Proceedings of the 16th International Conference on Manufacturing Systems – ICMaS
ISSN 1842-3183
University POLITEHNICA of Bucharest, Machine and Manufacturing Systems Department
Bucharest, Romania

STRESSES STATES IN RIBBED AND PLANES CIRCULAR PLATES

Radu IATAN, Carmen POPA

Abstract*: In this paper is presented the analyze of stresses states for a plane and a ribbed plate, to observe the advantage of the rigidify. The plates, of the same dimensions, are solicited at 0, 3 MPa pressure. For comparison, we used the analytical, finite elements and experimental methods for the plane plate and for the ribbed plate, we used the finite elements and experimental methods.*

Key words: *circular plate with ribs, stresses states, numerical method, experimental method, analytical method.*

1. INTRODUCTION

Circular or annular plates, of constant or variable thickness, connected with rigidity elements-by casting, bonding or welding-, are met in numerous engineering domains. Radial and/or annular ribs can be disposed symmetrical or not, toward the middle surface of the proper plate.

The searches had been done to establish the displacements and stresses states at plates rigidified with ribs can be grouped in:

a) Approximate calculus methods of the stresses and displacements states.

b) Methods which abase the study at behaviour of the compound elements: plates and ribs, that are considered with different leaning ways.

c) Calculus methods that abase the structural orthotropic at material orthotropic.

d) Numerical methods [5].

e) Experimental methods [1, 2, 4].

2. PLANE PLATE ANALYZE

2.1. Elements finite method

We analyze the plane plate, having 32 holes, and geometrical characteristics from Fig. 1, using finite element method. We consider that the plate is fixed on circumference of the holes for the screws, which clamp this plate by the experimental recipient [3].

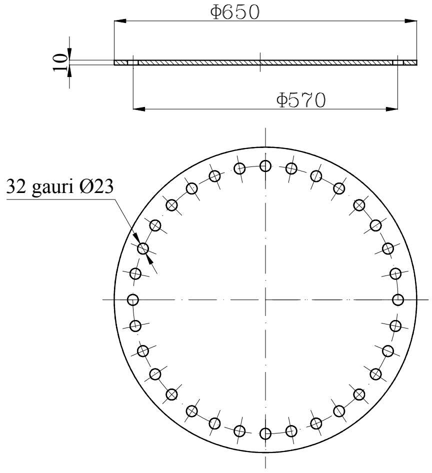

Fig. 1. Geometrical characteristics of the circular plane plate.

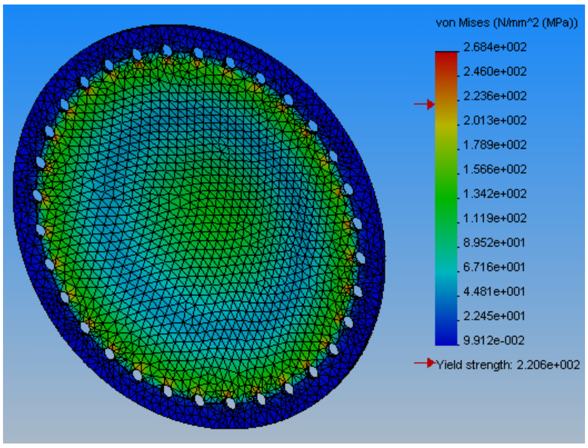

Fig. 2. Stresses of the fixed plane plate, at 0, 3 MPa pressure, using COSMOSWORKS 7.0 program.

We present the calculus variant with finite elements, using COSMOSWORKS 7.0 program.

The plate stresses distribution, at 0.3 MPa pressure is presented in Fig. 2.

Stresses from Fig. 3 are obtained at 0.3 pressure MPa, using a plan which pass through the centres of two exactly contrary holes, which are situated between two neighbour holes. Stresses values are given in Table 1.

2.2. Analytical method

In this case the plane plate is considered fixed on the line of the centres of the holes, at r_{cr} = 285 mm. If it is supposed at a value of the pressure of 0.3 MPa, we obtain the maximal value of stress on the fixed line, like in Table 2. We observe that the two values are near.

2.3. Experimental method

In the experimental case, we take into account the measuring of specific linear deformations of the external points of the plate and calculus of the radial, circumferential and equivalent stresses, in the same conditions, using the strain gauges [3].

The components of the experimental stall are presented in Fig. 4. The zones where the strain gauges are fixed on the plate are presented in Fig. 5. The strain gauges, which are used, are KM120, with R = 120 Ω resistance and K = 2.04 ± 2 % elastic constant.

