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OPTIMIZATION IN THE ELASTIC LINEAR FIELD OF THIN SHELL CYLINDER-SPHERE GRP UNDER SMALL INTERNAL CONSTANT AND UNIFORM PRESSURE

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OPTIMIZAREA ÎN CÂMP ELASTIC LINIAR A UNEI ÎNVELITORI CILINDRU-SFERĂ GRP SUPUSĂ UNEI PRESIUNI INTERNE CONSTANTE ŞI UNIFORME

Articolul prezintă un studiu cu privire la optimizarea unui profil de învelitoare cilindru-sferă GRP (Glass Reinforsed Plastic), calculată în domeniul elastic linear pentru o valoare mică de presiune constantă și uniformă. Se prezintă rezultatele cercetărilor făcute de J.Leach [4] pentru câteva profile de învelitoare, relativ la starea de tensiuni și deformaţii utilizând programul BOSOR [4] bazat pe metoda diferenţelor finite. În continuare se prezintă rezultatele cercetărilor făcute de autoare relativ la trei învelitori cilindru-sferă, optimizate prin impunerea a trei tensiuni echivalente von Mises constante pe întreaga învelitoare, utilizând metoda propusă de autoare [2] care are la bază ecuaţiile de echilibru ale teoriei clasice în domeniul elastic linear. Analiza stării de tensiuni și deformatii este realizată cu ajutorul analizei FEM utilizând programul NASTRAN V4.0 [5], pentru cele trei situaţii de optimizare ale învelitorii cilindru-sferă prin programul OPTIMISES [3] rezultate prin impunerea a trei tensiuni echivalente von Mises σ_{Vme} = 5 MPa, σ_{Vme} = 9,007 MPa, respectiv σ_{VMe} = 17,96 MPa.

La sfârșit se face o analiză cuprinzând rezultatele opţinute relativ la tensiunile circumferenţiale, echivalente von Mises, și relativ la deplasarea totală, pentru profilele optimizate, evidenţiind rezultatele obţinute prin metoda propusă de Dora Florea [3].

The article presents a study about optimizing a parcel profile cylinder-sphere GRP (Glass Reinforsed Plastic), calculated in linear elastic for a small value constant and uniform pressure.

Cuvinte cheie: optimizare, design, tensiune echivalentă von Mises, deplasare totală, GRP

Keywords: optimization, design, santers von Mises, total displacement, GRP

1. Introduction

Researches made by J. Leach [4] upon the stress and strain for the GRP vessel of type sphere-cylinder with regard at the junction region design under internal, constant, uniform pressure, evidencing as acceptable solution from point of view of the stress and strain distribution, the configuration from fig.1(case 12). The study made used the difference finite method and analysis of the stress and strain state used the programme BOSOR, imposing for the concentration coefficient defined with circumferential stress the value 1.

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$$SCF = \frac{Maxum\ Cyrcumferential\ stress\ in\ the\ sphere}{Cyrcumferential\ stress\ in\ cylinder} = \frac{\sigma_{czmax}}{pD/2t} \quad (1)$$

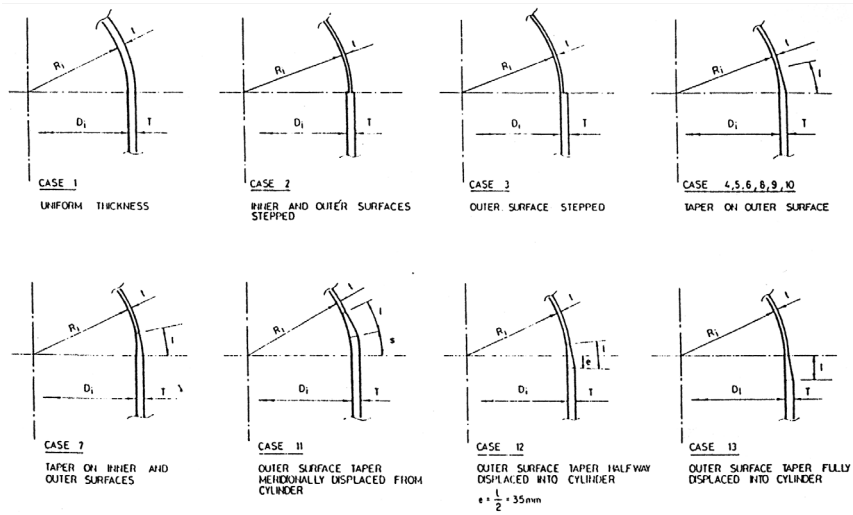

Fig.1 Jonction vessel studded by J. Leach [4]

The analytic and experimental result evidenced that the internal circumferential stress are dominated and has the great values in the

cylinder, and the difference of circumferential stress values between cylinder and sphere is 5.2 MPa in comparation with the sphere-cylinder GRP shell no optimized with constant thickness of 10 mm, where the difference is 12 MPa.

