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Modular structure of the calculation of composite shell Structures - tank boiler at various types of loading

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ABSTRACT. The problems of modeling the processes of deformation of composite shell structures are considered. The systems of differential equations of motion (equilibrium) for the cylindrical and spherical parts of structures are given. We describe the modular structure of the calculation of shell structures - tank boiler.

KEYWORDS: Cylindrical and spherical shell, tank boiler, variation method, finite difference method, stress-strain state, comprehensive program.

I. INTRODUCTION

Composite shell structures (coating and overlap in construction, thermal power plants, gas and oil pipelines, high pressure vessels, car bodies, tank boilers, tunnel lining) have significant specificity of structural forms, manufacturing technology, operating conditions, physical and mechanical properties of the materials used [1-2].

Many issues related to the design of thin-walled structures and structures are brought to the study of the stress-strain state and strength of the shell structures.

Questions of modeling and automating the solution of problems of shell structures are one of the urgent problems of the mechanics of a deformable solid.

Numerous results in the field of construction of the general theory and particular problems of shells were summarized in a number of monographs of famous scientists who played a major role in the development of this science and received world recognition: V.Z. Vlasova, A.L. Goldenweiser, V.V. Novozhilova, A.I. Lurye, A. Lyava, S.P. Timoshenko, S.A. Ambartsumyan, A.S. Volmira.

Among the foreign scientists who have made a great contribution to the construction of the theory of shells, it should be noted G. Reissner, E. Meissner, V. Flyuge, L. Donnell, A.E. Green and P.M. Nagdi, V.T. Koiter, K. Trusdella, N. Hoffa.

The most common methods for solving boundary value problems of shell theory are the finite difference method, the finite element method, and the SK Numerical Integration method. Godunov.

A number of scientists were engaged in the development of calculation methods for rolling stock, in particular, tank wagons [3-6].

In [3], the main provisions for assessing the strength of cars and methods for calculating the strength of wheelsets, frames and bodies of cars, tank-boilers are set forth. In [4], a method for determining the critical pressure for a tank boiler supported by an elastic frame is described. The calculation is based on the equations of the half-moment less theory of V.Z. Vlasov shells. The solution of the resolving equation is given in the initial parameters.

In [5], a method was proposed for determining the natural oscillation frequencies of the tank shell using the Ritz method, taking into account the influence of a fluid (load) on the free oscillations of the shell, and it is assumed that the fluid is incompressible and the shell is completely filled.

In [6], the general provisions of the updated calculations of the strength of cars and their constituent parts are considered using the finite element method. It also provides information on modern software packages for computer modeling and design engineering calculations.

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When forming a computational model from the point of view of theories of V.Z. Vlasov shells, the tank boiler is considered as a composite structure consisting of a cylindrical shell associated with a spherical shell (bottom) and supported by a frame [4].

A. SETTING BOUNDARY VALUE PROBLEMS.

Using the geometric hypothesis [1], the displacements of an arbitrary point of the shell body spaced normal from the middle surface are presented.

Taking into account the Cauchy formulas and the relations of Lame coefficients, refined formulas for the definition of deformations are obtained.

It is believed that the shell structure is loaded within elastic limits, then the stress components are determined by the generalized Hooke law.

To obtain the equation of motion for the cylindrical and spherical parts of the shell structures - the tank boiler, they used the Hamilton-Ostrogradsky variational equation [2]:

$$\int_t (\delta T - \delta \Pi + \delta A)dt = 0 \tag{1}$$

In determining the variation of kinetic energy, potential energy and the work of external forces, the following relationships are used:

$$\int_t \delta T dt = \int_t \int_v \left(\rho \frac{\partial U_\alpha}{\partial t} \delta \frac{\partial U_\alpha}{\partial t} + \rho \frac{\partial U_\beta}{\partial t} \delta \frac{\partial U_\beta}{\partial t} + \rho \frac{\partial U_\gamma}{\partial t} \delta \frac{\partial U_\gamma}{\partial t} \right) dvdt, \quad \int_t \delta \Pi dt = \int_t \int_v \left(\sigma_\alpha \delta l_{\alpha\alpha} + \sigma_\beta \delta l_{\beta\beta} + \sigma_{\alpha\beta} \delta l_{\alpha\beta} \right) dVdt,$$

$$\int_t \delta A dt = \int_t \int_v \left(P_1 \delta U_\alpha + P_2 \delta U_\beta + P_3 \delta U_\gamma \right) dVdt + \int_t \int_s \left(q_1 \delta U_\alpha + q_2 \delta U_\beta + q_3 \delta U_\gamma \right) dsdt +$$

$$+ \int_t \int_{s_1} \left(\varphi_1 \delta U_\alpha + \varphi_2 \delta U_\beta + \varphi_3 \delta U_\gamma \right) dS_1 dt \Big|_\alpha + \int_t \int_{S_2} \left(f_1 \delta U_\alpha + f_2 \delta U_\beta + f_3 \delta U_\gamma \right) dS_2 dt \Big|_\beta . \tag{2}$$