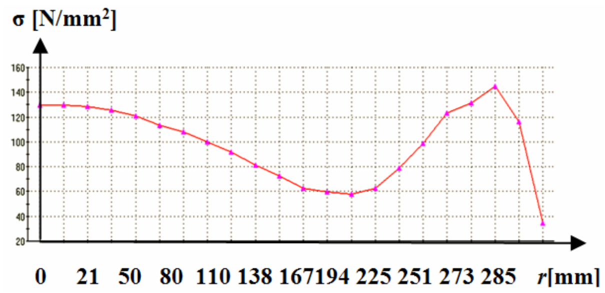

Fig. 3. Stresses of the fixed plane plate, using a plan which pass through the centres of two exactly contrary holes, which are situated in a median plan between two neighbour holes at 0.3 MPa pressure, using COSMOSWORKS program.

Table 1

Stresses σ [N/mm²], at 0.3 MPa pressure for the fixed plane plate

r [mm]	0	7	21	36	50	66
p=0.3MPa	129.8	129.7	128.3	125.4	120.9	113.5

80	95	110	124	138	152	167
108.1	99.88	91.58	81.19	72.56	62.68	59.79

178	194	211	225	239	251
57.99	62.67	78.74	98.57	123	131.6

262	273	285
145	116	34.77

Table 2

Stresses σ [N/mm²], at 0.3 MPa pressure, for the fixed plane plate, using finite elements and analytical methods

p[MPa]	σ [N/mm²] Finite elements method	σ [N/mm²] Analytical method
0.3	145.0	182.8

We had been read the radial and circumferential deformations values, both at the increase and the decrease of the pressure, having the values: 0.0, 0.5; 1.0; 0.15; 0.2; 0.25; 0.3 MPa. We had been realized the processing of the experimental data using Mathematic program, accepting a linear variation, which depend of attempt pressure. We have been obtained the equivalent stresses values, which are represented in the table 3, using the fourth resistance criterion. So, we had been obtained the Fig. 6.

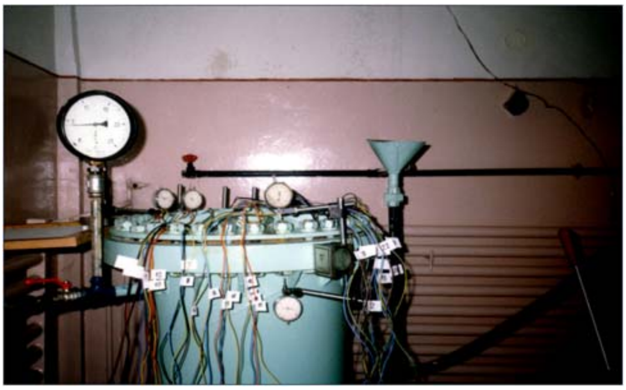

Fig. 4. Experimental stall.

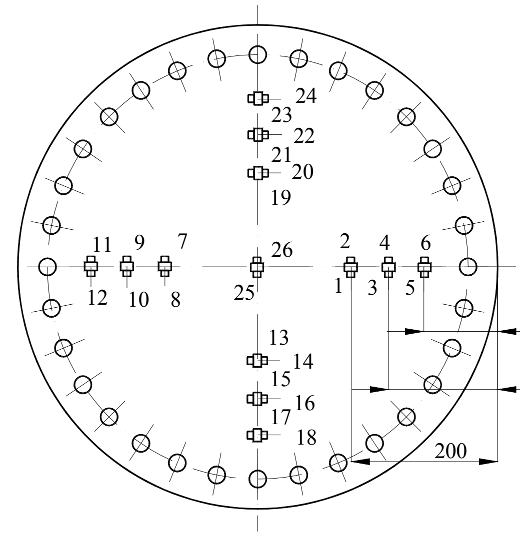

Fig. 5. The position of the strain gauges on the plane plate.

Table 3

The values of the equivalent stresses, which are theoretical and experimental calculated (MA), (MEF) and (ME), at 0.3 MPa pressure, for the plane plate

p [MPa]	*r* [mm]	σ_e [N/mm²] MA	σ_e [N/mm²] MEF	σ_e [N/mm²] ME	Obs.
0.3	0	118.8	130.1	121.3	σ_e (IV)
	125	76.1	83.8	77.2	σ_e (IV)
	175	51.0	66.7	58.2	σ_e (IV)
	225	75.0	74.4	70.7	σ_e (IV)

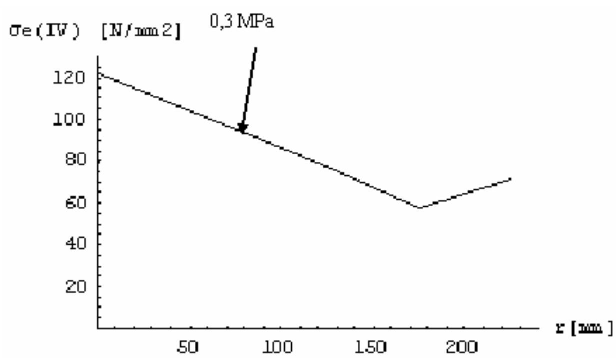

Fig. 6. The variation of the equivalent stresses which are calculated on the basis of the fourth resistance theory, for the plane plate, for 0.3 MPa pressure.

