SOME GAS-DYNAMIC FUNCTIONS IN EQUILIBRIUM FLUXES OF DISSOCIATING NITROGEN TETROXIDE

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Expressions are obtained for various gas-dynamic functions of dissociating nitrogen tetroxide, taking account of the nonideality of the gas.

As is known dissociating nitrogen tetroxide is a promising heat carrier and working medium for nuclear power plants.

Gas-dynamic functions must play a large role in solving various problems in the dynamics of a reacting system

$$N_2O_4 \rightleftarrows 2NO_2 \rightleftarrows 2NO + O_2.$$

A series of important gas-dynamic functions are now derived. In [1], it was found that*

$$\frac{T_0}{T} = 1 + \frac{1}{\eta}\frac{k_T - 1}{k_T}\left\{\frac{1}{2}x^2M^2 - [(Z_{ef})_{p_0,T} - (Z_{ef})_{p,T}]\right\}, \tag{1}$$

where

$$x^2 = \frac{Z_{ef}^2}{\eta - \frac{R}{\mu_{N_2O_4} C_{pef}}\omega^2}. \tag{2}$$

Relating the critical velocities of the dissociating and ideal gases through the correction coefficient ξ_{cr}, the following expression may be written

$$a_{cr}^2 = \xi_{cr}^2 2\frac{k}{k+1}\frac{R}{\mu_{N_2O_4}}T_0. \tag{3}$$

The sound velocity in dissociating gas was obtained in [1] in the form

$$a = x\sqrt{\frac{RT}{\mu_{N_2O_4}}}. \tag{4}$$

Transforming from Eq. (4) to the critical velocity, i.e., taking $T = T_{cr}$, it is found that

$$a_{cr}^2 = x_{cr}^2\frac{RT_{cr}}{\mu_{N_2O_4}}. \tag{5}$$

According to Eqs. (3) and (5)

$$\xi_{cr}^2 = \frac{k+1}{2k}x_{cr}^2\frac{T_{cr}}{T_0}. \tag{6}$$

Since $Ma = \lambda a_{cr}$, solving Eqs. (3) and (4) simultaneously gives

$$M^2x^2T = \lambda^2\xi_{cr}^2 2\frac{k}{k+1}T_0$$

or, substituting x^2M^2 from here into Eq. (1), appropriate transformations give an expression for the gas-dynamic function in the form

$$\frac{T_0}{T} = \left\{1 + \frac{1}{\eta}\frac{k_T - 1}{k_T}[(Z_{ef})_{p,T} - (Z_{ef})_{p_0,T}]\right\}\left(1 - \frac{1}{\eta}\frac{k_T - 1}{k_T}\frac{k}{k+1}\xi_{cr}^2\lambda^2\right)^{-1}. \tag{7}$$

*In the present work, a zero subscript denotes stagnation parameters.

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Using the equation of the adiabatic of the dissociating gas

$$\frac{T_0}{T} = \left(\frac{p_0}{p}\right)^{\frac{k_T-1}{k_T}}, \tag{8}$$

an expression is written for another gas-dynamic function

$$\frac{p_0}{p} = \left\{1 + \frac{1}{\bar{\eta}} \frac{k_T - 1}{k_T} \left[(Z_{\mathrm{ef}})_{p,T} - (Z_{\mathrm{ef}})_{p_0,T}\right]\right\}^{\frac{k_T}{k_T-1}} \left(1 - \frac{1}{\bar{\eta}} \frac{k_T - 1}{k_T} \frac{k}{k+1} \xi_{\mathrm{cr}}^2 \lambda^2\right)^{-\frac{k_T}{k_T-1}}. \tag{9}$$