A system of differential equations with boundary and initial conditions is obtained from a variational equation. To solve boundary problems, the Bubnov – Galerkin method was used:

$$U = \sum_n U_n(\alpha,t) \cos \frac{n\pi\beta}{\beta_1}, \quad V = \sum_n V_n(\alpha,t) \sin \frac{n\pi\beta}{\beta_1}, \quad W = \sum_n W_n(\alpha,t) \cos \frac{n\pi\beta}{\beta_1} \tag{3}$$

As a result, after some transformations, systems of differential equations for **cylindricalshells** were obtained [9]:

$$a_1^{(1)} \frac{\partial^2 W_n}{\partial t^2} + a_2^{(1)} \frac{\partial^4 W_n}{\partial t^2 \partial \alpha^2} - a_3^{(1)} \frac{\partial^2 V_n}{\partial t^2} - a_4^{(1)} \frac{\partial^4 W_n}{\partial \alpha^4} + a_5^{(1)} \frac{\partial^2 W}{\partial \alpha^2} - a_7^{(1)} W_n - a_8^{(1)} V_n - a_6^{(1)} \frac{\partial U_n}{\partial \alpha} + Z_n = 0;$$

$$- a_1^{(2)} \frac{\partial^2 U_n}{\partial t^2} + a_2^{(2)} \frac{\partial^2 U_n}{\partial \alpha^2} + a_4^{(2)} \frac{\partial V_n}{\partial \alpha} + a_3^{(2)} \frac{\partial W_n}{\partial \alpha} - a_5^{(2)} U_n + X_n = 0;$$

$$- a_2^{(3)} \frac{\partial^2 V_n}{\partial t^2} + a_1^{(3)} \frac{\partial^2 W}{\partial t^2} - a_4^{(3)} \frac{\partial U_n}{\partial \alpha} + a_3^{(3)} \frac{\partial^2 V_n}{\partial \alpha^2} + a_5^{(3)} W_n - a_6^{(3)} V_n + Y_n = 0; \tag{4}$$

Border conditions:

$$\left[b_1^{(1)} \frac{\partial^3 W_n}{\partial \alpha^3} - b_2^{(1)} \frac{\partial W_n}{\partial \alpha} - b_3^{(1)} \frac{\partial V_n}{\partial \alpha} - b_4^{(1)} U_n + \bar{Z}_n \right] h \delta W_n \Big|_\alpha = 0; \quad \left[- b_1^{(2)} \frac{\partial U_n}{\partial \alpha} + b_2^{(2)} W_n - b_3^{(2)} V_n + \bar{X}_n \right] h \delta U_n \Big|_\alpha = 0;$$

$$\left[b_1^{(3)} \frac{\partial W_n}{\partial \alpha} - b_2^{(3)} \frac{\partial V_n}{\partial \alpha} + b_3^{(3)} U_n + \bar{Y}_n \right] h \delta V_n \Big|_\alpha = 0; \quad \left[- b_1^{(4)} \frac{\partial^2 W_n}{\partial \alpha^2} + b_2^{(4)} W_n \bar{M}_n \right] h \delta \frac{\partial W_n}{\partial \alpha} \Big|_\alpha = 0 . \tag{5}$$

Initial conditions:

$$\left[m_1^{(1)} \frac{\partial W_n}{\partial t} - m_2^{(1)} \frac{\partial^3 W_n}{\partial t \partial \alpha^2} + m_3^{(1)} \frac{\partial^2 V_n}{\partial t \partial \alpha} \right] t_0 h \delta W_n \Big|_\alpha = 0; \quad m_1^2 \frac{\partial U_n}{\partial t} t_0 h \delta U_n \Big|_t = 0;$$

$$\left[m_1^{(3)} \frac{\partial W_n}{\partial t} + m_2^{(3)} \frac{\partial V_n}{\partial t} \right] t_0 h \delta V_n \Big|_\alpha = 0 \cdot \qquad (6)$$

