

STUDIES ABOUT THE COMPUTATIONAL TECHNIQUES USED TO DESIGN AND OPTIMIZATION THE FORM OF THE FOOD INDUSTRY EQUIPMENTS

C. Tache, L. Predescu, D. Dumitru, M. Zaharia

VALAHIA University of Târgoviște, blv. Regele Carol I, no.2, 130024, Dâmbovița,
E-mail: carmen_tache@yahoo.com

Abstract

This paper presents an computational method (software MathCAD) used to calculate the dimensions for an food industry equipment, when it is knower the inside diameter, inside pressure, work temperature and capacity of the analyzed equipment.

Using this method it is obtained a data bases about the dimensions necessary to design and, after that, to optimization the form of equipment (pressure vessel).

Keywords: *computational calculus, pressure vessels, food industry*

1. INTRODUCTION

The food industry equipments are used for keeping and conservation the different fluid, solid or gas substances, and for technological purposes.

The pressure vessels are hermetical closed and working pressured (figure 1).

The component elements of pressure vessels must be designed and executed for resist to their strains (pressure, temperature) during the functioning.

In the same time, during the functioning, the pressure vessel must be hermetical closed, and must keep the shape.

The tension-cracking or breaking of the pressure vessel it is very dangerous for the environment (room and workers). For this reason it is necessary a big attention for all steps to realized the pressure

vessel, from conception and designed calculus to construction, pressure test, transportation, assemblage, functioning and periodical checking.

Assuming the resistance conditions, the gas proof ness and the rigidity of the pressure vessel, can say that the food equipment is economical realized and safe in functioning.

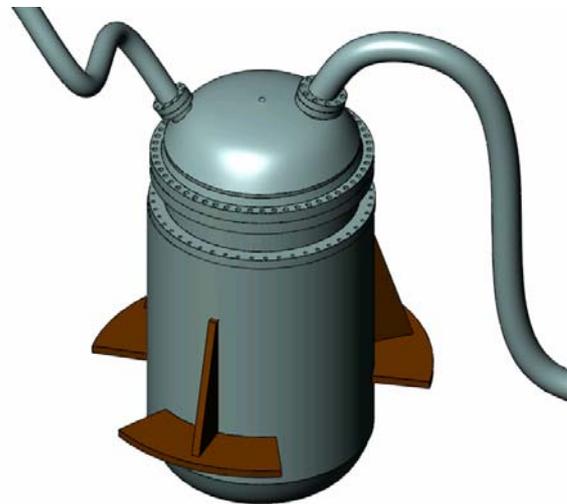
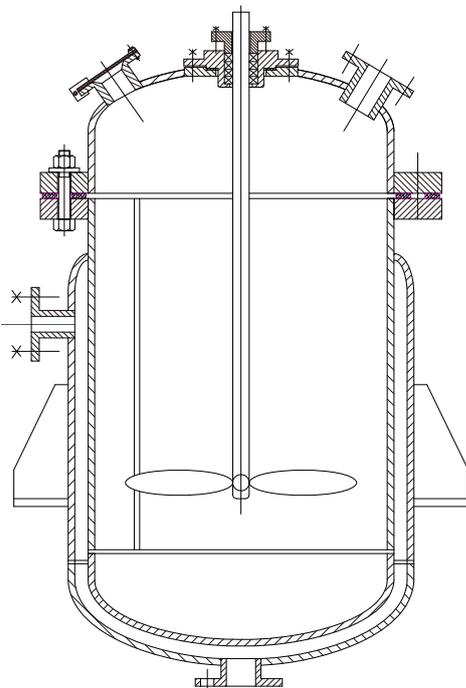


Figure 1. The pressure vessel

Figure 2. The pressure vessel (main section)

2. THE DESIGN THEME

This paper presents the utilization of some software's (Mathcad, SolidWorks) for design a

ϕ limit of material flow at the working temperature

σ_{20} breaking limit of the material at 20 degrees centigrade

pressure vessel used in food industry, beginning to the proposed theme:

Make the technical documentation for the design of a pressure vessel with slim walls, having filler inlet-outlet, and helix mixer. The pressure vessel is making by weld shell rings and is used to processing the food; it is know:

- the internal pressure: p
- working temperature: T
- the internal diameter: D_i
- the volume of the pressure vessel: V_{rec}
- the material of the pressure vessel: K47

3. EVALUATION OF THE DESIGN PARAMETERS

Beginning to the initial dates from the proposed theme, using the Mathcad software, it is determinate the values of the design parameters; these values are necessary to representation the pressure vessel, using the SolidWorks software.

