STUDIES REGARDING STRUCTURAL PROPERTIES OF CHEMICAL INDUSTRY EQUIPMENT

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An adequate and optimized equipment plays a very important role in the chemical industry. Due to the way an equipment is designed, it can be subject to certain types of structural deformations. This aim of this study is to show the importance of fortifies openings that are made to connect the pipes with pressure vessels. The development of chemical and petrochemical installations led to the need for continuous research of the vessel's coatings for a better understanding of design of these structures to be operate in maximum safety. The openings contribute to destabilization of structure for a pressure vessel and make it dangerous to use.

Keywords: pressure vessel, stress concentrators, internal pressure.

INTRODUCTION

In mechanical engineering, revolution coatings, as structural elements are in a top position and are used in the construction of equipment, pipelines, etc. Pressure vessels, reactors used in the chemical and petrochemical industries, nuclear reactors, pipelines used in drilling operations, oil and natural gas carrying, are in the category of coatings.

The development of the chemical and petrochemical industries, installations using such equipment has also led to the need for continuous research of the coatings for a deeper understanding of the problems involved in the design of these structures, whose operation must be done in maximum safety. Pressure vessels are part of complex systems and installations. Therefore, openings in their sheaths and pipes required to allow connection to the system to which they belong. All these openings lead to geometric discontinuities in the sheaths and to stress concentrators (Jinescu, 1983). Fittings are technological elements, through which the connection is made for pipes, tubes, or other components/devices of the equipment (Pavel, 1998).

The complex geometry of machine components and structures makes it impossible to use the fundamental formulas of the strength of materials. Existence of section changes, holes, channels, notches and changes in geometric configuration lead to a complex stress distribution (Radeş, 2010) and can occur areas with height local stress, called concentration of mechanical stresses. Stress concentration factor **a**$_k$ (formula 1 and formula 2), can be written as:

- in case of tension or bending stresses (for normal stresses):

$$\alpha_\sigma = \frac{\sigma_{max}}{\sigma_{nom}} \tag{1}$$

where

σ_{max} - maximum normal stresses

τ_{max} - maximum tangential stresses

- in case of shear or twisting stresses (for tangential stresses):

$$\alpha_\tau = \frac{\tau_{max}}{\tau_{nom}} \tag{2}$$

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where

σ_{nom} - normal stresses - empirically determined

τ_{nom} - tangential stresses - empirically determined

Geometric discontinuities change the distribution of stresses in their vicinity so that the stress equations are no longer valid. Such discontinuities are also called “stress peaks” and the regions in which they occur are called areas of stress concentrators. In this paper is defined the factor of concentration of stresses at the openings in coatings methods for evaluating its effect. The method of area replacement is to ensure that the reaction force of the material is greater than or equal to the pressure load. According to this method, the stress concentration factor, α_σ, in the joint (Fig. 1) is obtained in the form (Jinescu, 1986):

$$\alpha_\sigma = \frac{2 \cdot B \cdot T}{A \cdot D_m} \tag{3}$$

where

$$\left.\begin{aligned} A &= 0{,}8 \cdot \sqrt{D_m \cdot T} \cdot T + 0{,}8 \cdot \sqrt{d_m \cdot t} \cdot t \\ B &= \left(\frac{d_m}{2} + 0{,}8 \cdot \sqrt{D_m \cdot T}\right) \cdot \frac{D_m}{2} + 0{,}8 \cdot \sqrt{d_m \cdot t} \cdot \frac{d_m}{2} \end{aligned}\right\} \tag{4}$$

Figure 1 – section A - represents the areas of the cross sections subjected to pressure; Figure 1 – section B – represents the cross-sectional area subjected to stress.

where

D_m - average diameter of the cylindrical container;

d_m - average diameter of the connection;

T - wall thickness of the cylindrical container;

t - thickness of the connection wall.

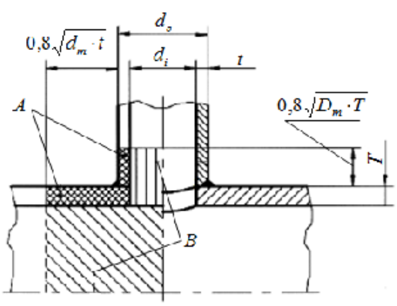

Figure 1. Cylindrical cover with non-penetrating connection

From a practical point of view, there is the problem of attenuating the stress concentration. The strength of the container or fitting cover can be improved by adding material around the hole. This addition of material in the area of influence of the concentration effect is called compensation, strengthening of the holes (Fig. 2) (Jinescu,

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1986). If the coating is provided with several concentrators, it may be more economical to thicken the entire coating instead of local consolidations.