For the spherical part of the shell structures, the following system of differential equations was obtained [10]:

$$-\alpha_1^{(3)} \frac{\partial^2 W_n}{\partial t^2} - \alpha_4^{(3)} \frac{\partial^2 V_n}{\partial t^2} - \alpha_2^{(3)} \frac{\partial^3 U_n}{\partial t^2 \partial \alpha} + \alpha_8^{(3)} \frac{\partial^4 W_n}{\partial t^2 \partial \alpha^2} - \alpha_6^{(3)} \frac{\partial^4 W_n}{\partial \alpha^4} - \alpha_5^{(3)} \frac{\partial^3 U_n}{\partial \alpha^3} - \alpha_9^{(3)} \frac{\partial^2 V_n}{\partial \alpha^2} + \alpha_7^{(3)} \frac{\partial^2 W_n}{\partial \alpha^2} + \alpha_{11}^{(3)} \frac{\partial W_n}{\partial \alpha} +$$

$$+ \alpha_{14}^{(3)} \frac{\partial V_n}{\partial \alpha} + \alpha_{13}^{(3)} \frac{\partial U_n}{\partial \alpha} - \alpha_8^{(3)} W_n - \alpha_{12}^{(3)} U_n - \alpha_{10}^{(3)} V_n + Z_n = 0;$$

$$-\alpha_2^{(2)} \frac{\partial^2 W_n}{\partial t^2} - \alpha_1^{(2)} \frac{\partial^2 V_n}{\partial t^2} - \alpha_8^{(2)} \frac{\partial^2 W_n}{\partial \alpha^2} + \alpha_9^{(2)} \frac{\partial^2 V_n}{\partial \alpha^2} - \alpha_5^{(2)} \frac{\partial W_n}{\partial \alpha} - \alpha_7^{(2)} \frac{\partial U_n}{\partial \alpha} - \alpha_{10}^{(2)} \frac{\partial V_n}{\partial \alpha} + \alpha_4^{(2)} W_n - \alpha_6^{(2)} U_n - \alpha_3^{(2)} V_n + Y_n = 0;$$

$$-\alpha_1^{(1)} \frac{\partial^2 U_n}{\partial t^2} + \alpha_3^{(1)} \frac{\partial^3 W_n}{\partial t^2 \partial \alpha} + \alpha_4^{(1)} \frac{\partial^2 V_n}{\partial \alpha^2} - \alpha_8^{(1)} \frac{\partial^3 W_n}{\partial \alpha^3} + \alpha_2^{(1)} \frac{\partial^2 U_n}{\partial \alpha^2} + \alpha_5^{(1)} \frac{\partial W_n}{\partial \alpha} + \alpha_9^{(1)} \frac{\partial U_n}{\partial \alpha} + \alpha_6^{(1)} \frac{\partial V_n}{\partial \alpha} + \alpha_8^{(1)} W_n - \alpha_{10}^{(1)} U_n -$$

$$-\alpha_7^{(1)} V_n + X_n = 0. \qquad (7)$$

with boundary:

$$\left[-b_1^{(1)} \frac{\partial U_n}{\partial \alpha} - b_2^{(1)} \frac{\partial^2 W_n}{\partial \alpha^2} + b_3^{(1)} W_n - b_4^{(1)} V_n - b_5^{(1)} \frac{\partial W_n}{\partial \alpha} - b_6^{(1)} U_n + X(\varphi_1) \right] h \delta U_n \Big|_\alpha = 0;$$

$$\left[-b_1^{(2)} U_n - b_2^{(2)} \frac{\partial V_n}{\partial \alpha} + b_3^{(2)} \frac{\partial W_n}{\partial \alpha} - b_4^{(2)} W_n + Y(\varphi_2) \right] h \delta V_n \Big|_\alpha = 0;$$

$$\left[-b_1^{(3)} \frac{\partial^2 U_n}{\partial t^2} + b_2^{(3)} \frac{\partial^3 W_n}{\partial t^2 \partial \alpha} - b_3^{(3)} \frac{\partial^2 U_n}{\partial \alpha^2} - b_4^{(3)} \frac{\partial^3 W_n}{\partial \alpha^3} + b_5^{(3)} \frac{\partial W_n}{\partial \alpha} - b_6^{(3)} \frac{\partial V_n}{\partial \alpha} + b_7^{(3)} W_n - b_8^{(3)} \frac{\partial^2 W_n}{\partial \alpha^2} - b_9^{(3)} \frac{\partial U_n}{\partial \alpha} + b_{10}^{(3)} U_n - \right.$$

$$\left. - b_{11}^{(3)} V_n + Z(\varphi_3) \right] h \delta W_n \Big|_\alpha = 0; \quad \left[-b_1^{(4)} \frac{\partial U_n}{\partial \alpha} - b_2^{(4)} \frac{\partial^2 W_n}{\partial \alpha^2} + b_3^{(4)} W_n - b_5^{(4)} \frac{\partial W_n}{\partial \alpha} - b_6^{(4)} U_n - \overline{M}(\varphi_1) \right] h \delta \frac{\partial W_n}{\partial \alpha} \Big|_\alpha = 0; \qquad (8)$$