2. Optimization of the cylinder-sphere vessel through the method proposed by Dora A.T.Florea [2]

The principle of the optimization method proposed by Dora A.T. Florea [2] has at the basis the four Theory of resistance named and the Theory of potential deviation energy, the purpose being to obtain an equivalence von Mises stress uniform in the vessel sphere-cylinder.

$$\sigma_{ech} = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - (\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1)} \leq \sigma_a \qquad (2)$$

The programme OPTIMISES [3] which compute the optimal thickness of the contour consider the circumferential stress σ_θ, meridian stress σ_φ and axial stress σ_x equations, obtained from the equations system what defined the stress state used the classic theory in the elastic linear field for the thin shells.

The study consider shell sphere-cylinder with geometrical parameters: diameter of the sphere D = 1000 mm, thinness of the shell t = 10 mm, from isotropy and homogenous material GRP (Glass Reinforsed Plastic), with module of Young E = 7E+3, and Poisson coefficient μ = 0.34, under and the internal, constant and uniform pressure p = 0.4 MPa.

The optimization of extern contour with OPTIMISES [3] programme it can achieve for various values of equivalents von Mises stress, which has the maximum values in the cylinder on internal face for the shell with constant thickness. The maximum equivalence von Mises stress is the result of sizing vessel considering the allowing stress σ_a.

In this paper it considers three values for the equivalence von Mises stress for to be realised:

1) maxim equivalence von Mises stress in the cylinder σ_{evmc} = 17.96 MPa
2) maximum equivalence von Mises stress in the sphere σ_{evms} = 9.077 MPa
3) a small value of equivalence von Mises stress in the sphere σ_{evms} which is σ_{evm3} = 5 MPa

The contour optimized with aid OPTIMISES programme [3] for the equivalence Von Miss stress σ_{evmc}=17.96 MPa, what is the equivalence von Mises stress on internal surface of cylinder for the shell with constant thickness h = 10 mm, and studded with NASTRAN V.4.0 programme [5] it present in figure2.

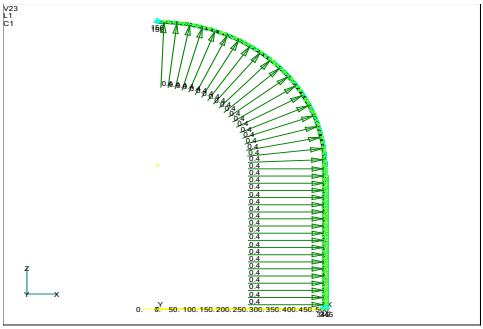

Fig. 2 Optimized contour at the value σ_{evmc} = 17.96 MPa

In the figure 3 it presented the variation of equivalente von Mises stress, the circumferential stress, axial stress, shear stress and radial stress, for the optimized contour (figure 2) and in the figure 4 it presented the total displacement for the same optimized contour.

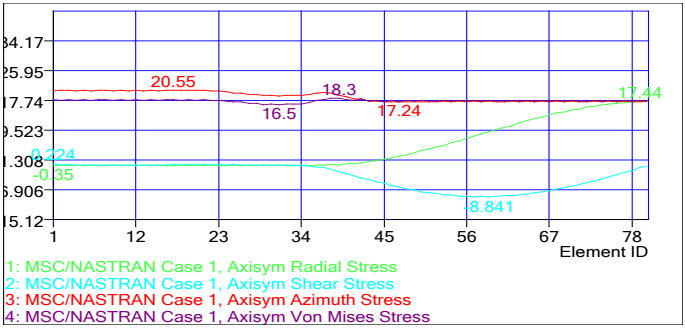

Fig. 3 Stresses in the optimized contour (figure 2)

Optimized contour with the OPTIMISES programme [3] for the value of equivalence von Mises stress σ_{evms} = 9.077 MPa what represents the mximum value of equivalence von Mises stress which is in the sphere on the internal surface for the model of the shell of constant thickness h

= 10 mm, studded with NASTRAN V.4.0 [5], it presented in figure 5. In figure 6 it presented variation of equivalence von Mises stress, circumferential stress, axial stress, shear stress and radial stress and in figure 7 it show total displacement of the contour. Optimized contour with the OPTIMISES programme[3] for a value of equivalente von Mises stress σ_{evms} = 5 MPa, and studded with NASTRAN V.4.0 programme [5], it show in figure 8.