Then the equations of state

$$p_0 = \rho_0 (Z_{\mathrm{ef}})_{p_0,T_0} \frac{R}{\mu_{N_2O_4}} T_0,$$

$$p = \rho (Z_{\mathrm{ef}})_{p,T} \frac{R}{\mu_{N_2O_4}} T \tag{10}$$

lead to the function

$$\frac{\rho_0}{\rho} = \frac{(Z_{\mathrm{ef}})_{p,T}}{(Z_{\mathrm{ef}})_{p_0,T_0}} \left\{1 + \frac{1}{\bar{\eta}} \frac{k_T - 1}{k_T} \left[(Z_{\mathrm{ef}})_{p,T} - (Z_{\mathrm{ef}})_{p_0,T}\right]\right\}^{\frac{1}{k_T-1}} \left(1 - \frac{1}{\bar{\eta}} \frac{k_T - 1}{k_T} \frac{k}{k+1} \xi_{\mathrm{cr}}^2 \lambda^2\right)^{-\frac{1}{k_T-1}}. \tag{11}$$

In the above expressions

$$\frac{k_T - 1}{k_T} = \frac{R}{\mu} \frac{\omega}{C_{p\mathrm{ef}}}, \tag{12}$$

$$\bar{\eta} = \frac{1}{2} (\eta_0 + \eta). \tag{13}$$

The coefficients η and ω for dissociating nitrogen tetroxide take the following form [2]

$$\eta = (1 + \alpha_{10} + \alpha_{10}\alpha_{20}) \left(1 + \sum_{i=1}^{3} \sum_{j=0}^{4} \frac{a_{ij}\pi^i}{\tau^j}\right) - p \left\{(1 + \alpha_{10} + \alpha_{10}\alpha_{20}) \times \right.$$
$$\times \left(\frac{\partial Z}{\partial p}\right)_T - \left(1 + \sum_{i=1}^{3} \sum_{j=0}^{4} \frac{a_{ij}\pi^i}{\tau^j}\right) \left[(1 + \alpha_{20}) \frac{\alpha_{10}(1 - \alpha_{10})}{6p} \times \right.$$
$$\left.\left. \times (1 + \alpha_{10} + \alpha_{10}\alpha_{20})(3 + \alpha_{20}) + \frac{\alpha_{10}\alpha_{20}(1 - \alpha_{20})}{6p} (1 + \alpha_{10} + \alpha_{10}\alpha_{20})\right]\right\}, \tag{14}$$

where

$$\left(\frac{\partial Z}{\partial p}\right)_T = \frac{1}{p} \left[\pi \left(a_{10} + \frac{a_{11}}{\tau} + \frac{a_{12}}{\tau^2} + \frac{a_{13}}{\tau^3} + \frac{a_{14}}{\tau^4}\right) + \right.$$
$$\left. + 2\pi^2 \left(a_{20} + \frac{a_{21}}{\tau} + \frac{a_{22}}{\tau^2} + \frac{a_{23}}{\tau^3} + \frac{a_{24}}{\tau^4}\right) + 3\pi^3 \left(a_{30} + \frac{a_{31}}{\tau} + \frac{a_{32}}{\tau^2} + \frac{a_{33}}{\tau^3} + \frac{a_{34}}{\tau^4}\right)\right]. \tag{15}$$

The expression for ω takes the form

$$\omega = Z(1 + \alpha_{10} + \alpha_{10}\alpha_{20}) + T \left[(1 + \alpha_{10} + \alpha_{10}\alpha_{20}) \left(\frac{\partial Z}{\partial T}\right)_p + \right.$$
$$+ \left(1 + \sum_{i=1}^{3} \sum_{j=0}^{4} \frac{a_{ij}\pi^i}{\tau^j}\right) \left\{(1 + \alpha_{20}) \frac{\alpha_{10}(1 - \alpha_{10})}{6RT^2} \left[\Delta H_{p1}(3 + 3\alpha_{10} - \alpha_{20} + \right.\right.$$
$$+ \alpha_{10}\alpha_{20}) + \alpha_{20}\Delta H_{p2}(2 + 3\alpha_{10} + \alpha_{10}\alpha_{20})\right] +$$
$$\left.\left. + \frac{\alpha_{10}\alpha_{20}(1 - \alpha_{20})}{6RT^2} \left[\Delta H_{p2}(2 + \alpha_{10}\alpha_{20}) - \Delta H_{p1}(1 - \alpha_{10})\right]\right\}\right], \tag{16}$$