and initial conditions:

$$\left[C_1^{(1)} \frac{\partial U_n}{\partial t} + C_2^{(1)} \frac{\partial^2 W_n}{\partial t \partial \alpha} \right] h \delta U_n \Big|_t = 0; \quad \left[C_1^{(2)} \frac{\partial V_n}{\partial t} + C_2^{(2)} \frac{\partial W_n}{\partial t} \right] h \delta V_n \Big|_t = 0;$$

$$\left[C_1^{(3)} \frac{\partial W_n}{\partial t} + C_2^{(3)} \frac{\partial^2 U_n}{\partial t \partial \alpha} - C_3^{(3)} \frac{\partial^3 W_n}{\partial t \partial \alpha^2} + C_4^{(3)} \frac{\partial V_n}{\partial t} \right] h \delta W_n \Big|_t = 0. \qquad (9)$$

Now the system of equations (4) - (6) and (7) - (9) can be represented in the vector form. To do this, we introduce the following vectors:

$$U_n = (W_n U_n V_n)^T; \; F_n = (Z_n X_n Y_n)^T. \qquad (10)$$

According to (10), the system of differential equations (4) can be written in the form:

$$A_1 \frac{\partial^2 U_n}{\partial t^2} + A_2 \frac{\partial^4 U_n}{\partial t^2 \partial \alpha^2} + A_3 \frac{\partial^4 U_n}{\partial \alpha^4} + A_4 \frac{\partial^2 U_n}{\partial \alpha^2} + A_5 \frac{\partial U_n}{\partial \alpha} + A_6 U_n + E F_n = 0 \qquad (11)$$

Here the matrix A_i has a third order

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$$A_1=\begin{pmatrix}-a_1^{(1)} & 0 & -a_3^{(1)}\\ 0 & -a_1^{(2)} & 0\\ a_1^{(3)} & 0 & -a_2^{(3)}\end{pmatrix};\ A_2=\begin{pmatrix}a_2^{(1)} & 0 & 0\\ 0 & 0 & 0\\ 0 & 0 & 0\end{pmatrix};A_3=\begin{pmatrix}-a_4^{(1)} & 0 & 0\\ 0 & 0 & 0\\ 0 & 0 & 0\end{pmatrix};A_4=\begin{pmatrix}a_5^{(1)} & 0 & 0\\ 0 & a_2^{(2)} & 0\\ 0 & 0 & a_3^{(3)}\end{pmatrix};$$

$$A_5=\begin{pmatrix}0 & -a_6^{(1)} & 0\\ a_3^{(2)} & 0 & a_4^{(2)}\\ 0 & -a_4^{(3)} & 0\end{pmatrix};A_6=\begin{pmatrix}-a_7^{(1)} & 0 & -a_8^{(1)}\\ 0 & -a_5^{(2)} & 0\\ a_5^{(3)} & 0 & -a_6^{(3)}\end{pmatrix};\ E=\begin{pmatrix}1 & 0 & 0\\ 0 & 1 & 0\\ 0 & 0 & 1\end{pmatrix}.$$

Elements of the matrix A_i are given in [9,12].

The initial conditions (6) are written in the vector form:

$$\left[M_1\frac{\partial U_n}{\partial t}+M_2\frac{\partial^3 U_n}{\partial t\partial\alpha^2}+M_3\frac{\partial^2 U_n}{\partial t\partial\alpha}\right]\tau_0 h\delta U_n\Big|_t=0 \quad (12)$$

Here

$$M_1=\begin{pmatrix}m_1^{(1)} & 0 & 0\\ 0 & m_1^{(2)} & 0\\ m_1^{(3)} & 0 & m_2^{(3)}\end{pmatrix};M_2=\begin{pmatrix}-m_2^{(1)} & 0 & 0\\ 0 & 0 & 0\\ 0 & 0 & 0\end{pmatrix};M_3=\begin{pmatrix}0 & 0 & m_3^{(1)}\\ 0 & 0 & 0\\ 0 & 0 & 0\end{pmatrix}.$$

Now, following the vector notation (10), the system of differential equations (7) can be represented as:

$$A_1\frac{\partial^2 U_n}{\partial t^2}+A_2\frac{\partial^4 U_n}{\partial t^2\partial\alpha^2}+A_3\frac{\partial^3 U_n}{\partial t^2\partial\alpha}+A_4\frac{\partial^4 U_n}{\partial\alpha^4}+A_5\frac{\partial^3 U_n}{\partial\alpha^3}+A_6\frac{\partial^2 U_n}{\partial\alpha^2}+A_7\frac{\partial U_n}{\partial\alpha}+A_8U_n+EF_n=0 \quad (13)$$

The initial conditions are also written in the vector form:

$$\left[B_1\frac{\partial U_n}{\partial t}+B_2\frac{\partial^2 U_n}{\partial t\partial\alpha}+B_3\frac{\partial^3 U_n}{\partial t\partial\alpha^2}\right]h\delta U_n\big|_t=0 \quad (14)$$

Here matrices A_i and B_i are of third order [10,12].

