ABSTRACTS OF ARTICLES DEPOSITED AT VINITI*

INVESTIGATION OF GEOMETRICAL AND OPERATING-CONDITION PARAMETERS OF PULSATION GAS-COOLING APPARATUS

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The design of a new apparatus for cooling gas, operating on the principle of nonstationary energy exchange between the working (cooled) and receiving (heated) gases, is proposed in [1]. The energy exchange takes place in dead-end tubes, where the receiving gas is compressed and expanded periodically under the action of a fluctuating stream of the working gas. However, [1] presents purely descriptive data and there are no results of theoretical or experimental investigations into the processes occurring in the apparatus. This paper examines the influence of several geometrical and operating-condition parameters on the thermal characteristics of the pulsation gas cooler.

The experiments are carried out on an air test-bed with an initial pressure of up to $40 \cdot 10^5$ N/m^2.

Measurements of the pressure pulsations made by a piezoelectric-ceramic transducer show that the periodic compression of the gas in the inlet sections of the receiving tubes causes the generation of shock waves alternating with a system of rarefaction waves. The presence of the shock waves leads to the heating of the receiving gas. Analogous processes occur in resonance tubes [2]. It is established that the temperature is distributed nonuniformly along the lengths of the receiving tubes and the maximum temperatures correspond to the regions in which an incident shock wave meets a reflected compression wave.

The investigations carried out show that an increase in the length of the receiving tubes (within the range of magnitudes under investigation) gives rise to a growth in the gas cooling effect due to the following reasons. First, the heating of the working gas by the compression wave generated by the reflection of the system of rarefaction waves off the end of the receiving tubes (reflection off a free surface) is reduced or disappears entirely. Secondly, the influence of the thermal mass exchange between the working and receiving gases is reduced due to the region of heated gas moving further away from the intake apertures of the tubes. Thirdly, the transfer of heat from the receiving gas is intensified due to the increase in the receiving tube surface.

The thermal characteristics of the apparatus are influenced substantially by the distance between the nozzle and the apertures of the receiving tubes. If the nozzle is brought close to the receiving tubes, the temperature in the central tubes is raised and the temperature in the outer tubes is lowered, since, with the angle of stream deviation remaining approximately the same, its contact with the outer tubes is broken. The maximum gas cooling effect is then observed for a relative distance between the nozzle and the tubes equal to 10 calibers of the nozzle.

An increase in the pressure drop causes an increase in the kinetic energy of the stream and the intensity of the shock waves in the tubes and, thus, to a rise in their temperature and, ultimately, to an increase in the efficiency of the cooling of the working gas.

It should be noted that the frequency of the fluctuations of the stream for an unvarying gas distributing chamber design and insignificant nozzle displacements is dependent primarily on the geometrical dimensions of the tubes and resonators. The initial pressure and the

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pressure drop in the range of variations under investigation have practically no influence on the frequency of the pulsations of the stream.

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THEORY OF BROWNIAN MOVEMENT IN NONEQUILIBRIUM GAS

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The derivation of the Fokker—Planck equation for the distribution function of noninteracting Brownian particles in a nonequilibrium gas is presented. In addition to the forward movement, the Brownian particles also participate in rotational movement. The starting point is the kinetic Boltzmann equation for the distribution function of the Brownian particles. The interaction of the particles and gas molecules is imulated by the interaction of rough spheres. The tensors of the coefficients of dynamic friction and diffusion in space of the particle velocity, which are dependent on the flow rate gradients of the gas stream, are found.

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THERMAL STRESSES IN A TRANSVERSALLY ISOTROPIC HALF-SPACE WITH A HEAT SOURCE, THERMALLY INSULATED BOUNDARY SURFACE, AND MIXED MECHANICAL CONDITIONS

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A semiinfinite elastic transversally isotropic half-space related to a cylindrical system of coordinates r, z is examined.

The isotropy plane is parallel to the boundary surface. A heat source with a capacity W is located at an internal point of the half-space.