$$\sigma_c := 254 \cdot \frac{N}{mm^2}$$

$$\sigma_{r20} := 500 \cdot \frac{N}{mm^2}$$

C_c safety coefficient

C_r safety coefficient

D_i the internal diameter of the recipient

Calculus of the wall thickness (s) for the cylindrical part of pressure vessel

$$A := \begin{pmatrix} \frac{\sigma_c}{C_c} \\ \frac{\sigma_{r20}}{C_r} \end{pmatrix} \quad \begin{matrix} \frac{\sigma_c}{C_c} = 1.693 \times 10^8 \text{ Pa} \\ \frac{\sigma_{r20}}{C_r} = 2.083 \times 10^8 \text{ Pa} \end{matrix}$$

$$\sigma_a := \min(A)$$

$$\sigma_a = 169.333 \frac{N}{mm^2}$$

$$\delta := \frac{p \cdot D_i}{2\phi \cdot \sigma_a - p}$$

Calculus of the design parameters

Dates:

$$D_i := 1400 \text{ mm} \quad \phi := 1$$

$$\begin{matrix} \sigma_{r200} := 464 \frac{N}{mm^2} \\ p := 25 \times 10^{-1} \frac{N}{mm^2} \\ V_{rec} := 4.5 \cdot 10^9 \frac{mm^3}{mm^2} \end{matrix} \quad \begin{matrix} C_r \\ C_c \end{matrix} := \begin{matrix} 2.4 \\ 1.5 \end{matrix}$$

where

working temperature: $T = 200$ degrees centigrade
material of the pressure vessel: K 47
coefficient of the weld resistance

$\delta = 10.412\text{mm}$ the wall thickness, resulted from the resistance calculus

$$v_c := 0.25 \frac{\text{mm}}{\text{yr}} \quad n := 10\text{yr}$$

v_c the corrosion speed $c_1 := v_c \cdot n$

n number of function years $c_1 = 2.5\text{mm}$ $c_2 := 1\text{-mm}$

$c := c_1 + c_2$ where c_1, c_2 coefficients

$$s := \delta + c$$

$s = 13.912\text{mm}$ the wall thickness for the cylindrical part of pressure vessel

The real thickness, will be:

$$s_{\text{real}} := 14\text{mm} \quad \text{STAS SR EN 10029/1994}$$

Calculus of the plate thickness for the pressure vessel bottom (s f)

$$c_3 := 1\text{-mm} \quad c_3 \text{ coefficient}$$

$$s_f := \delta + c_1 + c_2 + c_3$$

$$s_f := \left(\frac{p \cdot D_i}{2\phi \cdot \sigma_a - p} \right) + c_1 + c_2 + c_3$$

$$s_{\text{freal}} := 15\text{-mm}$$

$$s_f = 14.912\text{mm}$$

Hydraulics test

p_h the pressure for the hydraulic test

σ_{a20} the admissible resistance of the material (20 degrees centigrade)

σ_{c20} limit of the material flow (20 degrees centigrade)

$$\sigma_{c20} := 290 \frac{\text{N}}{\text{mm}^2}$$

$$\sigma_{a20} = 193.333 \frac{\text{N}}{\text{mm}^2}$$

$$\sigma_{a20} := \min(B)$$

$$B := \begin{pmatrix} \frac{\sigma_{c20}}{C_c} \\ \frac{\sigma_{r20}}{C_r} \end{pmatrix} \quad \begin{matrix} \frac{\sigma_{c20}}{C_c} = 1.933 \times 10^8 \text{Pa} \\ \frac{\sigma_{r20}}{C_r} = 2.083 \times 10^8 \text{Pa} \end{matrix}$$

σ_{at} admissible resistance of the material, to the working temperature

σ_r limit of the flow material to the working temperature

$$\sigma_r := 450 \frac{\text{N}}{\text{mm}^2}$$

$$C := \begin{pmatrix} \frac{\sigma_c}{C_c} \\ \frac{\sigma_r}{C_r} \end{pmatrix} \quad \begin{matrix} \frac{\sigma_c}{C_c} = 1.693 \times 10^8 \text{Pa} \\ \frac{\sigma_r}{C_r} = 1.875 \times 10^8 \text{Pa} \end{matrix} \quad \begin{matrix} \sigma_{at} := \min(C) \\ \sigma_{at} = 169.333 \frac{\text{N}}{\text{mm}^2} \end{matrix}$$

$$P_h := 1.25 \cdot p \cdot \frac{\sigma_{a20}}{\sigma_{at}}$$

$$P_h = 3.568 \frac{\text{N}}{\text{mm}^2}$$

σ_{ef} the effective stress which appear during the hydraulics test

$$\sigma_{ef} := \left(\frac{P_h}{2\phi} \right) \cdot \left[\left(\frac{D_i}{s_{\text{real}} - c_1 - c_2} \right) + 1 \right]$$

$$\sigma_{ef} = 239.645 \frac{\text{N}}{\text{mm}^2} \quad 0.9 \cdot \sigma_{c20} = 261 \frac{\text{N}}{\text{mm}^2}$$