where

$$Z = \left(1 + \sum_{i=1}^{3} \sum_{j=0}^{4} \frac{a_{ij}\pi^i}{\tau^j}\right); \tag{17}$$

$$\left(\frac{\partial Z}{\partial T}\right)_p = -\frac{1}{T}\left[\pi\left(\frac{a_{11}}{\tau}+\frac{2a_{12}}{\tau^2}+\frac{3a_{13}}{\tau^3}+\frac{4a_{14}}{\tau^4}\right)+\right.$$

$$\left.+\pi^2\left(\frac{a_{21}}{\tau}+\frac{2a_{22}}{\tau^2}+\frac{3a_{23}}{\tau^3}+\frac{4a_{24}}{\tau^4}\right)+\pi^3\left(\frac{a_{31}}{\tau}+\frac{2a_{32}}{\tau^2}+\frac{3a_{33}}{\tau^3}+\frac{4a_{34}}{\tau^4}\right)\right]. \tag{18}$$

The coefficients a_{1j}, a_{2j}, and a_{3j} are taken from Table 1 of [1]. Values of ΔH_{p1} and ΔH_{p2} are also given in [1] (see also [3]).

It will be taken into account below that

$$Z_{ef} = Z\varepsilon, \tag{19}$$

where

$$\varepsilon = 1+\alpha_{10}+\alpha_{10}\alpha_{20}. \tag{20}$$

The quantity C_{pef} appearing the Eq. (12) is taken from the table of [4], which was compiled on the basis of experimental specific-heat values C_{pef} of the system

$$N_2O_4 \rightleftarrows 2NO_2 \rightleftarrows 2NO + O_2$$

in the gas phase [5]. The quantity ξ_{cr} appearing in Eqs. (7), (9), and (11) must be determined.

The velocity of sound in dissociating nitrogen tetroxide may be written in the form

$$a = y\sqrt{k\frac{R}{\mu_{N_2O_4}}T}, \tag{21}$$

where

$$y = (Z_{ef})_{p,T}/k\sqrt{\eta - \frac{R}{\mu_{N_2O_4}C_{pef}}\omega^2}. \tag{22}$$

The critical velocity of dissociating nitrogen tetroxide may evidently be written in the form

$$a_{cr} = y_{cr}\sqrt{k\frac{R}{\mu_{N_2O_4}}T_{cr}}, \tag{23}$$

$$y_{cr} = (Z_{ef})_{p_{cr},T_{cr}}/k\sqrt{\eta_{cr} - \frac{R}{\mu_{N_2O_4}(C_{ef})_{cr}}\omega^2_{cr}}. \tag{24}$$

The critical velocity of the dissociating gas may be related through the correction coefficient ξ_{cr} to the expression for the critical velocity of an ideal gas

$$a_{cr} = \xi_{cr}\sqrt{2\frac{k}{k+1}\frac{R}{\mu_{N_2O_4}}T_0}. \tag{25}$$

Solving Eqs. (23) and (25) simultaneously, it is found that

$$\xi^2_{cr} = \frac{k+1}{2}y^2_{cr}\frac{T_{cr}}{T_0}. \tag{26}$$

Determining the value of the critical temperature from Eq. (7) with $\lambda = 1$ and $T = T_{cr}$ and substituting it into Eq. (26), the result obtained, after appropriate transformations, is

$$\xi^2_{cr} = \frac{k+1}{2}y^2_{cr}\left[1+\frac{1}{\eta}\frac{k_T-1}{k_T}\left\{\frac{k}{2}y^2_{cr} - [(Z_{ef})_{p_0,T_{cr}} - (Z_{ef})_{p_{cr},T_{cr}}]\right\}\right]^{-1}. \tag{27}$$