The boundary surface is thermally insulated. In the section of the boundary inside a circle of radius R the normal stresses are equal to zero and in the fixed section outside the circle the normal displacements are equal to zero. There are no shearing stresses along the whole boundary. The material complies with the equations of the generalized Hooke's law, which take into account thermal influences.

The thermal elasticity problem is solved by integral Hankel transform method.

The displacement transforms and the normal and shearing stress transforms, which contain two unknown functions, can be found by applying the Hankel transform to the equations in displacements of the thermal elasticity problem and to the generalized Hooke's law.

Satisfying the requirement that the shearing stress at the half-space boundary be equal to zero, one unknown function is expressed in terms of the other. If the other boundary conditions are satisfied, a system of paired integral equations is obtained.

The stress components are determined by solving the given system of equations and using the inverse Hankel transform formulas. The improper integrals occurring in the formulas obtained are found in a closed form. An example of a numerical calculation is given.

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TEMPERATURE FIELD IN A HOLLOW CYLINDER WITH A VARIABLE COEFFICIENT OF HEAT TRANSFER ON THE SURFACE

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UDC 536.24.02

1. A mixed edge problem of stationary thermal conductivity with a variable coefficient of heat transfer Θ is examined:

$$\begin{gathered}\frac{1}{r}\cdot\frac{\partial}{\partial r}\left(r\frac{\partial u}{\partial r}\right)+\frac{\partial^2 u}{\partial z^2}=0,\ \rho<r<1,\ 0<z<l,\\ u(r,\ 0)=u(r,\ l)=0,\ u(\rho,\ z)=U(z),\\ \frac{\partial u}{\partial r}+\Theta(z)\,u=0\quad\text{for}\ r=1.\end{gathered}\tag{1}$$

The solution to the problem (1) is constructed in the form of a Fourier expansion through a full system of eigenfunctions $\{\sin(n\pi z/l)\}_{n=1}^{\infty}$ with series coefficient which can be determined from the corresponding infinite system of linear algebraic equations. The matrix elements and the column of free terms of this system are given in terms of the Fourier coefficients of the unknown functions $\Theta_{(z)}$ and $U_{(z)}$. The convergence of the method of reducing the approximate solution of the infinite system in the case of random piecewise-continuous functions $\Theta(z)$ and $U(z)$ is demonstrated.

2. The mixed edge problem is solved when the coefficient of heat transfer $\Theta(\phi)$ is a function of the polar angle:

$$\begin{gathered}\frac{1}{r}\cdot\frac{\partial}{\partial r}\left(r\frac{\partial u}{\partial r}\right)+\frac{1}{r^2}\cdot\frac{\partial^2 u}{\partial\varphi^2}=0,\ \rho<r<1,\ -\pi<\varphi<\pi,\\ u(r,\ \varphi)=u(r,\ \varphi+2\pi m),\ m=\pm 1,\ \pm 2,\ \ldots,\\ u(\rho,\ \varphi)=U(\varphi),\ \frac{\partial u}{\partial r}+\Theta(\varphi)\,u=0\ \text{for}\ r=1.\end{gathered}\tag{2}$$

The solution to the problem (2) is found in the form of a Fourier expansion through a full system of eigenfunctions $\{\exp(in\ \phi)\}_{n}^{\infty}=-\infty$. The coefficients of this expansion are a complex numerical sequence satisfying an infinite system of linear algebraic equations. The convergence of the method of reducing the solution of the infinite system with complex matrix elements obtained is proved.

3. The method shown of solving the problems formulated above can be used to calculate the stationary temperature fields in the hollow cylinders under examination. The practical importance of such problems is due to the fact that the case of a variable coefficient of heat transfer Θ can simulate the cooling of a hollow cylinder with a fluid flow flowing past it as well as the removal of heat from the side surface through a discrete system of thermal contacts. The thermal contact problems correspond to giving the coefficient of heat transfer Θ in a third-order boundary condition in the form of a step function which takes on constant values at the thermal contacts and is equal to zero at the thermally insulated sections of the side surface.