B.APPLICATION OF THE FINITE DIFFERENCE METHOD (FOR THE CYLINDRICAL PART).

To the solution of the boundary value problem (11), (5) and (6), we apply the method of finite differences of the second order of accuracy [2, 7, 8]. Introduce the grid $\overline{\omega}_{h\tau}=\{\alpha=ih,t_k=k\tau(i=0,1,...,N;k=0,1,...k)\}$ with step $h=\frac{1}{N}$ and $\tau=\frac{T}{k}$ respectively on the segments $0\le\alpha\le1$; $0\le t\le T$, $U_{ni}^{(k)}=\left[W_{ni}^kU_{ni}^kV_{ni}^k\right]^T$ -net functions in the region $\overline{\omega}_{h\tau}$.

The vector equation (11), the initial condition (6) after approximation have the form:

$$B_nU_{n,i-1}^{k+1}+C_nU_{n,i}^{k+1}+B_nU_{n,i+1}^{k+1}+\overline{A}_nU_{n,i-2}^{k}+\overline{B}_nU_{n,i-1}^{k}+\overline{C}_nU_{n,i}+\overline{D}_nU_{n,i+1}^{k}+\overline{A}_nU_{n,i+2}^{k}+B_nU_{n,i-1}^{k-1}+C_nU_{n,i}^{k-1}+$$
$$+B_nU_{n,i+1}^{k-1}-\tau^2F_{n,i}^k=0.(15)$$

$$\left[\overline{M}_1U_{n,i-1}^{k+1}+\overline{M}_2U_{n,i}^{k+1}+\overline{M}_3U_{n,i+1}^{k+1}-\overline{M}_1U_{n,i+1}^{k+1}-\overline{M}_1U_{n,i-1}^{k-1}-\overline{M}_2U_{n,i}^{k-1}-\overline{M}_3U_{n,i+1}^{k-1}\right]t_0h\delta U_{n,i+1}^{k-1}=0\,(16)$$

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We believe that the cylindrical shell is clamped at $\alpha=0$ and $\alpha=1$. In this case, the boundary conditions in the vector form are written as:

$$U_{n,0}^{j}=0;\ A'U_{n,-1}^{j}=A'U_{n,1}^{j};\ U_{n,N}^{J}=0;\ A'U_{n,N+1}^{j}=A'U_{n,N-1}^{j} \quad (17)$$

The systems of difference equations (15) are rewritten taking into account the boundary conditions (17) when $i=1,2,\ldots,N-2,N-1$. As a result, we have the following system of equations:

$$B_n U_{n,i-1}^{k+1}+C_n U_{n,i}^{k+1}+B_n U_{n,i+1}^{k+1}=b_{n,i}, \quad (18)$$

where

$$b_{n,i}=\tau^2 F_{n,i}^{k}-(\overline{A}_n U_{n,i-2}^{k}+\overline{B}_n U_{n,i-1}^{k}+\overline{C}_n U_{n,i}^{k}+\overline{D}_n U_{n,i+1}^{k}+\overline{A}_n U_{n,i+2}^{k}+B_n U_{n,i-1}^{k-1}+C_n U_{n,i}^{k-1}+B_n U_{n,i+1}^{k-1}).$$

The solution to this equation can be written as:

$$U_{n,i}^{k+1}=f_i-H_i U_{n,i+1}^{k+i} \quad (19)$$

where $f_i=(C_n-B_n H_{i-1})^{-1}(b_{n,i}-B_n f_{i+11})$, $H_i=(C_n-B_n H_{i-1})^{-1}B_n$

From the formula (19) when $i=N-1$ we have:

$$U_{n,N-1}^{k+1}=f_{N-1}-H_{N-1}U_{n,N}^{k+1} \quad (20)$$

Here $U_{n,N}^{k+1}$ on the border is zero, it means

$$U_{n,N-1}^{k+1}=f_{N-1}\quad,\quad f_{N-1}=(C_n-B_n H_{N-2})^{-1}(b_{n,N-1}-B_n f_{N-2}). \quad (21)$$

During the reverse pass, the other values of the displacement vector $U_{n,i}^{k}$ are determined.