3. RIBBED PLATE ANALYZE

3.1. Elements finite method

We analyze the ribbed plate, having 32 holes, and geometrical characteristics from Fig. 7, using finite element method. We consider that the plate is fixed on circumference of the holes for the screws, like in the case of the plane plate [3].

We present the calculus variant with finite elements, using COSMOSWORKS 7.0 program, too.

The plate stresses distribution, at 0.3 MPa pressure is presented in Fig. 8.

Stresses from Fig. 9 are obtained at 0.3 pressure MPa, using a plan which pass through the centres of two exactly contrary holes, which are situated between two neighbour holes. Stresses values are given in Table 4.

3.2. Experimental method

In the experimental case, we take into account the measuring of specific linear deformations of the external points of the plate and calculus of the radial, circumferential and equivalent stresses, in the same conditions, like in the case of the plane plate, using the strain gauges [3].

The zones where the strain gauges are fixed on the plate are presented in Fig. 10. We use the strain gauges, too.

We have been obtained the equivalent stresses values, which are represented in the Table 5, using the fourth resistance criterion. So, we had been obtained Fig. 11.

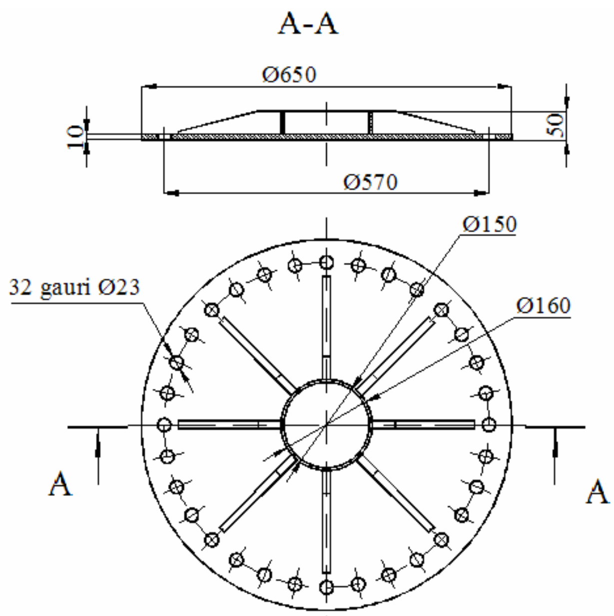

Fig. 7. Geometrical characteristics of the circular ribbed plate.

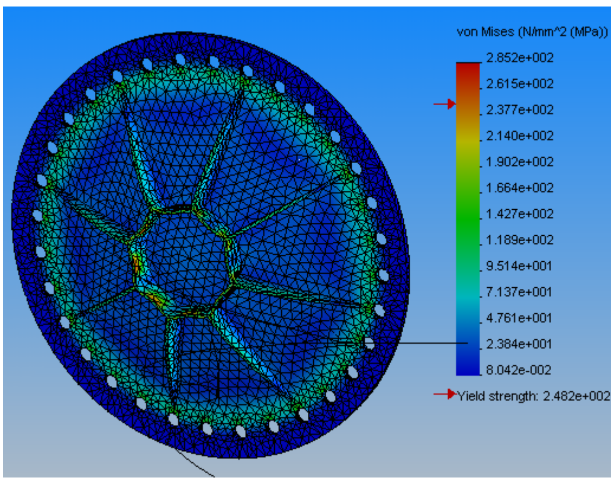

Fig. 8. Stresses of the fixed ribbed plate, at 0, 3 MPa pressure, using COSMOSWORKS 7.0 program.

