DETERMINATION OF CRITICAL PARAMETERS OF COMPRESSION FLOW IN A QUASI-CONSISTENT APPROXIMATION DUE TO GAS DYNAMIC IMPACT OF A GAS-TIGHT PISTON ON A TWO-DIMENSIONAL TARGET

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A flow of double wave type is considered during expansion of a polytropic gas into a vacuum along an oblique wall, which is described by a self-similar solution to the relevant initial boundary value problem (IBVP) at $\gamma = 5/3$ [1]:

$$c_1(\xi) = \left(2M(\xi)\right)^{-1}\left(3 + c_0^2\left(\operatorname{tg}^2\alpha - 2\right)\right)\Big/\sqrt{2 + c_0^2\left(\operatorname{tg}^2\alpha - 2\right)},$$

$$2M(\xi) = -6c_0^3 + 2.25c_0^3\operatorname{tg}^2\alpha + 3c_0^3\operatorname{tg}^{-2}\alpha + \frac{17\sqrt{2}}{8}c_0^3\left(\operatorname{tg}^2\alpha - 2\right)^{3/2}\operatorname{arctg}\sqrt{\frac{1}{2}\left(\operatorname{tg}^2\alpha - 2\right)} + \qquad (1)$$

$$+\,9.5 - \frac{1}{4}c_0^2\left(\operatorname{tg}^2\alpha - 2\right) - \left(2 + c_0^2\left(\operatorname{tg}^2\alpha - 2\right)\right)^{-1} - \frac{17\sqrt{2}}{8}c_0^3\left(\operatorname{tg}^2\alpha - 2\right)^{3/2}\operatorname{arctg}c_0\sqrt{\frac{1}{2}\left(\operatorname{tg}^2\alpha - 2\right)}.$$

In a quasi-consistent approximation, gas-dynamic flow parameters are specified by the following functions

$$c(\xi,\vartheta) = c_0(\xi) + c_1(\xi)\vartheta,\quad u(\xi,\vartheta) = u_0(\xi) + u_1(\xi)\vartheta,\quad v(\xi,\vartheta) = v_1(\xi)\vartheta. \qquad (2)$$

We interpret the solution of the initial IBVP in a quasi-consistent approximation in terms of compression when the starting moment of the gas motion in the double wave is negative $t_0 < 0,$ then the critical value of the speed of sound in the double wave c_0^* is determined by the following condition

$$c_0^* = \min\left\{\left(\frac{\beta}{\beta - \operatorname{tg}^2\alpha}\right)^{\varkappa/(1-\varkappa)}, M(\xi) = 0\right\}. \qquad (3)$$

If this condition is met, there is some peculiarity of the generated solution at the c_0^* point. By definition,

$$c_1(\xi) = \left.\frac{\partial c}{\partial\vartheta}\right|_{\vartheta=0},\ \text{then}\ \lim_{c_0\to c_0^*}\left.\frac{\partial c}{\partial\vartheta}\right|_{\vartheta=0} = \infty,$$

i. e. a gradient catastrophe occurs.

In the context of gas dynamics, presence of the obtained solution peculiarity means that there is a strong discontinuity of the $c(\xi,\vartheta)$ function at the c_0^* point during shock-free compression of an enclosed volume, which results in a change of the flow pattern within the double wave area and in formation of a shock wave. Figure 1 illustrates the $c_0^*(\alpha)$ dependence for different values of γ.

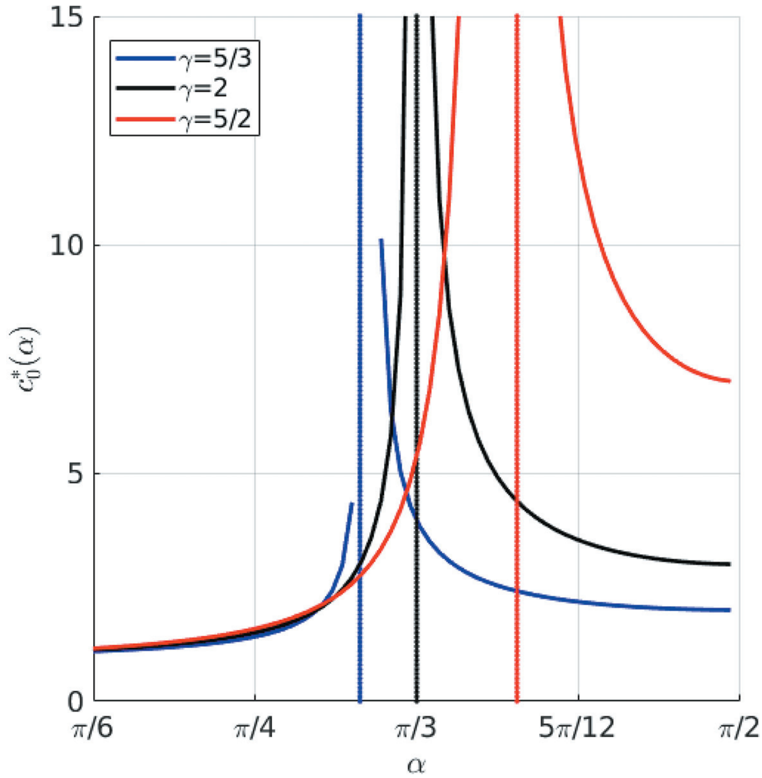

Fig. 1. c_0^* as a function of γ and α

References

1. **Ponkin, E. I.** Construction of a self-similar solution to the system of gas dynamics equations describing the outflow of polytropic gas into vacuum from an inclined wall in the inconsistent case [Text] // Journal of Samara State Technical University. Ser. “Physical and Mathematical Sciences”. – 2023. – Vol. 27, No. 2. – P. 336–356.