International Journal of Research
eISSN: 2348-6848 & pISSN: 2348-795X Vol-5 Special Issue-13
International Conference on Innovation and Research in Engineering, Science & Technology
Held on 23rd & 24th February 2018, Organized by Tulsiramji Gaikwad Patil College of Engineering & Technology, Nagpur, 441108, Maharastra, India.

The Computer Aided Design For The Pressure Wall Structures Analysis

Vidhyadhar Kshirsagar[1] Vijay Talodhikar[2]
[1,2]Assistant Professor, Mechanical Engineering Department
Tulsiramji Gaikwad-Patil College of Engineering and Technology, Nagpur

Abstract: The paper consist of the computer aided design model of the pressure wall structure analysis and comparison of both the reference and calculated data too. Analysis of accuracy by Ansys solver analysis model of the CATIA V5 R19 system applied to analysis of pressure thin-wall structure. Comparison of analytical and FEM data.

Key words: pressure wall structure, deformation, meshing, computer aided design model

Introduction:

The pressure wall structures are the supporting members of the pressurised cylinder that are delimited by curvilinear areas with very low thickness compare to the other dimensions of the thin wall structure. The thin-wall structure is considered if $1/1000<h/Rmin<1/20$, when h is the pressure wall structure thickness and $Rmin$ is minimum curve radius of the central-line area of the thin-wall structure. For the gross thin-wall structures, means if $h/Rmin>1/20$, the shearing strains should be taken in account besides the flex straining, see fig.1.

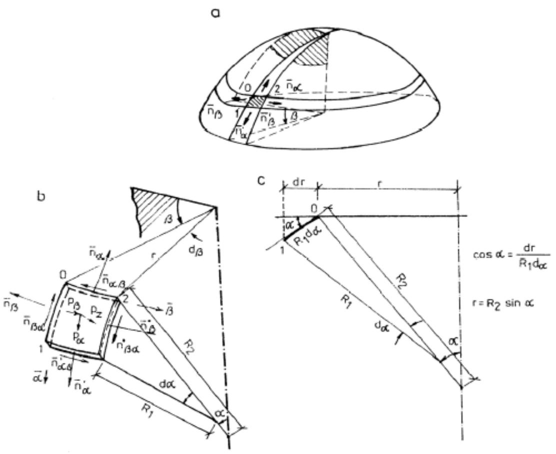

Fig.1. pressure wall structure cross-section and typical parameters

There is valid R1 = R2 = a, Pα = g sin α, Pz = g cos α, r = a sin α.

If the pressure wall structure is only nα, nβ and nαβ shirt sleeved, e.g. there is membrane forces action only, or if there is a low influence of the curving effect of the transverse forces comparing the mentioned above forces, there is possible to calculate the pressure wall structure using the diaphragm theory. The basic assumptions of the analysis are as follow:

1. The central-line area of the pressure wall structure is continuously curved
2. The pressure wall structure area load is distributed continually
3. The edges are bounded such way that there are only transmissions of the both normal forces and shear forces
4. Deformations caused from the creation of the membrane forces have only small impact on the curving effect.

Solution:

The above mentioned theory applies to detailed example of globular dome, which is distributed load g affected. The distributed load g is defined to area unit of the dome, parameter a is the radius of the globe, see fig. 2.

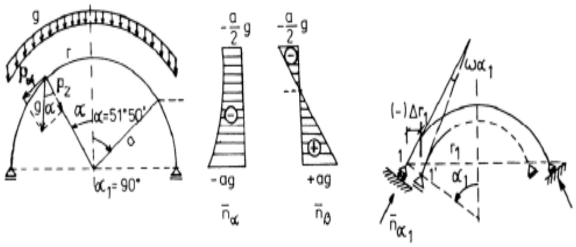

Fig.2. Globular dome affected by distributed load g to the unit of copula area, a radius of the globe.

