v_i – flow velocity components (i = 1, 2) on the axes x, y.

In equation (85), summation is carried out over the index i. Let's transform the complex plane $z = x + iy$ into a plane $\xi = \xi + i\eta$ by means of a function $\xi = f(z)$. We will denote the velocity potential and the flow function by $\varphi(x, y)$ and $\psi(x, y)$, and will introduce new variables

$$\xi = \psi(x, y); \ \eta = \varphi(x, y). \tag{86}$$

In this case, equation (83) will be:

$$\frac{\partial^2 T}{\partial \xi^2} + \frac{\partial^2 T}{\partial \eta^2} = k\frac{\partial^2 T}{\partial \eta} + \frac{k}{v^2}\frac{\partial T}{\partial t}. \tag{87}$$

Where: $v^2 = v_x^2 + v_y^2$.

Equation (87) represents the Fourier-Kirchhoff equation for transformed flow. In the case of a stationary problem ($dT/dt = 0$), it does not depend on v. This fact obviously simplifies its solution.

Regular heat and mass transfer systems. Heat exchange under high temperatures is often accompanied by physical and chemical phenomena of medium destruction and mass transfer. In this connection, physical fields will be described by the corresponding system of differential equations. Let's consider a continuum with transfer process under the n generalized forces. The energy conservation law will be represented by the gradients of their potentials φ_i:

$$\alpha_k \frac{\partial \varphi_k}{\partial t} = \sum_{i=1}^{n} \operatorname{div}\left(L_{ik} \operatorname{grad} \varphi_i\right) + f_k, \tag{88}$$

(k = 1, 2, …, n),

Where: L_{ik} – Onsager coefficients, determined by physical constants;

α_k – particular constants (for example, is φ_k – temperature, then $\alpha_k = c_k\rho_k$);

$f_k = w_k/\alpha_k$ – internal energy sources.

Quadratic form allows transforming the system of differential equations (88) of heat and mass transfer into the system:

$$\mu\partial\varphi \Big/ \partial t = \sum_{i=1}^{n} L_{ik}\,\Delta\varphi_i + w_i, \tag{89}$$

Where: μ – characteristic number of matrix A,

$$A = \left(L_{ik}\right),\ i, k = 1, 2, \ldots, n; \tag{90}$$

L_{ik} – real coefficients.

In general cases, functions of internal energy flow are nonlinear and depend on temperature and other parameters. For example, in case of a chemical oxidation reaction

$$w = g(T) - \lambda\nabla T - \omega(\rho), \tag{91}$$

Where: $g(T)$ – *particular* function of a chemical energy source;

$\lambda\nabla T$ – intrinsic energy loss by conduction;

$\omega(\rho)$ – losses related to internal energy exchange. In each particular case, the function us determined from physical considerations. In solving the system of differential equations (89), equations of mass continuity and multi-component mixture motion are also taken into account. If the latter is a viscous liquid, then the Navier-Stokes equation is used:

$$\dot{v} = \overline{F} - 1/\rho \operatorname{grad} P + v\nabla^2 v + v/3 \operatorname{grad} \operatorname{div} \overline{v}, \tag{91}$$

Where: $\dot{v}$ – kinematic viscosity factor;

P – pressure;

F – volume force.

The system (89) usually solved by the so-called eigen-functions or by numerical methods.

3. RESULTS AND DISCUSSION

We have considered the theory of interaction of any foundation with any foundation bed following the mathematical modeling of large systems in performing three mathematical spaces:

H^n – qualitative characteristics;

H^m – discrete parameters (DP);

H^k – continuous parameters (CP).

This allowed us to take into account all possible and conceivable variety of foundation soils (rock formations). Well-known mathematical models of deformable body behavior have been systematized for the first time. This includes elastic deformable body, viscoelastic deformable body; models of plastic and flowing medium; models of fluid motion and gas flow; models of thermal conductivity and of heat and mass transfer. Developed basis for mathematical modeling of interaction of foundations with foundation bed allows bringing the knowledge about these processes to real situation in the most adequate way.

Mathematical model presented in the paper allows making any experiment along with the representation of real systems S_1 –foundation and S_2 –foundation bed in any medium and for any time interval. The final conclusion of the research on this issue gives grounds to suggest that alternative solutions do not exist. In popular foreign works, such approach to the issue is not found [15, 16]. The theory of mathematical modeling of LS is a linear phenomenon, according to the way of foundations interacting foundation beds. In the Republic of Kazakhstan, it is widely used by authors in the field of mining sciences. In our opinion, science will be developing if the theoretical bases of mathematical modeling of LS presented in the article are applied.

4. CONCLUSION

In the article, the full spectrum of physical processes and their mathematical models have been systematized following the theory of mathematical modeling of large systems in the interaction of any foundation with any foundation bed (rock formation) for the first time. A complete description of all currently known models of physical processes in the interaction of foundations with foundation beds is of paramount importance not only in the theory of foundations and foundation beds, but also in designing surface and underground structures. This article is a leading one due to a generalization of all currently known physical processes in the interaction of foundations with foundation beds.

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