The determined value of s is accepted if:

$$\sigma_{ef} \leq 0.9 \cdot \sigma_{c20} = 1 \quad (\text{positive result})$$

In this case, the determined value of s is accepted.

Calculus of the ellipsoidal cover

-the high of the bellied cover, measured in:

$$H := 0.25 D_i \quad H = 0.35\text{m}$$

-the high of the cylindrical cover part:

$$h := s_{\text{freal}} + 15\text{mm} \quad h = 0.03\text{m}$$

Calculus of the recipient volume (the high H1 of the recipient)

-the recipient volume is equal with the sum of the cylindrical parts volumes, and the calottes volumes:

$$V_{\text{rec}}(H1) := \pi \cdot 700^2 \cdot H1 + 2 \cdot \pi \cdot 700^2 \cdot 30 + \pi \cdot 700^2 \cdot 161 + 2 \cdot \left(\frac{\pi \cdot 350}{6} \right) \cdot (350^2 + 3 \cdot 700^2)$$

$$H1 := 2.32310^3 \pi$$

$$H1 := \frac{4.5 \cdot 10^9 - \left[2 \cdot \pi \cdot 700^2 \cdot 30 + \pi \cdot 700^2 \cdot 161 + 2 \cdot \left(\frac{\pi \cdot 350}{6} \right) \cdot (350^2 + 3 \cdot 700^2) \right]}{\pi \cdot 700^2}$$

4. CONCLUSIONS

The design of some equipment necessary to the food industry for preparation and conservation the food, assume some calculus more or less difficult, function of their complexity.

Thus, it is obtained the necessary dimensions for representation of the equipment shape.

Utilization of some software's (Mathcad) can permit the limitation for the time calculus, because:

- it is introduced in the program the general formulas for calculus and checking the design dimensions of equipment;
- it is calculate automatically the equipment dimensions, after introducing the initial dates.

The calculate dimensions can be automatically introduced into a data basis from a design software (SolidWorks) where can obtained (using the specifically commands) the constructive shape of the equipment.

5. REFERENCES

D.LAZAR, S.TURCU, I.VOICA, *Recipient sub presiune cu amestecator, Indrumar de proiectare*, Institutul Politehnic Bucuresti, 1979;

V.JINESCU, V. MARGINEANU, R.IATAN, I OPREAN, G.TANASE, V.CHIRIAC, *Utilajul si tehnologia constructiilor mecanice. Utilaj tehnologic.*, Ed. Didactica si Pedagogica Bucuresti, 1983;

M. ZAHARIA, C. TACHE, L.PREDESCU, D.DUMITRU, *RECIPIENTE CU PEREȚI SUBȚIRI* *Îndrumar de Proiectare*, Editura Paideia, București, 2005

Software Mathcad 11, Single user Edition;

Mathcad 11, *User's Guide*, Mathsoft Engineering & Education, Inc. Cambridge, USA, November 2002;

Software SolidWorks, 2003.

V. V. NOSACH and B. M. BELYAEV, : *"Calibrating horizontal cylindrical steel tanks by a geometric method"*, Measurement Techniques, Vol. 43, No. 9, 2000, pp. 783-788.

V. V. NOSACH and B. M. BELYAEV, : *"Salient features of procedures for geometric calibration of large vertical cylindrical tanks"*, Measurement Techniques, Vol. 46, No. 1, 2003, pp. 53-55.

O. V. SOLODUN, : *"Investigation of forced oscillations in circular cylindrical vessels separated by diametrical barriers"*, Nonlinear Oscillations, Vol. 5, No. 1, 2002, pp. 83-98.

B. V. LUNKIN, I. S. VOSTRIKOV and N. A. KRIKSUNOVA, : *"Principle of the design of the sensitive element of a radiowave transducer for measuring the amount of a liquid randomly distributed in a spherical tank"*, Measurement Techniques, Vol. 42, No. 8, 1999, pp. 769-775.