The surface force equation is valid:

$$P_\alpha = 2\pi a^2 g \int_0^\alpha \sin\alpha \, d\alpha = 2\pi a^2 g\,(1-\cos\alpha) \qquad (1)$$

Pα is resultant force of all surface forces and it always lays in the pressurised body axle as a consequence the rotating structure geometry and Pα is positive value if it leads down.

International Journal of Research
eISSN: 2348-6848 & pISSN: 2348-795X Vol-5 Special Issue-13
International Conference on Innovation and Research in Engineering, Science & Technology
Held on 23rd & 24th February 2018, Organized by Tulsiramji Gaikwad Patil College of Engineering & Technology, Nagpur, 441108, Maharastra, India.

$$\overline{n}_\alpha = -ag\frac{1}{1+\cos\alpha} \qquad (2)$$

For the inside normal force, the equation is valid:

$$\overline{n}_\beta = ag\left(\frac{1}{1+\cos\alpha} - \cos\alpha\right) \qquad (3)$$

From the figure 2 there is known a characteristic of the inside forces. The tangential forces acting in the bottom direction make the press higher and the equal-length forces change value sign when an angle α=1/(1+cos α). The parameters of the deformation of pressure wall structure according to *u* and *w* [1], [2] are defined as follow:

$$u = A\sin\alpha\left[\ln\frac{1+\cos\alpha}{1+\cos\alpha_1} - \frac{1}{1+\cos\alpha} + \frac{1}{1+\cos\alpha_1}\right] \qquad (4)$$

$$w = A\left\{\cos\alpha\left[\ln\frac{1+\cos\alpha}{1+\cos\alpha_1} + \frac{1}{1+\mu} + \frac{1}{1+\cos\alpha_1}\right] - 1\right\} \qquad (5)$$

$$A = \frac{a^2 g(1+\mu)}{E\,h} \qquad (6)$$

For the fibre deformation per unit the equation is valid:

$$\varepsilon_\alpha = -\frac{ga}{Eh}\frac{1+\mu(1-\cos\alpha-\cos^2\alpha)}{1+\cos\alpha} \qquad (7)$$

$$\varepsilon_\beta = \frac{ga}{Eh}\frac{1-\cos\alpha-\cos^2\alpha+\mu}{1+\cos\alpha} \qquad (8)$$

There are valid equations for the pressure wall structure load stress as follow:

$$\sigma_\alpha = \frac{E}{1-\mu}(\varepsilon_\alpha + \mu\varepsilon_\beta) \qquad (9)$$

$$\sigma_\beta = \frac{E}{1-\mu^2}(\varepsilon_\beta + \mu\varepsilon_\alpha) \qquad (10)$$

The pressure wall structure deformations caused by sliding load are ignored. A slewing of the tangent line is defined using equation

$$\overline{\omega}_\alpha = -\frac{a\,g}{E\,h}(1+\mu)\sin\alpha \qquad (11)$$

And the radius extent is

$$\overline{\Delta r} = \frac{a^2 g}{E\,h}\sin\alpha\left[\frac{1+\mu}{1+\cos\alpha} - \cos\alpha\right] \qquad (12)$$

Putting the real values R1=R2=a= 500 mm; g=5Nmm-2; μ=0,3; E=2.105MPa; h=3mm, α=51°50´ to above equations, we get the result numbers: Pα=3.106N; α *n* = 1,545.103Nmm-1; *n*β= 0Nmm-1; α ω = -0,004258; Δr1 = 0,304mm.

Consequently the computer aided design model was created for the given example and found results were compared to the

The computer aided design model:

The area model based on the given dimensions has been created. Using the hardness analysis, the real dome properties were set to given area (e.g. material kind, the wall thickness, deposition, the area loading by distributed load, the grid define – mesh), see fig. 3.

The calculation was based in accordance to the considerations as follow:

1. Centre-line area of the pressure wall structure is continuously curved.

2. The load of the pressure wall structure surface is continuous over the all object area.

3. The ages are bonded such way, that only both the normal and sliding forces are relayed.

4. The shape changes due to the membrane forces generation cause negligible bending effect only.

Example was solved by FEM, what is the module Ansys\ solver CATIA V5 R19 system [3].