C.THE MODULAR STRUCTURE OF THE CALCULATION.

Note that on the basis of the above algorithm, a modular structure has been developed for solving problems of shell structures - tank boiler and describes the structure of the software package. A comprehensive program is implemented in C # in MS Windows.

Analytical solutions and numerical results are obtained for analyzing the stress – deformed state of the composite shell structures of the boiler tank under various types of loading. The nature of changes in the calculated values for different values of the intensity of external loads and boundary conditions is shown.

In the process of creating a modular structure, the main attention was paid to the following principles [9]: 1) the principle of a systems approach; 2) taking into account the prospects for the development of computer hardware; 3) the principle of the optimal combination of user capabilities - by designers and automation; 4) the principle of ensuring flexibility, sustainability and reliability of operation; 5) the principle of creating an algorithmic system for calculating shell structures.

As noted, the basic principle of constructing algorithms and software systems is the principle of modularity, which is that the program with the help of which the general problem is solved must consist of several modules.

A module is a sequence of logically related operations that performs a well-defined function and is designed as a separate program. The purpose of the module is to perform certain transformations of the original data into a unique result.

Based on the numerical implementation algorithm, a software package was developed and implemented using modules designed as procedures and functions.

The complex of programs works in the dialogue mode. As a result of the dialogue, the parameters are set: the geometrical and mechanical characteristics of the shell.

The created interface assumes output of the calculation results, in the form of tables and graphs, and recording them in individual files for further consideration and analysis.

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On the basis of the developed models and a set of programs, studies of the stress – deformed state of the shell under various types of loading and boundary conditions were carried out.