Expansion of Eq. (27) gives

$$\xi^2_{cr} = \frac{k+1}{y^2_{cr}}\left[1+\frac{1}{\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\left\{\frac{k}{2}y^2_{cr}[(1+\alpha_{10}+\alpha_{10}\alpha_{20})_{p_0,T_{cr}}\times\right.\right.$$

$$\left.\left.\times\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)_{p_0,T_{cr}} - (1+\alpha_{10}+\alpha_{10}\alpha_{20})_{p_{cr},T_{cr}}\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)_{p_{cr}T_{cr}}\right]\right\}\right]^{-1}. \tag{28}$$

Taking account of Eqs. (12), (19), and (20), Eqs. (7), (9), and (11) are reduced successively to the form

$$\frac{T_0}{T} = \left\{1+\frac{1}{\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}[(Z_{ef})_{p,T} - (Z_{ef})_{p_0,T}]\right\}\left(1-\frac{1}{\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\frac{k}{k+1}\xi^2_{cr}\lambda^2\right)^{-1}, \tag{29}$$

$$\frac{p_0}{p}=\left\{1+\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}[(Z_{ef})_{p,T}-(Z_{ef})_{p_0,T}]\right\}^{\varkappa_T-1}\left(1-\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\frac{k}{k+1}\xi^2_{cr}\lambda^2\right)^{\varkappa_T-1}, \quad (30)$$

$$\frac{\rho_0}{\rho}=\frac{(Z_{ef})_{p,T}}{(Z_{ef})_{p_0,T_0}}\left\{1+\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}[(Z_{ef})_{p,T}-(Z_{ef})_{p_0,T}]\right\}^{-\frac{1}{k_T-1}}\left(1-\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\frac{k}{k+1}\xi^2_{cr}\lambda^2\right)^{-\frac{1}{k_T-1}}. \quad (31)$$

Equations (29)-(31) are gas-dynamic functions as a ratio of the stagnation parameters to the parameters of a flux of dissociating nitrogen tetroxide.

For an ideal gas, where $\alpha_{10}=0$; $\alpha_{20}=0$; $\bar\eta=1$; $\omega=1$; $\xi_{cr}=1$; $k_T=k$, Eqs. (29)-(31) take the usual form for a perfect gas, that is

$$\left(\frac{T_0}{T}\right)_{id}=\left(1-\frac{k-1}{k+1}\lambda^2_{id}\right)^{-1}, \quad (32)$$

$$\left(\frac{p_0}{p}\right)_{id}=\left(1-\frac{k-1}{k+1}\lambda^2_{id}\right)^{-\frac{k}{k-1}}, \quad (33)$$

$$\left(\frac{\rho_0}{\rho}\right)_{id}=\left(1-\frac{k-1}{k+1}\lambda^2_{id}\right)^{-\frac{1}{k-1}}. \quad (34)$$

Now consider other gas-dynamic functions that take a large value when introduced in the corresponding calculations. The continuity equation is used in the form

$$G=\rho wF. \quad (35)$$

Then using the equation of state

$$p_0=(Z_{ef})_{p_0,T_0}\,\rho\,\frac{R}{\mu_{N_2O_4}}T_0, \quad (36)$$

and also $\lambda = w/a_{cr}$, and taking account of Eqs. (23) and (11), Eq. (35) is written in the form

$$G=\frac{Fp_0}{\frac{R}{\mu_{N_2O_4}}T_0}(1+\alpha_{10}+\alpha_{10}\alpha_{20})^{-1}_{p,T}\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)^{-1}_{p,T}\times$$
$$\times\xi_{cr}\sqrt{2\frac{k}{k+1}\frac{R}{\mu_{N_2O_4}}T_0}\;\lambda\left\{1+\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\times\right.$$
$$\times\left[(1+\alpha_{10}+\alpha_{10}\alpha_{20})_{p,T}\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)_{p,T}-(1+\alpha_{10}+\alpha_{10}\alpha_{20})_{p_0,T}\times\right.$$
$$\left.\left.\times\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)_{p_0,T}\right]\right\}^{\frac{1}{k_T-1}}\left(1-\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\frac{k}{k+1}\xi^2_{cr}\lambda^2\right)^{-\frac{1}{k_T-1}}. \quad (37)$$