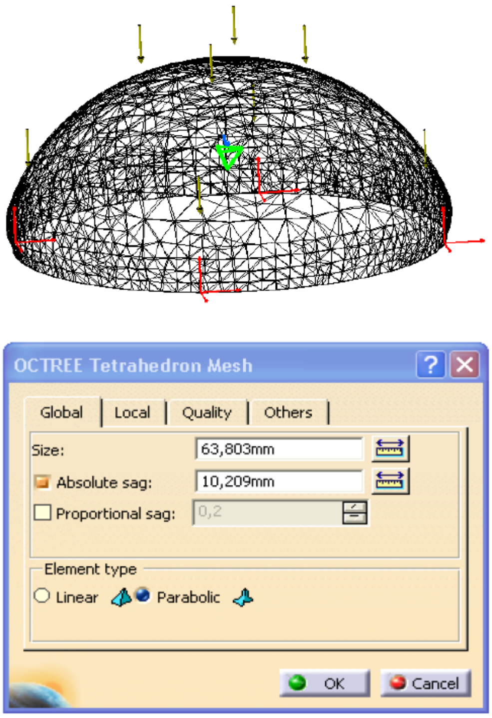

Fig.3. The computer calculation model of the cupola. Mesh typ Octree tetrahedron, Nodes 10 746, Elements 5210, Current error 6,196%, Restraint translation 1;2;3, Load - Surface for density 5 MPa,

After the hardness calculation was complete, there were the results generated as follow:
Deformation of the cupola, see fig. 4.

1. Von Mises stres, fig. 5.

2. The surface forces, see fig. 6.

3. The shape changes after animation, see fig.7a,b.

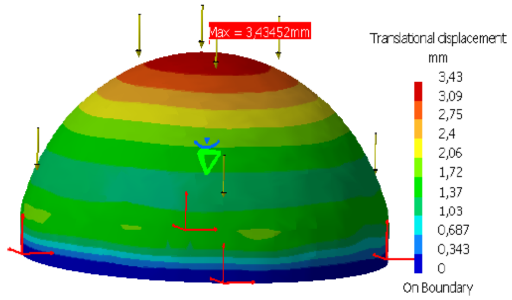

Fig.4. Deformation of the pressurized globe

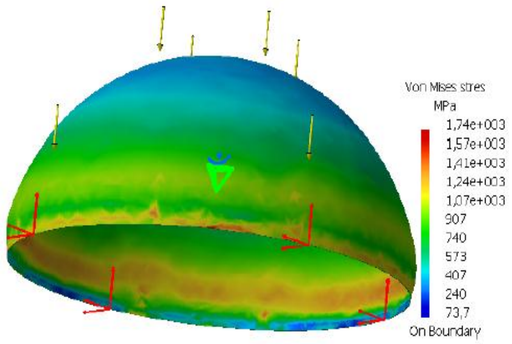

Fig.5. Von Mises stres map

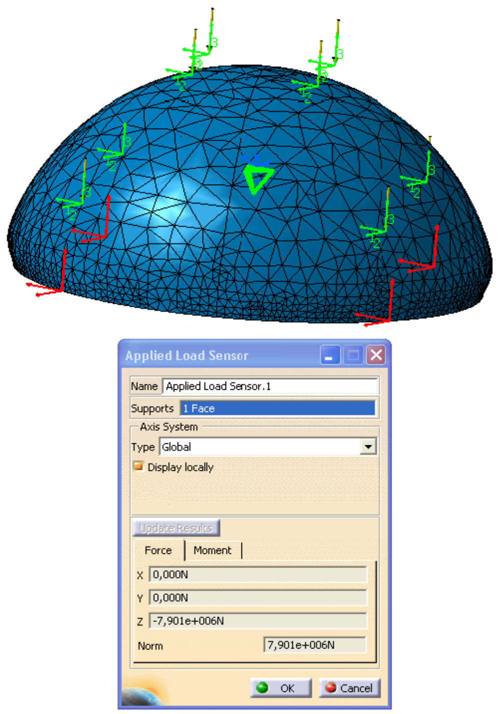

Fig.6. The surface forces Pα.