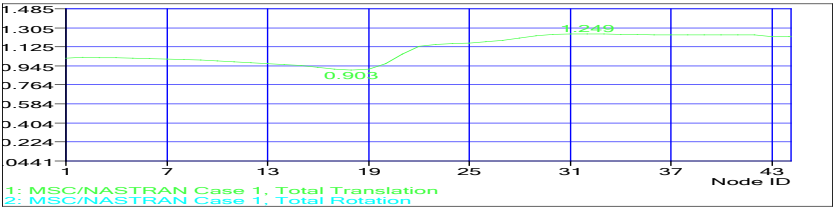

Fig. 4 Total displacement for the contour (figure 2)

The equivalence von Mises stress, radial stress, axial stress, shear stress which it is show in figure 9, and the total displacement of the contour is presented in figure 10 for the optimized contour from figure 8.

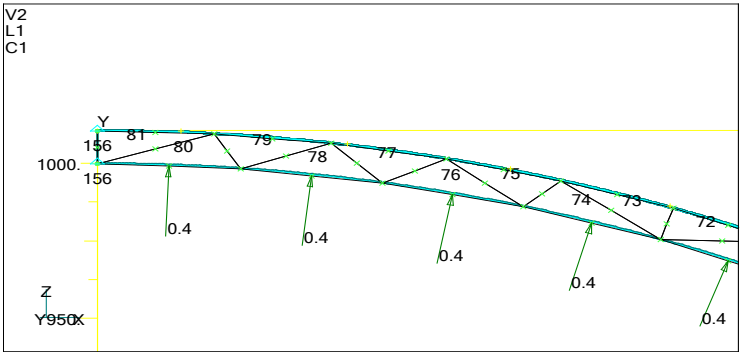

Fig. 5 Optimized contour at the value σ_{evms} = 9.077 MPa (detail of sphere)

3. Results and conclusions

■ The results obtained with analysis with NASTRAN V.4.0 programme [5] for the studded contours it is presented in Table 1, where is presents the circumferential stress σ_c, minimum and

maximum, on the interior face of contour, the equivalence von Mises stress σ_{vm}, maximum and minimum, on the interior face of contour, the displacement of nodes δ, maximum and minimum, on the interior contour and the difference $\Delta\sigma_c$, $\Delta\sigma_{vm}$, $\Delta\delta$.

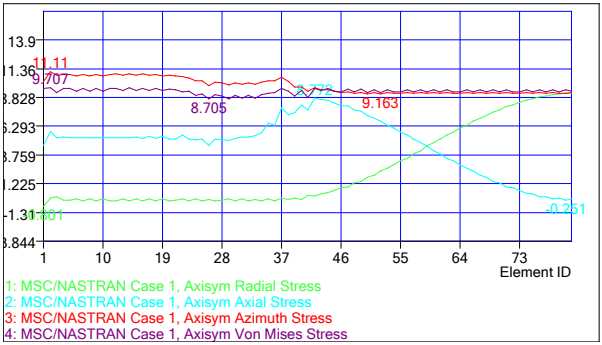

Fig. 6 Stresses in the optimized contour (figure 5)

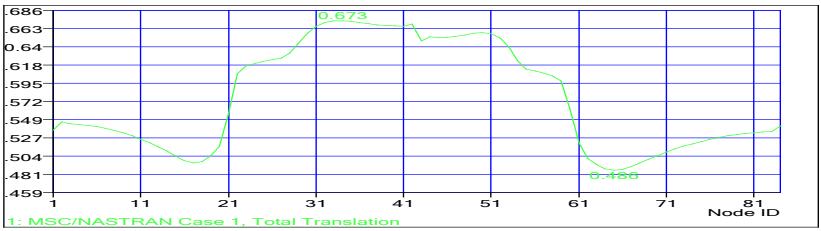

Fig. 7 Total displacement for the optimized contour (figure 5)

In the Table 1 position 5, for the contour studded by J. Leach, the values of von Mises stress σ_{vm}^{*} are the stress in the exterior contour for the transition zone, where are the maximum values for the σ_{vm}.