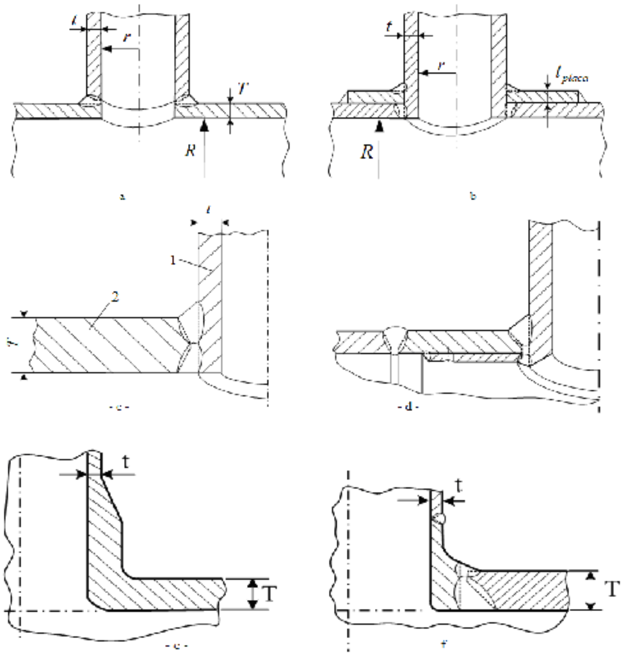

Figure 2. Opening without compensation (a, c); Reinforcement of holes with reinforcement plate (b; d); Consolidation of the holes by thickening the connection (e; f)

EXPERIMENTAL

Determining the maximum diameter of the opening that does not require compensation for the cylindrical body of a column.

The radius of curvature for spherical or cylindrical coatings is obtained as follows:

$$r_{is} = \frac{D_e}{2} \quad e_{a,s} = \frac{D_i}{2} \tag{5}$$

Maximum length of the coating contributing to the strengthening of the opening, measured along the average surface of the coating:

$$l_{so} = \sqrt{(2r_{is} + e_{c,s}) \cdot e_{c,s}} \tag{6}$$

The maximum diameter of an opening without compensation according to SR EN 13445 is given by the relation:

$$d_{max1} = \min\left(0,5 \cdot D_i; \frac{e_a \cdot l_{so} \cdot \frac{f - 0,5 \cdot P}{P} - r_{is} \cdot l_{so}}{0,5 \cdot r_{is} + 0,5 \cdot e_a}\right) \tag{7}$$

$$d_{max2} = 0,15 \cdot \sqrt{(2r_{is} + e_a) \cdot e_a} \tag{8}$$

$$d_{max} = \max\left(d_{max1}; d_{max2}\right) \tag{9}$$

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RESULTS AND DISCUSSIONS

In a cylindrical shell joined by a domed or hemispherical bottom, with the large base of a conical shell, with a flat bottom or with any type of flange, the distance w, must comply with the condition:

$$w \geq w_{min} = \max\left(0{,}2\sqrt{(2r_{is} + e_{c,s}) \cdot e_{c,s}};\, 3e_{a,s}\right) \quad (10)$$

$$r_{is} = \frac{D_e}{2} - e_{a,s} = \frac{D_i}{2} = 700\ mm \quad (11)$$

Maximum length of the casing which contributes to the strengthening of the opening, measured along the average surface of the casing:

$$l_{so} = \sqrt{(2r_{is} + e_{c,s}) \cdot e_{c,s}} = \sqrt{(2 \cdot 700 + 12) \cdot 12} = 130{,}17\ mm \quad (12)$$

$$d_{max1} = \min\left(0{,}5 \cdot 1400;\, \frac{12 \cdot 130{,}17 \cdot \frac{139{,}33 - 0{,}5 \cdot 0{,}12}{0{,}12} - 700 \cdot 130{,}17}{0{,}5 \cdot 700 + 0{,}5 \cdot 12}\right) \quad (13)$$

$$d_{max1} = \min(700; 4836{,}385) = 700\ mm \quad (14)$$

Diameter that does not require compensation:

$$d_{max2} = 0{,}15 \cdot \sqrt{(2 \cdot 700 + 12) \cdot 12} = 19{,}52\ mm \quad (15)$$

Maximum diameter that does not require compensation:

$$d_{max} = \max(700; 19{,}52) = 700\ mm \quad (16)$$

The distance between an opening and a discontinuity of the coating must be:

$$w \geq w_{min} = \max\left(0{,}2\sqrt{(2 \cdot 700 + 12) \cdot 12} = \max(26{,}03; 36)\right) \quad (17)$$

$$w \geq w_{min} = 36\ mm \quad (18)$$

Calculations show that the openings on the cylindrical body of the column do not require compensation. The check ports and two other connections will be compensated with a reinforcing ring because they have large stress concentrators.

CONCLUSIONS

The traditional way to compensate for an opening or connection is to "thicken" material close to the opening, in addition to the minimum required thickness of the coating.

Important disadvantages of the compensation method:

- does not provide information on the stresses in the casing and connection.
- the method cannot be extended to situations where we have additional loads other than internal pressure.

The advantage of the method is that of its simplicity of application.

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