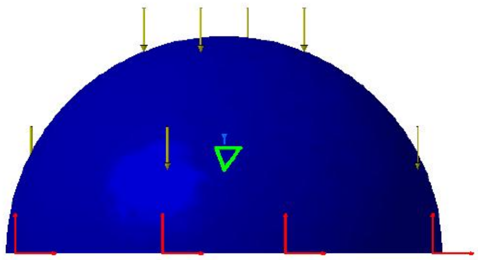

Fig.7a The shape of dome globe before the deformation

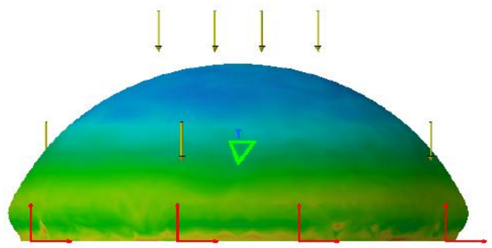

Fig.7b The shape of dome globe after the deformation

Results:

There was made a comparison of all parameters' results between the both data, calculated by the computer aided design module and analytical. See Tab. 1.

	α [°]	Δr [mm]	$P_α$ [N]	$σ_α$ [MPa]
Analytical data	0	0	0	187
	51,8	0,304	3.10^6	898
	90	2,708	$7,85.10^6$	1292
Computer data	0	0	0	330
	51,8	0,343	4.10^6	889
	90	3,43	$7,9.10^6$	1330

Conclusion:

From the above table 1, it is known that there is insignificant difference between the analytical data and computer model calculation data. The imprecision's that occurs in the calculation can be explained by parameters like: a size, kind and a number of the mesh nodal points. And more, for the purpose of the creation of dome globe bonds, such simplifications have been used those substitute slide bonds in the analytical way of calculation by solid kind (to prevent dome globe moving in the space). Conclusions resulted from mentioned above are that module Ansys solver is the sufficiently accurate for the hardness calculation of the rotating thin-wall structures too. Mainly the constructors and designers will appreciate this possible application. On the basis of the accuracy verification of Ansys solver modul calculation, several hardness analysis have been

References:

[1] E. Roos, K. Maile-Werkstoffkunnde fur Ingenieure Berlin 2005.

[2] J.R.Barber- InternediateMechanics of Materials Springer Science +Bussines Media B. V. 2000, 2011

[3] Kalaus-Dieter Arndt, Joachim Ihme, Holger Bruggemmann- Festigkeislehre fu Wirtshaftsingenieure-Springer Fachmedien GmbH
2011.

[4] S.A. Bernshtein "Soprotivlenije Materiallov", Moskva 1961.

[5] N.M. Beljajev "Soprotivlenije Materiallov" , Moskva 1962.

[6] E.P.Popov "Mechanics of Materials", 1976 New Jersey.

[7] Mac Neal, R., Harder, R. L., (1985). A Proposed Standars Set of Problems to Test Finite Element Accuracy, Finite Element Design, Vol.1, pp.3-20.

[8] Cecil G. Armstrong, Trevor T. Robinson and Hengan Ou., (2008) Recent advances in CAD/CAE Technologies for thin-walled structures design and analysis, Fifth Internacional Conference on Thin- Walled Structures, Brisbane, Australia

[9] Abramovicz, W., (2003) Thin-walled structures as impact energy absorbes, Thin-walled structures 41, p. 91-107

[7] Bischoff, M., Bletzinger, K.-U., Wal, W.A., Ramm, E., (2004), Models and Finite Elements for Thin-Walled Structures, Encyclopedia of ComputationalMechanics, John Wiley &Sons, Ltd.