■ For the optimized shell through the method Dora A.T. Florea [2] at the equivalence von Mises stress σ_{evmc}=17.96 MPa, case 2, the differences of value von Mises stress in the whole shell is 1,8 MPa. Through the optimization at the equivalence von Misses stress σ_{evms} = 9.077 MPa, case 3, it obtain the variation of the equivalence von Mises stress of 1.002 MPa in the whole shell and for the optimization of the shell at σ_{evm3} = 5 MPa, case 4, results a variation of equivalence von Mises stress of 0.671 MPa in the whole shell. For the shell with profile proposed by J. Leach, case 5, the difference of the equivalence von

Mises stress is 3.735 MPa for interior contour of shell and of 7.26 MPa for the exterior contour of shell.

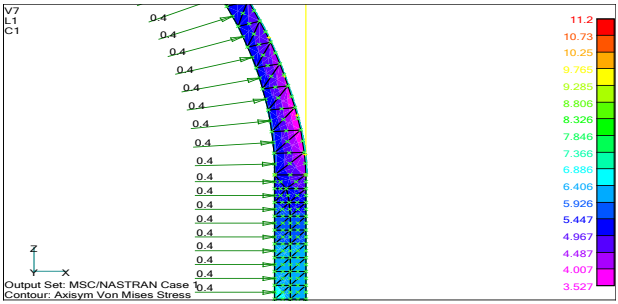

Fig. 8 Optimized contour for σ_{evms} = 5 MPa (detail of contour)

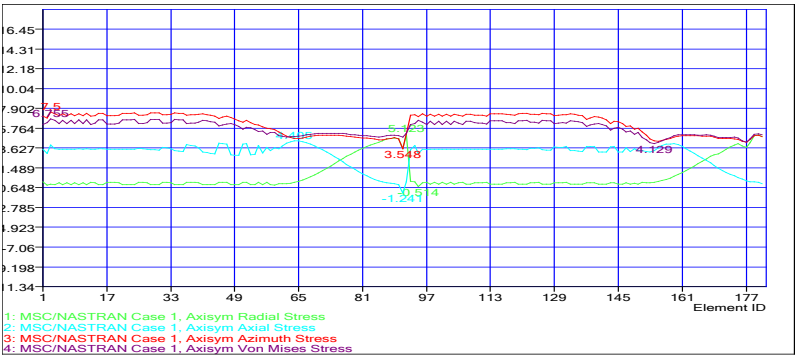

Fig. 9 Stresses in the optimized contour (figure 8)

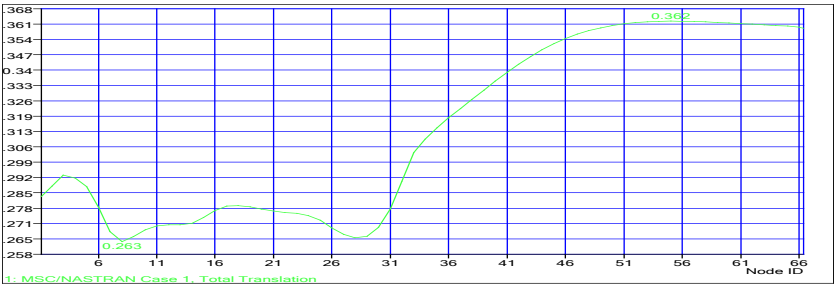

Fig.10 Total displacement of the contour figure 8

Table 1

No	Contour	σ_c[MPa]		$\Delta\sigma_c$	σ_{vm}[MPa]		$\Delta\sigma_{vm}$	δ[mm]		$\Delta\delta$
		min	max	[MPa]	min	max	[MPa]	min	max	[mm]
1	h=10 p=0.4 Mpa	22	10	12	9.354	17.82	8.4	0.667	1.244	0.577
2	optimized σ_{evmc}=17.96 Mpa	17.4	20.55	3.11	16.5	18.3	1.8	0.903	1.249	0.346
3	optimized σ_{evms} = 9.077 Pa	9.11	11.11	2	8.705	9.707	1.002	0.48	0.673	0.193
4	optimized σ_{evms}=5 MPa	4.4	5.805	1.405	4.45	5.121	0.671	0.263	0.362	0.099
5	J.Leach	18.9	23.88	4.98	17.16 15.59	20.895 22.85*	3.735 7.26*	1.246	0.955	0.291

■ The conclusion is that for the model optimized by method proposed by Dora A.T. Florea [2] the results obtained are better that results obtain of J. Leach relative at the circumferential stresses, the equivalence von Mises stresses and the displacement values for the case 2, 3 and 4 from Table 1.

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