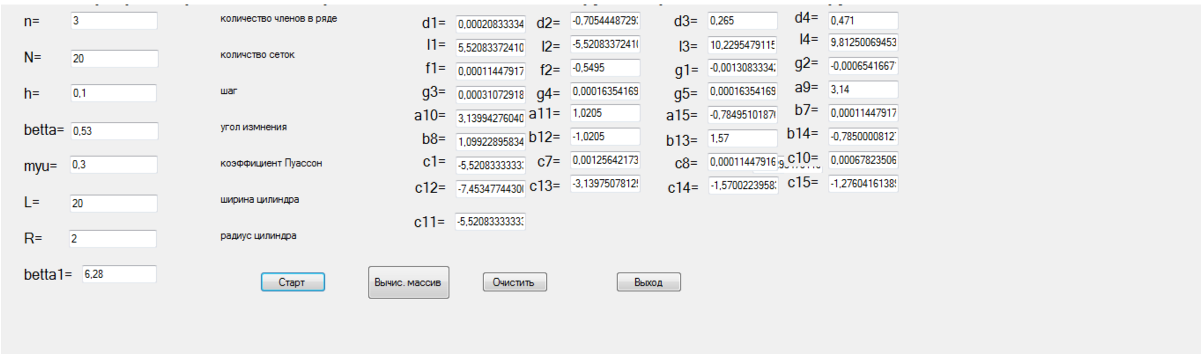

Fig.1. Inputting raw data and calculating coefficients

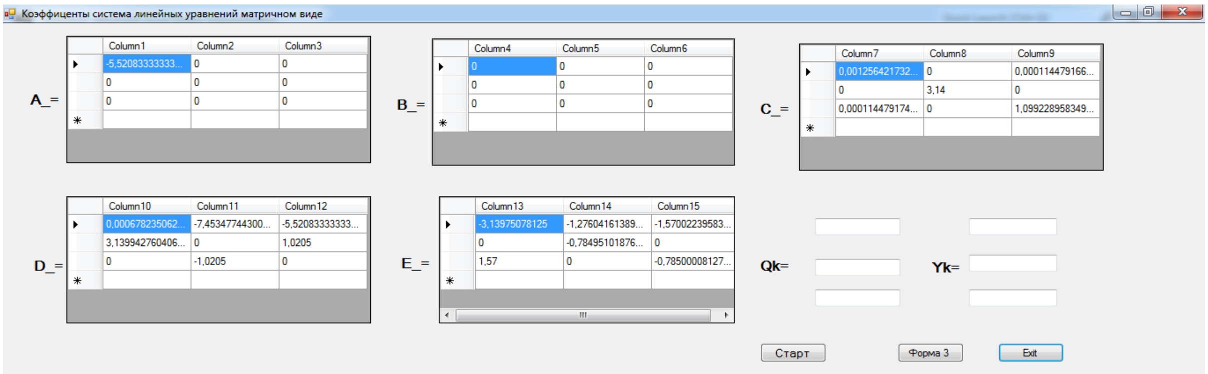

Fig.2. Calculations of coefficients of the system of differential equations

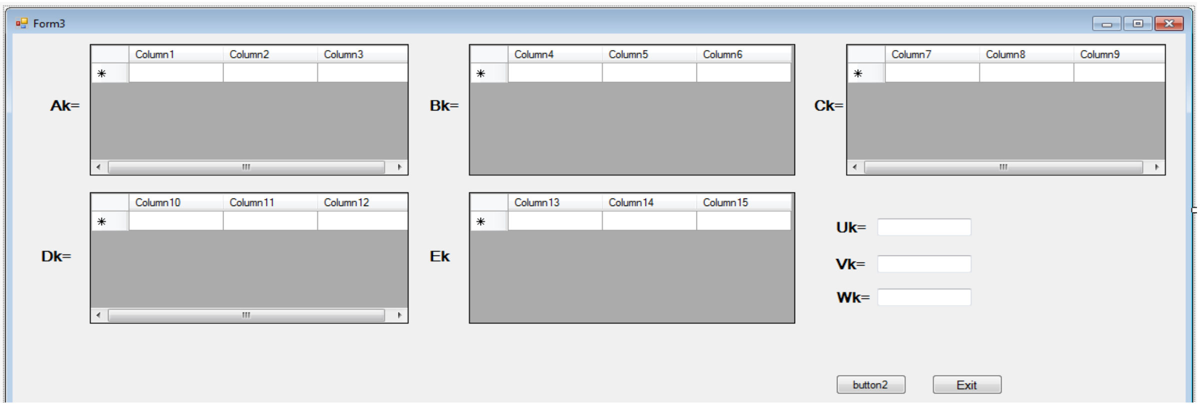

Fig.3. Calculations of coefficients of algebraic equations and displacement components

The maximum value of the strain and stress. **Table 1.**

10^5N Indicators		$F_1 = 5.6$	$F_2 = 5.8$	$F_3 = 6.0$	$F_4 = 6.2$	$F_5 = 6.4$
axle def. mm. 10^2	X	0,15174	0,15716	0,15716	0,168	0,17342
	Y	2,2827	2,3543	2,3643	2,5273	2,6089
	z	0,8348	0,8646	0,8647	0,9243	0,9541

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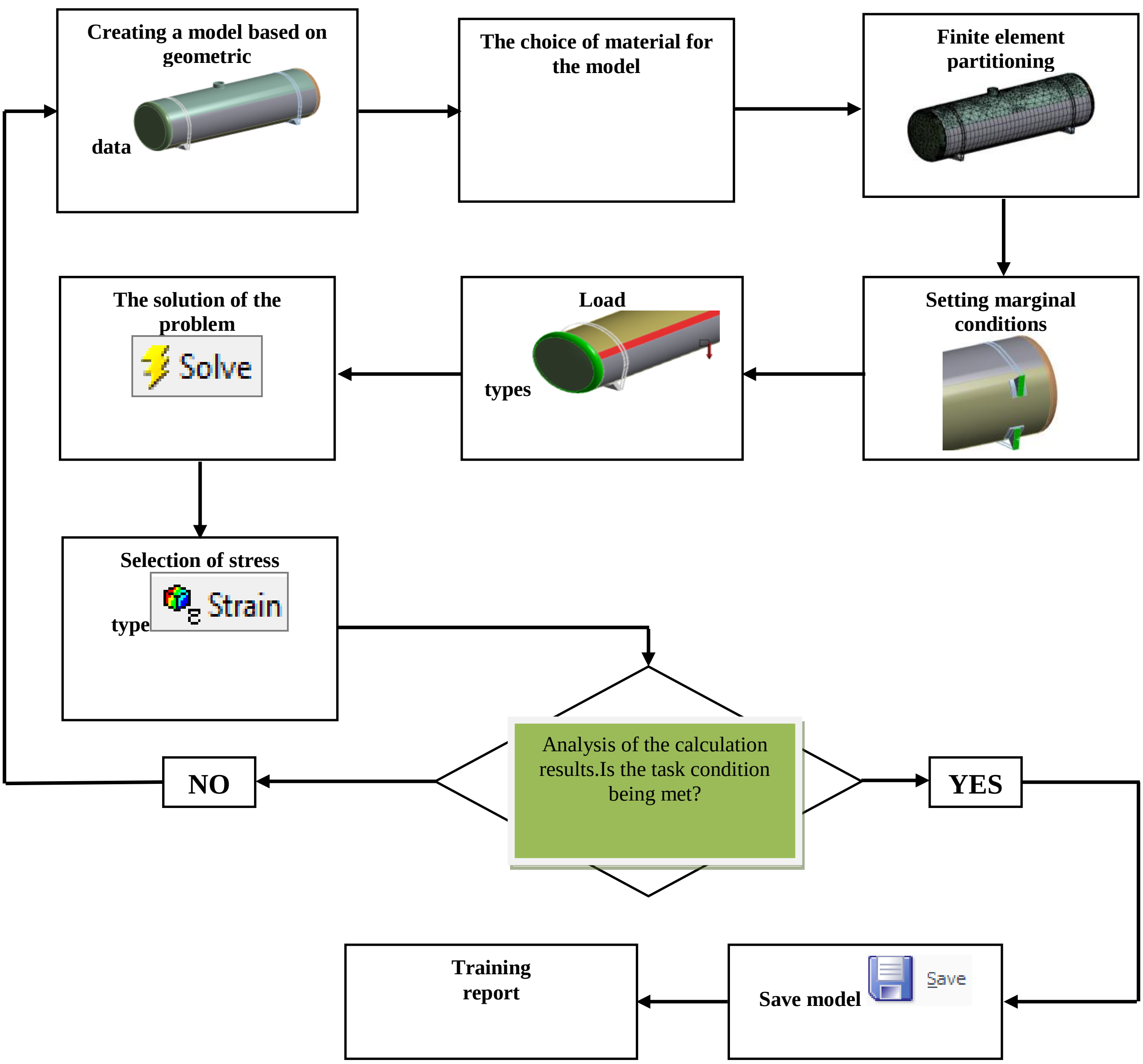
Normal tense MPa.10^{-5}	σ_x	5,9013	6,1121	6,1121	6,5336	6,7443
	σ_y	2,3254	2,6126	2,6156	2,7961	2,8862
	σ_z	2,8732	2,9758	2,9758	3,1813	3,8371
Catel. Tension MPa.10^{-5}	τ_{xy}	1,9866	2,0575	2,0575	2,1994	2,2704
	τ_{xz}	1,6974	1,7581	1,7582	1,8973	1,9399
	τ_{yz}	4,1315	4,2791	4,2791	4,5742	4,7218

