determine the wall thickness fulfilling the structural requirements.

This paper describes the particular models designed and the detailed FEM calculation carried out to determine the wall thickness of partitioned tanks. The results extensively expose two design proposals which vary in the use or not of a bracing system. The Eurocodes have been used for calculation purposes and also when determining the stainless-steel requirements (grade 1.4306, equivalent to international AISI 304 L, and with a yield stress of 200N/mm2). The load combinations refer to hydrostatic pressures, maintenance load, snow, wind and a simplified earthquake action. The hydrostatic pressure accounts for the most critical structural scenario and therefore, the mechanical design must keep special attention to determine the thickness of the cylindrical tanks analysed. Von Misses stress criteria together with particular deformation service limits determines, in case of the exempted cylinder a thickness of 18 mm. On the other hand, the tank with a particular inner bracing system results in 12 mm thickness. The crossed inner partitioned walls are 10 mm thick and with a specified corrugated form. Finally, conclusions remark the more relevant findings determined and set the basis upon further analysis.

References

[1] EN 1993-4.2.