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FINITE ELEMENT METHOD PRESSURE VESSEL CALCULATION AND ANALYSIS OF THE EFFECTS OF THE BUTT WELDED JOINTS ON A CARRYING CAPACITY OF A STRUCTURE

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Abstract: In present paper, after calculation using the finite element method (FEM), stress distribution on the model of a part of the pressurized boiler shell without welded joints (WJ), with transversal WJ, longitudinal WJ and crosspoint location of WJ is analyzed. Also, FEM calculation and comparative analysis of the effects of WJ on the stress distribution have been conducted using the tank for liquid carbon dioxide as an example, on which, in addition to the shell sheet-metal and heads with necessary openings and elements such as saddles with supports and hangers, transversal and longitudinal butt WJ, have been modelled.

Keywords: FEM, WJ, Calculation, Analysis of stress distribution

1. Introduction

Based on calculation of the thickness of cylindrical shell and head-wall of the vessels for liquid CO_2 with volume V=23 m^3, an outer diameter, D_o = 1900 mm and with the test pressure, p_t = 26 bar, made of the material P 355N L2 [1,2], according to standard SRPS EN 13445-3 [3], adopted thickness is e = 10 mm. This calculation is based on the formulas for calculation of stresses in the thin walls of the shells and on the empirical safety factors [4]. Based on these formulas it has been calculated that the tangential stress are σ_t = 245.7 MPa, and the axial stress σ_a = 122.8 MPa. The cylindrical part of the vessel was made by butt welding of sheet metal, with both transversal and longitudinal WJ. Their shape induces stress concentration in their vicinity, Fig. 1, which affects the stress distribution throughout the structure of the vessel, too.

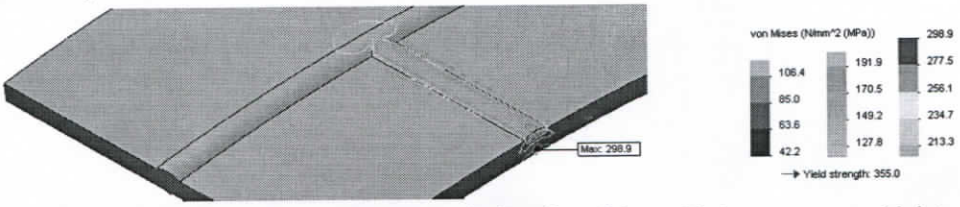

Fig. 1. Stress distribution at the crosspoint location of the welded pressure vessel joints

Stress values in the WJ, obtained by FEM calculation on the part of the vessel shell exposed to the test pressure, are presented in Tab. 1.

Tab. 1. Comparative stress values on the part of the pressure vessel shell

The part of the vessel shell exposed to pressure of 2.6 MPa		FEM (von Mises stresses)		Formulas (Normal stresses)
		σ_{min}, MPa	σ_{max}, MPa	σ, MPa
Without WJ,	Transversal	241.6	245.9	245.7
	Longitudinal			122.8
With Butt	transversal WJ	238.6	245.0	/
	longitudinal WJ	28.7	310.7	/
	crosspoint WJ	42.2	298.9	/

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2. Stress distribution on the model of the pressure vessel shell without and with WJ

To see the difference of stress distribution, two models of the vessels were made (with and without WJ), and after the FEM calculation the comparative analysis of the stress distribution was also conducted, Fig. 2.

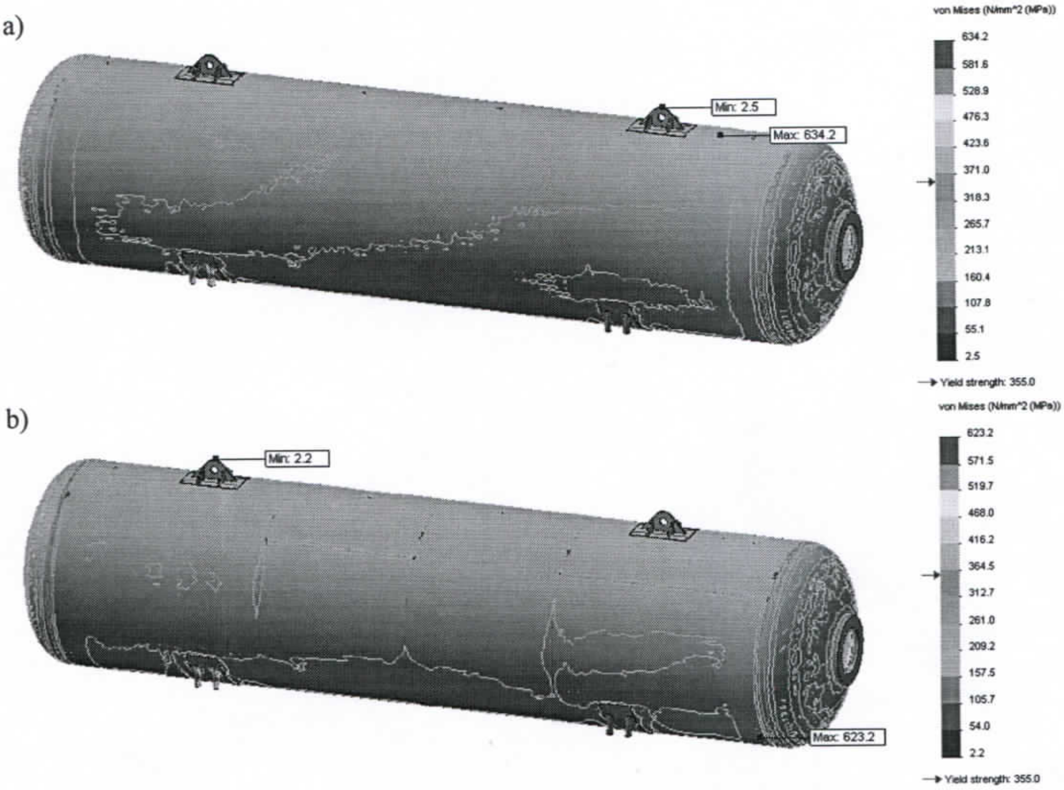

Fig. 2. Stress distribution on the model of the vessel exposed to pressure of 2.6 MPa, a) without and b) with modelled butt WJ

3. Conclusions

By analyzing the stress distribution after FEM calculation one can see a completely different picture of the stress distribution on the vessel modelled with and without a model of butt WJ, as expected, which tells us that to fully understand the behaviour of welded structures the FEM calculation on the model on which the WJ are also modelled is required.

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Author Index