Table 4

Stresses σ [N/mm²], at 0.3 MPa pressure, for the fixed plate with ribs

r [mm]	**0**	**7**	**21**	**36**	**50**	**66**	**80**	**95**	**110**	**124**	**138**	**152**	**167**	**178**	**194**	**211**	**225**	**239**	**251**	**262**	**273**	**285**
***p*=0.3MPa**	36.92	36.44	35.6	32.89	28.14	23.85	41.5	40.38	31.28	30.11	31.05	30.66	27.72	25.71	17.73	13.75	29.82	45.91	54.89	75.68	71.25	15.1

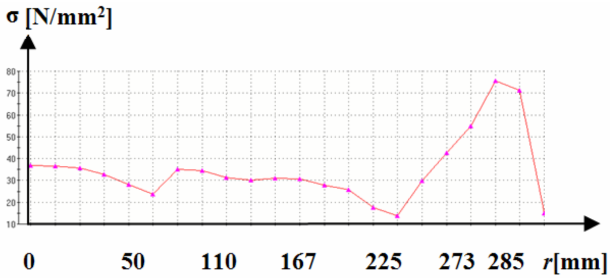

Fig. 9. Stresses of the fixed ribbed plate, using a plan which pass through the centers of two exactly contrary holes, which are situated in a median plan between two neighbor holes at 0.3 MPa pressure, using COSMOSWORKS program.

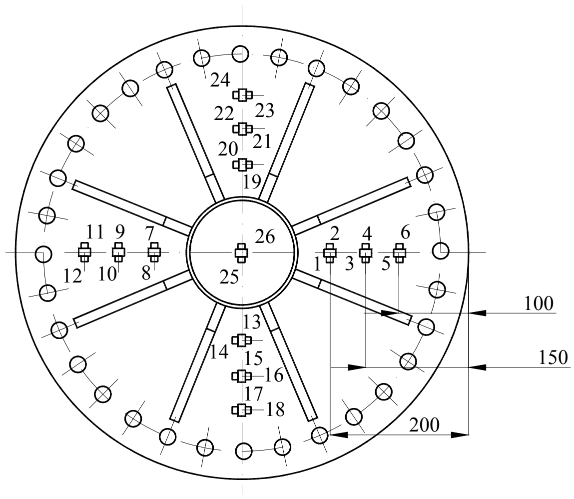

Fig. 10. The position of the strain gauges on the ribbed plate.

Table 5

The values of the equivalent stresses, which are theoretical and experimental calculated (MA), (MEF) and (ME), at 0.3 MPa pressure, for the ribbed plate

p **[MPa]**	***r*** **[mm]**	σ_e **[N/mm²]**			**Obs.**
		MA	**MEF**	**ME**	
0.3	0	-	59.00	39.20	σ_e (IV)
	125	-	54.10	32.4	σ_e (IV)
	175	-	73.0	27.10	σ_e (IV)
	225	-	81.5	66.0	σ_e (IV)

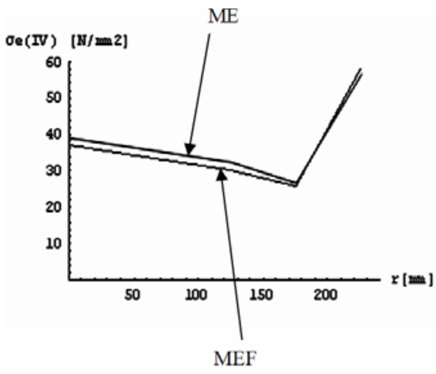

Fig. 11. The variation of the equivalent stresses which are calculated on the basis of the fourth resistance theory, for the ribbed plate, for 0.3 MPa pressure.

4. RESULT COMPARISON

We take into account the deformations, respectively stresses values, which are produced in different points of the plate. As we infer from the comparison of the results, we observe the advantage of the rigidity of the plate. In this case the values of the stresses lower about three times. Closed values are obtained using the variants of calculus: analytical, finite elements and experimental.

REFERENCES

[1] Cheung, M., Wenchang, L. (1992). *Finite strip method combined with other numerical methods for the analysis of plates*, Computers and structures, vol. 45, nr. I, 1992, pp. 79-85.

[2] Henry, W. A. (1997). *Elements of experimental stress analysis,* Pergamon Press, London, 1977**.**

[3] Popa, C. (2006). *Cercetări privind solicitările plăcilor plane circulare rigidizate cu nervuri radiale cu geometrie variabilă* (*Researces regarding stress in circular plates re-inforced with radial ribs with variable geometry*), Doctoral thesis*,* Bucharest (in Romanian).

[4] Theocaris, S. P. (1997). *Experimental stress analysis,* Edit. Technică, Bucharest.

[5] Zienkiewicz, O. (1991). *The finite element method*, vol. 1-2, Mc Graw-Hill, London, 1991.

Authors:

PhD, Radu I. IATAN, Professor, University POLITEHNICA of Bucharest, Processing Equipments Department,
E-mail: r_iatan@yahoo.com
PhD, Carmen T. POPA, Lecturer, University VALAHIA of Targoviste, Mechanical and Mecatronic Department,
E-mail: carmenpopa[1]2001@yahoo.com