For comparative analysis, the stress - strain state of the composite shell structures of the boiler tank was calculated using the ANSYS complex. The implementation of the calculation algorithm is attached in the form of Form-1.

Form-1.



II. COUNCLUSION

A system of differential equations of motion (equilibrium) is obtained for the cylindrical part of shell structures with boundary and initial conditions. To solve boundary-value problems, the combined method, the Bubnov-Galerkin method and the finite-difference method are used.

The structure of the software package for solving boundary problems of shell structures of the boiler tank is described. For comparative analysis, the stress - strain state of the composite shell structure - tank boiler using the ANSYS complex was calculated.

REFERENCES

[1] Vlasov V.Z. The general theory of shells and its applications in engineering - M.: Gostekhizdat, 1949, 761c.
[2] Buriev T. Algorithmization of the calculation of the bearing elements of thin-walled structures. T.: Izd. "Fan", 1986, - 244s
[3] Vershinsky S.V. and others. Calculation of cars for strength. - M.: Mashinostroenie, 1971.-432s.
[4] Koturanov V.N. The loading elements of the structures of cars. M.: Transport, 1991.-238c.
[5] Osipov T.A. Determination of natural frequencies of tank boilers. Proceedings of MIIT, 1968, p. 71-79
[6] Morchiladze I.G., Sokolov A.M., Sokolov M.M. Design, construction, calculation and testing of cars. M.: IBS-Holding, 2009.-522c.
[7] Godunov S.K., Ryabenky V.S. Difference schemes. M. Science, 1973. 400 p.
[8] Samara A.A., Nikolayev E.S. Methods for solving grid equations. –M.: Science, 1978,589 p.
[9] Abdusattarov A., Yuldashev T., Sabirov N.Kh., Rasulmukhamedov MM. The equations of motion and the formation of difference boundary value problem of composite shell structures // Proceedings of the International Scientific Conference "The current state and prospects for the development of structural mechanics", Samarkand, SamGASI, 2017, June 16-17, p.115-120
[10] Abdusattarov A., Yuldashev T., Sabirov N.Kh. To the formation of a difference boundary value problem of the spherical part of composite shell structures // Vestnik TashIIT, 2017, №1, p. 35-44
[11] Abdusattarov A., Sabirov N.Kh., Rasulmukhammedov M.M. The program for calculating cylindrical shell structures under static loads // Agency on Intellectual Property of the Republic of Uzbekistan. Certificate №DGU 05551. 08/10/2018
[12] Sabirov N.Kh., Abdusattarov A., Yuldashev, T. Equity of the order of calculating the conical part of shell structures // The European Science Review, Austria, 2017, №9-10, p35 -41.