flow; 1, magnitude relating to the distributor channel; l, to the magnitudes relating to the porous wall and the inlet main line a subscript was not assigned.

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EFFECT OF THE INLET TEMPERATURE ON ENERGY DISTRIBUTION IN EDDY THERMOTRANSFORMERS

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The article presents the results of the experimental investigation of the effect of energy separation in eddy thermotransformers with inlet temperatures of the working substance $500 \leq T_1^* \leq 2000°K$.

Rank's eddy thermotransformers, operating at inlet temperatures $T_1^* > 500°K$, are used in aircraft, rocket, and power engineering for solving a number of specific problems [1]. At such temperatures the magnitude of the effect of thermotransformation may be greatly influenced by the variability of the thermophysical properties of the working substance. To find more accurate characteristics of high-temperature eddy thermotransformers, experimental investigations were carried out with a carefully insulated cylindrical pipe with diameter $d_{pi} = 20$ mm and relative length $l = L/d_{pi}$ equal to 9 times the bore, and with a rectification cross at the hot end.

The experimental setup was a gas generator which made it possible to ascertain the flow rate of the working substance with specified parameters being fed to the inlet of the swirler of the eddy thermotransformer.

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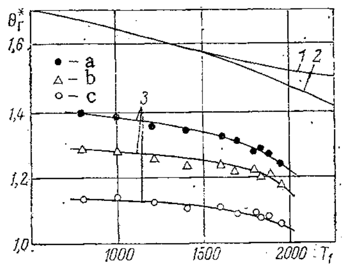

Fig. 1

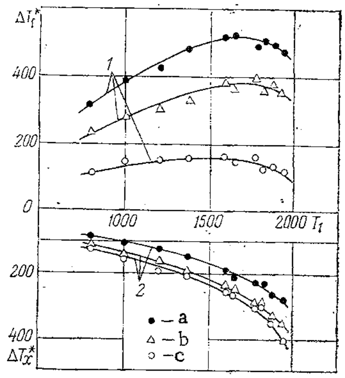

Fig. 2

Fig. 1. Values of the relative heating effects: 1, 2) theory, with and without dissociation taken into account, respectively; 3) experiment; $\overline{l}_K = 9$; $\overline{F}_c = 0.1$; $\overline{r}_d = 0.5$; $P_1^* = 0.5$ MPa; a) $\mu = 0.81$; b) 0.7; c) 0.51; 1, 2) 0.7.

Fig. 2. Absolute values of the heating effect ΔT_h^* and of the cooling effect ΔT_x^* on the inlet temperature: $\overline{l}_K = 9$; $\overline{F}_c = 0.1$; $\overline{r}_d = 0.5$; $P_1^* = 0.5$ MPa; 1) ΔT_h^* K; 2) ΔT_x^* K; a–c) see Fig. 1.

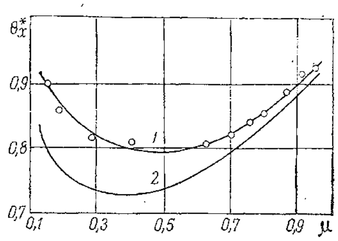

Fig. 3. Dependence of the relative magnitudes of the cooling effects on the mass fraction of the cool flow: $\overline{l}_K = 9$; $\overline{F}_c = 0.1$; $\overline{r}_d = 0.5$; $P_1^* = 0.5$ MPa; $T_1^* = 1940$°K; 1) experiment; 2) calculation.

Pressures were measured with manometers of accuracy class 1.5, and temperatures were measured with thermocouples groups KhK, KhA, and PP. Secondary apparatus in temperature measurements were automatic recorders type KSP-4 with the corresponding graduations. Flow rates were measured with standard nozzles that were made to specifications applying to the production and installation of standard converging devices. The maximum relative errors in setting up the experiments in the temperature range at the inlet to the swirler $500 < T_1^* < 2000$ were: for temperature 5%, pressure 2.8%, relative fraction of the cool flow $\mu = G_x/G_1$ 5.4%.

The method of processing the observation results made it possible to take the existing heat losses into account.

The results of the experiments shown in Fig. 1 confirm the good qualitative agreement between the experimental curves with the theoretical ones that were calculated by a method explained in [2] and made more accurate for the case of high temperatures at the inlet to the swirler of the eddy thermotransformer [3]. With increasing temperature at the inlet to the swirler of the thermotransformer the magnitude of the relative effects of heating decreases. This could be explained by the reduced radial pressure gradients, the reduction being caused by the continuous drop of the adiabatic index k in the temperature range $500 \leq T_1^* \leq 1500$°K [3]. A certain increase of the gas constant in this range of T_1^* leads to an increased level of the circumferential speeds, and this would be bound to lead to increased radial pressure gradients. However, the drop of the adiabatic index has a more substantial effect on the radial pressure gradient, and this decreases continuously. This drop impairs the efficiency of the microcooling cycles put into effect by the turbulent moles in their displacement due to the pulsations of the velocity component in a field with a radial pressure gradient.

The absolute value of the heating effects represents a substantial magnitude (at $T_1^* > 1500°K$ and $\mu > 0.7\Delta T_h > 350°K$, Fig. 2), and it may find the most widespread application in the solution of specific problems in engineering and chemical technology. The magnitude of the heating effects is greatly influenced by the dissociation of the components contained in the gas mixture of the combustion products. This leads to an addition reduction of the heating effects and to increased depth of cooling of the relative fraction of the cooled flow, which is particularly noticeable with large values of μ on which the effect of dissociation manifests itself particularly strongly on account of the high heating of the hot component of the flow (Fig. 3). The increase in temperature at the "hot" end of the eddy thermotransformer upsets the equilibrium of the dissociating gas, and this results in a chemical reaction which, according to the Le Chatelier–Brown principle, will be directed toward reducing the factor that upsets the equilibrium, i.e., to reduced effects of heating and to increased effects of cooling.

The results of the experiments confirmed the influence of the dependence of the thermophysical properties on the effects of energy distribution in eddy thermotransformers. Beginning at 1500°K, the principal decrease of the effects of heating occurs on account of the intensified dissociation of the combustion products.

NOTATION

d_{tr}, r_{tr}, Diameter of the eddy thermotransformer; $\bar{l}_K = l_{tr}/d_{tr}$, relative length of the energy separation chamber; T_1^*, P_1^*, full gas temperature and pressure at the inlet to the swirler; G_1, flow rate of the compressed gas; G_X, flow rate of the cooled flow; ΔT_X, ΔT_h, effects of cooling and heating in the eddy thermotransformer; $\theta_h = T_h^+/T_1^+$, relative heating; d_d, r_d, diameter and radius, respectively, of the diaphragm slit; $\bar{r}_d = r_d/r_{tr}$, relative radius of the diaphragm slit; F_c, area of the inlet tangential channels; $\bar{F}_c = 4F_c/\pi d_{tr}^2$, relative magnitude of the area of the inlet tangential channels.

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