A Precise Determination of the Thermal Diffusivity of Zinc

RICHARD H. FRAZIER, *Massachusetts Institute of Technology*
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Results are given of tests to determine with precision the thermal diffusivity of a very pure sample of zinc. The over-all probable error is shown to be 0.13 percent. The method of test was presented in detail in a former paper.

IN order to demonstrate further the method developed for the precise determination of the thermal diffusivity of solids[1] (which until the instance of the tests herein reported had been applied only to nickel rods) tests were made on a rod of very pure zinc.[2] The rod had the following analysis:[3]

Cadmium	0.000 percent
Iron	0.003
Lead	0.000
Zinc (by difference)	99.997

Six runs gave the results in Table I, uncorrected for pendulum calibration. From these data

TABLE I.

Run	p(sec.$^{-1}$)	ΔT	Average T
37	0.004,992,5 ±0.000,003,2	5.67°C	23.74°C
38	0.005,025,0 ±0.000,002,5	5.47	23.82
39	0.004,978,9 ±0.000,001,6	5.07	23.67
40	0.004,979,4 ±0.000,001,6	6.56	24.48
42	0.004,961,6 ±0.000,002,8	5.70	24.04
43	0.004,979,8 ±0.000,002,5	5.45	25.32

the most probable value is, $p=0.004,986,2 \pm 0.000,005,8$ sec.$^{-1}$, and the application of the pendulum correction factor of $1.000,63 \pm 0.000,05$ gives finally, $p=0.004,989,3 \pm 0.000,005,8$ sec.$^{-1}$. For this specimen, $L=14.001 \pm 0.001$ cm and $\rho=7.144 \pm 0.004$ g·cm^{-3}; and since $p=k\pi^2/4c\rho L^2 = \alpha^2\pi^2/4L^2$,

$$\alpha^2 = 0.396,4 \pm 0.000,5 \text{ cm}^2\cdot \text{sec.}^{-1}$$

and

$$k/c = 2.832 \pm 0.004 \text{ g}\cdot\text{cm}^{-1}\cdot\text{sec.}^{-1}.$$

Results obtained for k and c by other experimenters[4] give values for k/c ranging from 2.79 to 3.00, depending upon the combinations used. The thermal conductivity data are scattered over a range of nearly 2 percent, the figure given by the *International Critical Tables* as the "best value" and the figure given by the Reichsanstalt being at the upper and lower extremes, respectively. The specific heat data are scattered over a range of nearly 5 percent. However, the data relate to samples having various states of purity and produced by various manufacturing processes. In comparison with these variations, the figures reported for density of rolled zinc vary only slightly.

The tests reported here were made during the past summer, so that conditions were quite similar to those for nickel rod C, the first rod reported upon, i.e., the ambient temperature was approximately the same, obtained naturally, without the use of the blower outfit previously described, and the water temperature fluctuated almost inappreciably. In only one run, No. 43,

[1] See *Precision Method for Determining the Thermal Diffusivity of Solids*, Phys. Rev. **39**, 515 (1932) and *Further Data on the Thermal Diffusivity of Nickel*, Phys. Rev. **40**, 592 (1932). The method and apparatus whereby the results reported here were obtained are explained in these papers. The symbols used here are defined in the first paper.

[2] The rod is of cold rolled, unannealed "Bunker Hill Zinc" supplied by courtesy of The Platt Bros. & Company, and ground to precise uniform diameter by courtesy of Cincinnati Grinders, Incorporated. The Platt Bros. & Company furnished also the sheet zinc used in the apparatus. The inner zinc guard tube was furnished by courtesy of the United Wire and Supply Corporation, and the outer zinc guard tube by courtesy of the Fulton Sylphon Co.

[3] Analysis by Arthur D. Little, Inc. The impurities determined are the ones normally expected in commercial zinc. A weighable amount of cadmium could not be found in 31 g, nor a weighable amount of lead in 8.643 g. The precision of the determination of the iron is estimated to be within 0.0005 percent, i.e., 0.003±0.0005 percent.

[4] The results of a number of determinations of thermal conductivity, specific heat, and density (as well as many other properties) of zinc are summarized in Circular of the Bureau of Standards, No. 395, *Zinc and Its Alloys*.

was a slight correction applied because of a change of water temperature. A difference which did exist between the conditions for the tests on the zinc rod and those on the nickel rods was that the vacuum was 1.5 to 2.5 microns of mercury for the former as compared with 1 micron or less for the latter. Therefore a small correction was applied to the data of each run to compensate for the effect of the increased lateral flow of heat. The design of the apparatus was substantially the same as for nickel rod D, the second rod reported upon, except for a change in the length of the specimen and hence also the guard tubes, in order to keep p roughly the same size as for the nickel rods. Small constantin wires were used to form the thermocouple with the zinc rod. The junctions of the constantin with the copper leads to the galvanometer were laid very close together between large metal blocks (from which they were electrically insulated) and so introduced no appreciable net electromotive force.

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