Fig. 1 are much lower than for PMR; this illustrates that, apparently, because of the presence of counter-flowing vortices, the reaction volume of commercial apparatus of this type is not used efficiently.

The results obtained demonstrate quantitatively the significant advantage of reactors in which the conditions approximate the regime of ideal displacement.

LITERATURE CITED


INVESTIGATION OF STRESS WAVES IN STRONGLY ABSORBING MEDIA

IRRADIATED WITH SHORT LASER PULSES

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The photoacoustic (PA) effect is widely employed for studying the physical properties of gases and condensed media. The theoretical aspects of photoacoustic generation under the action of pulsed laser radiation are discussed in [1, 2]. The analytical solutions, proposed by many authors, for the dynamical problem of thermoelasticity for irradiated bodies make it possible to calculate the profile of a stress wave as a function of the conditions of irradiation and the elastic and optical properties of the medium, but in so doing the real time dependence of the intensity in the laser pulse is usually neglected.

A comparative analysis of the forms of the theoretical and experimentally recorded photoacoustic pulses makes it possible not only to check the correctness of the mathematical models, based on which the working equations are constructed, but it also makes it possible to obtain information about the parameters that strongly affect the profile of the photoacoustic wave. Thus in [3] the temperature dependence of the absorption coefficient for iron and copper was studied by the method of comparison. In [4] the form of the optoacoustic pulses produced in weakly absorbing liquid by focused laser radiation was investigated.

We shall show that the size of the beam in the focus can be determined by comparing the form of the acoustic wave calculated from the equations of [5] and the profile of the experimentally obtained signal. In performing the calculations we selected the value of the parameter sought that gave the best agreement with experiment. The accuracy of the method was not worse than ±30%. The agreement was significantly better in the initial phase of the bipolar signal than in the final phase; this is explained in [4] by the fact that the real intensity function of the radiation does not have the Gaussian form assumed in the calculations. It is no less important to use an accurate intensity function when studying strongly absorbing media, while the transit time of the wave over the characteristic absorption depth is comparable to the width of the laser pulse. In [6] it is shown that for metallic samples the distribution of displacements in a photoacoustic wave is virtually identical to the shape of the laser pulse.

Fig. 1. The shape of photoacoustic pulses as a function of the linear absorption coefficient. k = 40 (1), 70 (2), 110 (3), 180 (4), and 300 (5) cm⁻¹.

The real intensity distribution in the laser pulse can be taken into account when calculating the stress distribution in a photoacoustic wave by using an equation of the form

\[ F(\xi)_{\eta T} = R \int_0^\infty f(\eta - \eta T) \cdot G(\eta, \xi) \, d\eta. \]  

where \( F(\xi)_{\eta T} \) is the stress distribution in the acoustic wave at the dimensionless time \( \eta T \); \( \xi \) is the dimensionless coordinate; \( R \) is an amplitude factor; \( f(\eta) \) is the intensity distribution in the laser pulse; and, \( G(\eta, \xi) \) is Green's function.

The shape of the photoacoustic signal as a function of the linear absorption coefficient is shown in Fig. 1. The calculations were performed for a laser pulse with a Gaussian distribution of the intensity. For Green's function we used the solution of the dynamic problem of uncoupled thermoelasticity for the case of one-dimensional strain of a linearly elastic half-space for a medium heated instantaneously by electromagnetic radiation [7]:

\[ G(\eta, \xi) = \begin{cases} -\exp(-\xi) \cosh \eta, & \xi \geq \eta, \\ \exp(-\eta) \sinh \xi, & \xi < \eta. \end{cases} \]  

\( \xi = x/c; \eta = t \cdot c / \lambda; \lambda \) is the characteristic absorption depth; and, \( c \) is the velocity of propagation of the photoacoustic wave. Equation (2), describing the stress distribution in the longitudinal wave, was derived in the approximation of a stationary temperature distribution in the absorption zone. In this case the effect of heat conduction on the formation of a distributed source of heat is not taken into account. It was assumed that the absorption of the radiation is described by Bouguer's law \( I = I_0 \exp(-x/\lambda) \). This approximation can be used if \( a/c \lambda \ll 1 \) [7], i.e., \( a < 1 \text{ cm}^2/\text{sec}, c \sim 10^5 \text{ cm/sec}, \) and \( \lambda \gg 10^{-5} \text{ cm} \) (\( a \) is the thermal diffusivity).

The intensity distribution in the laser pulse was given by the equation

\[ I = I_0 \exp(-B\eta^2), \]  

where

\[ B = 4(\lambda/c\tau_p)^2 \ln 2; \]  

and \( c \) is the velocity of sound.

For the case when \( \eta T \) is large, Eq. (1) together with Eqs. (2) and (3) can be written in the form

\[ F(\xi)_{\eta T} = R \left( -\exp(-\xi) \right) \int_0^\infty \exp(-B(\eta - \eta T)^2 - \eta) \, d\eta + \exp \xi \int_0^\infty \exp(-B(\eta - \eta T)^2 - \eta) \, d\eta. \]  

Keeping in mind Eq. (4), it is easy to see that the main parameter determining the shape of the photoacoustic pulse is the ratio \( \lambda/c\tau_p = \tau_w/\tau_p \) (\( \tau_w \) is the time over which the wave traverses a distance equal to the characteristic absorption depth and \( \tau_p \) is the width of the laser pulse). Figure 1 shows for each curve the corresponding value of the linear absorption coef-