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DYNAMIC STABILITY OF CYLINDRICAL BEARING ROTOR

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UDC 531.391.5

In stability theory the movement of the rotating shaft of a rotor relative to the unmoving block of a cylindrical bearing under the action of the force of its own weight, the force of the elasticity of the shaft, and also of the resultant force of the reaction of the fluid in the shaft space due to the presence of eccentricity is known to be always unstable. In order to stabilize the transverse movement of the rotor axis, a damper which generates a resistance force proportional to the velocity of the center of mass of the rotor $\vec{F} = -b\vec{r}$ is required.

In this article it is demonstrated that under certain conditions in the actual bearing system a dissipative force which stabilizes the instability may be generated as a result of the forward movement of the center of mass of the rotor at a certain velocity $\vec{r}$ along an untwisting spiral within the maximum permissible limits of the magnitude of the space ε. The magnitude of this force is one of the components of the principal normal stress vector. The field of the pressure in the space is determined as a result of solving a set of linearized equations of movement for the appropriate boundary conditions.

An inequality for the asymptotic instability of the unperturbed movement is obtained which relates the angular velocity of the rotor ω, the coefficient of elasticity of the rotor shaft k, and the value of the eccentricity at the equilibrium position r_0. It is shown that the line of eccentricity at the equilibrium position will not lie along the horizontal (as is normally asserted in previously published material), but passes at a certain angle to it such that the center of the rotor is located below a horizontal line drawn through the center of the bearing.

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INFLUENCE OF DIMENSIONS OF STRAIGHTENING CROSSPLATE ON CHARACTERISTICS OF VORTEX TUBE

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UDC 533.697

Straightening crossplates, fitted to the hot end of a vortex tube and having a diameter equal to the internal diameter of this tube, are currently in use and can reduce the optimum length of the vortex tube to 9-10 calibers.

In this article we give the results of an experimental investigation into vortex tubes with a crossplate with enlarged radial dimensions, exceeding the magnitude of the internal diameter of the tube (see Fig. 1).

Tests are carried out on cylindrical and conical vortex tubes with a diameter in the nozzle section of D = 15 mm and a diaphragm opening diameter of d = 6.75 mm, which have a rectangular spiral inlet with an input section area of S = 15.7 mm² made in the form of an Archimedes screw.

Six cylindrical tubes with lengths of 2, 3, 4, 5, 7, and 9 calibers with a compressed air pressure of from 2-6 abs.atm are investigated. For each tube length and initial pressure the diameter of the crossplate is varied from 15 to 80 mm.

The conical tubes tested are 3 and 4 calibers in length. For each length the angle of taper is 1°, 1°46', 2°46', and 3°40'.

The results of the investigations show that vortex tubes with an enlarged-diameter straightening crossplate have a low optimum length (2 calibers for cylindrical and 3 calibers for conical tubes with a crossplate diameter D_c = 70 mm) and a higher degree of cooling than the normal vortex tubes. The zone of maximum thermal efficiency is displaced into a region of lower cold air relative flow rate magnitudes compared with long tubes.

For the conical tubes the increase in the angle of taper causes a rise in the optimum magnitude of the radial dimension of the crossplate. The optimum angle of taper in the tubes being tested is 1°30'-2°30', which is slightly less than in the normal conical tubes where this angle is equal to approximately 3°.

Thus, the length of the vortex tubes can be reduced to two to three calibers if the radial dimensions of the straightening crossplate are enlarged and the maximum cooling effect is then increased.

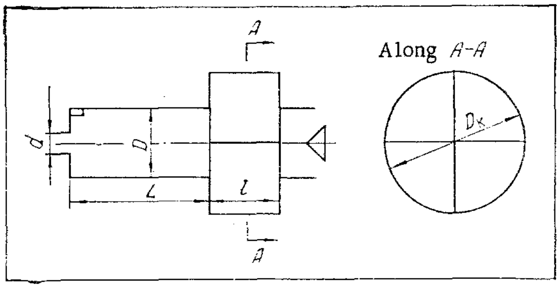

Fig. 1. Vortex tube with enlarged crossplate.

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