Effects of heat conduction and sample size on ultrasonic absorption measurements

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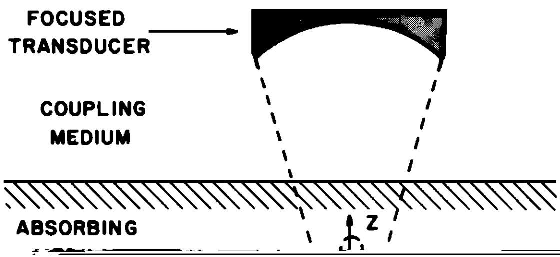
The absorption coefficient of a material can be determined by measuring the heating which occurs as a result of ultrasonic irradiation. When narrow focused beams are used to heat a sample, or

conduction to surrounding unheated regions becomes significant, complicating the relation



center of the focal region is given by[4]:

$$T_{\rm PD}(r,t) = \frac{2\alpha I_0 \Delta t}{\rho c[1 + (4kt/\beta)]} \exp\left(\frac{-r^2}{(4kt + \beta)}\right). \quad (5)$$

In practice, the first second of thermocouple reading is influenced by the localized "viscous heating" effect. Data obtained between 1 and 10 s are compared with Eq. (5) with α as the sole unknown coefficient to be determined by least

[redacted]

$\beta) \ll 1$.

More generally, when the thermocouple is not centered in the focal region, the rate of heating method would give

$$\frac{\partial T_{\mathrm{RH}}}{[redacted]} = \frac{2\alpha I_0}{[redacted]} e^{-r^2/(4kt+\beta)}. \quad (13)$$

[redacted]

$T(x_0, y_0, z_0, t)$

$$= \frac{Q_2}{8(\pi k t)} \exp\left(\frac{-(x_0^2 + y_0^2)}{4kt}\right)\left(1 + \operatorname{erf}\frac{z_0}{\sqrt{4kt}}\right). \quad (16)$$

[redacted]

The error function rises monotonically from 0 at zero argu-

[redacted]

history. Hence, for finite sample thickness we obtain:

$$T_{PD}(r=0,Z,t) = \frac{2\alpha I_0 \Delta t}{\ldots}\left(\mathrm{erf}\,\frac{Z}{\ldots}\right). \quad (22)$$

ter, records a slope at 0.5 s which is very close to the value of dT/dt obtained by using Eq. (1) with known values[8] of ρ, c, α, and I. Radial and axial heat conduction are not accounted attenuation. The scaled version is plotted along with the raw data from 0.75-mm depth in Fig. 4. From the theoretical result presented in Eq. (21). the remaining difference between the 0.75-and 2.5-mm heating curves should be at-

10
8
6
erature °c
5.00
2.50
1.25
ΔT
10
8
6
t, seconds
0 2 4 6 8 10 12 14
t, seconds

thus,

$$Z/\sqrt{4kt} > 1.2. \tag{27}$$

must hold for $t = 0.6$ s, we have $Z > 0.7$ mm. For pulse decay experiments, where we wish to maintain the inequality to

mately 1 mm deep. Radial heat flow in centered rate of heating experiments can also be neglected providing observation times are limited to 0.6 s, and the half-intensity beamwidth is

These results should lead to more accurate measure-