The flow rate, expressed in terms of the actual pressure in the given cross section, may be written if the stagnation pressure value from Eq. (9) is substituted into Eq. (37). Then it is found that

$$G=pF(1+\alpha_{10}+\alpha_{10}\alpha_{20})^{-1}_{p,T}\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)_{p,T}\xi_{cr}\sqrt{2\frac{k}{k+1}\frac{1}{R/\mu_{N_2O_4}T_0}}\;\lambda\left\{1+\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\times\right.$$
$$\times[(1+\alpha_{10}+\alpha_{10}\alpha_{20})_{p,T}\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)_{p,T}-$$
$$\left.-(1+\alpha_{10}+\alpha_{10}\alpha_{20})_{p_0,T}\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)_{p_0,T}]\right\}\left(1-\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\frac{k}{k+1}\xi^2_{cr}\lambda^2\right)^{-1}. \quad (38)$$

Now consider another gas-dynamic function, the reduced gas flow rate, i.e., the dimensionless current density

$$q=\frac{\rho w}{(\rho w)_{cr}}. \quad (39)$$

Taking account of Eq. (11) and bearing in mide that $w = a_{cr}\lambda$, the numerator of Eq. (39) is written in the form

$$\rho w = \lambda a_{cr}\rho_0 \frac{(Z_{ef})_{p_0,T_0}}{(Z_{ef})_{p,T}}\left\{1+\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\left[(Z_{ef})_{p,T}-(Z_{ef})_{p_0,T}\right]\right\}^{-\frac{1}{k_T-1}}\times$$
$$\times\left(1-\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\frac{k}{k+1}\xi_{cr}^2\lambda^2\right)^{\frac{1}{k_T-1}}. \quad (40)$$

As for an ideal gas, the reduced flow-rate function of dissociating nitrogen tetroxide is zero when $\lambda = 0$ and

$$\lambda = \frac{1}{\sqrt{\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\frac{k}{k+1}\xi_{cr}^2}}.$$

Taking $\lambda = 1$, the expression for the denominator in Eq. (39) is obtained in the form

$$(\rho w)_{cr} = a_{cr}\rho_0\frac{(Z_{ef})_{p_0,T_0}}{(Z_{ef})_{p_{cr},T_{cr}}}\left\{1+\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\left[(Z_{ef})_{p_{cr}T_{cr}}-\right.\right.$$
$$\left.\left.-(Z_{ef})_{p_0,T_{cr}}\right]\right\}^{-\frac{1}{k_T-1}}\left(1-\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\frac{k}{k+1}\xi_{cr}^2\right)^{\frac{1}{k_T-1}}. \quad (41)$$

Substituting ρw from Eq. (40) and $(\rho w)_{cr}$ from Eq. (41) into Eq. (39), and also taking account of the expression for (Z_{ef}), the gas-dynamic function of the reduced flow rate for dissociating nitrogen tetroxide is written in the expanded form

$$q = \lambda(1+\alpha_{10}+\alpha_{10}\alpha_{20})_{p_{cr},T_{cr}}\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)_{p_{cr},T_{cr}}\times$$
$$\times(1+\alpha_{10}+\alpha_{10}\alpha_{20})^{-1}_{p,T}\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)_{p,T}\left\{1+\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\times\right.$$
$$\times\left[(1+\alpha_{10}+\alpha_{10}\alpha_{20})_{p,T}\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)_{p,T}-(1+\alpha_{10}+\alpha_{10}\alpha_{20})_{p_0,T}\times\right.$$
$$\left.\left.\times\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)_{p_0,T}\right]\right\}^{-\frac{1}{k_T-1}}\left(1-\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\times\right.$$
$$\left.\times\frac{k}{k+1}\xi_{cr}^2\lambda^2\right)^{\frac{1}{k_T-1}}\left\{1+\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\left[(1+\alpha_{10}+\alpha_{10}\alpha_{20})_{p_{cr},T_{cr}}\times\right.\right.$$
$$\times\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)_{p_{cr},T_{cr}}-(1+\alpha_{10}+\alpha_{10}\alpha_{20})_{p_0,T_{cr}}\times$$
$$\left.\left.\times\left(1+\sum_{i=1}^{3}\sum_{j=0}^{4}\frac{a_{ij}\pi^i}{\tau^j}\right)_{p_0,T_{cr}}\right]\right\}^{\frac{1}{k_T-1}}\left(1-\frac{1}{\bar\eta}\frac{R}{\mu_{N_2O_4}}\frac{\omega}{C_{pef}}\frac{k}{k+1}\xi_{cr}^2\right)^{-\frac{1}{k_T-1}}. \quad (42)$$

On passing from dissociating to ideal gas $k_t = k$, $Z_{ef} = 1$, $\bar\eta = 1$, $\xi_{cr} = 1$, the result is a function known in gas dynamics for a perfect gas

$$q_{id} = \left(\frac{k+1}{2}\right)^{\frac{1}{k-1}}\lambda_{id}\left(1-\frac{k-1}{k+1}\lambda_{id}^2\right)^{\frac{1}{k-1}}. \quad (43)$$

As shown in [1, 2], all the gas-dyamic dependences of a perfect gas are absolutely inapplicable to dissociating gases, i.e., in the heat carriers and working media of nuclear power plants. The complication of the expressions obtained for the gas-dynamic functions of dissociating gas result from the physicochemical and thermophysical properties of these gases.

As is known, a favorable influence on the thermophysical properties of chemically reacting systems comes from the presence of large thermal effects in both stages of the reaction.

That heating of the gas is accompanied by heat absorption and consequently by decrease in molecular mass and increase in the gas content, while cooling of the gas is associated with heat liberation, resulting in increase in molecular mass and decrease in the gas constant, is sharply reflected in the structure of the formulas obtained.

It is sufficient to say that the complexity of the gas-dynamic functions obtained is directly related to the physics of the phenomena. For example, ε in Eq. (26) is the total number of moles as a result of dissociation. In Eq. (26), the degree of dissociation of both first-order and second-order reactions is taken.

In addition, all the gas-dynamic functions include the quantities η, ω, ξ_{cr}, and R/μ, depending also on the degree of dissociation. The desired quantities are greatly influenced by the effective isobaric specific heat C_{pef}, which is high in dissociating gases. Then, it must be noted that the quantity $k_T - 1/k_T$ appearing in all the expressions for the gas-dynamic functions, according to Eq. (12), depends also on C_{pef}, R/μ, and ω.

Thus, these considerations indicate, with great reliability, that the thermophysical and chemical properties of dissociating gases have a great influence on the gas-dynamic functions obtained.

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TWO METHODS OF CALCULATING THE VELOCITY PROFILE OF A NON-NEWTONIAN LIQUID IN CYLINDRICAL CHANNELS OF ARBITRARY CROSS SECTION

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Two approaches to solving the problem of the flow of non-Newtonian liquid in cylindrical channels of arbitrary cross section are analyzed: variational and iterative approaches.

Formulation of the Problem

In the hydromechanis of non-Newtonian liquid, the problem of the velocity distribution in laminar steady flow in cylindrical singly connected channels of arbitrary cross section is known to be very interesting and of great practical importance.

The system of motion and continuity describing the given problem may be written in the form

$$\frac{\partial}{\partial \chi_1}\left(\mu(I_2)\frac{\partial V}{\partial \chi_1}\right)+\frac{\partial}{\partial \chi_2}\left(\mu(I_2)\frac{\partial V}{\partial \chi_2}\right)=-\frac{\partial P}{\partial z}=\text{const}, \quad (1)$$

$$\frac{\partial V}{\partial z}=0 \quad (2)$$

with the boundary condition

$$V|_\Gamma=0, \quad (3)$$

where the second invariant of the deformation-rate tensor is

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