Thermal Conductivity of Liquid Zirconium

Preliminary Recommendation

The preliminary recommendation for the thermal conductivity of liquid zirconium is the value for the liquid at the melting point recommended by Mills et al. [1] in their recent review of thermal conductivities of liquid metals. Mills et al. recommend:

$$\lambda(l,m) \;=\; 36.5\; W{\cdot}m^{-1}{\cdot}K^{-1} \qquad \textbf{(1)}$$

where *λ(l, m)* is the thermal conductivity of liquid zirconium at the melting point. Mills et al. used the Weiderman Franz Lorentz rule to calculate this value from the melting point electrical resistivity measurements of Korobenko and Savvatimskii [2] because no data exist for the thermal conductivity of liquid zirconium. No temperature dependence for the thermal conductivity is available because of lack of data.

Uncertainty

The uncertainty is estimated as 10%. This uncertainty was determined by comparing values of the thermal conductivity of solid zirconium at the melting point calculated from electrical resistivity measurements with values obtained from analysis of thermal conductivity and thermal diffusivity measurements.

Discussion

Measurements of the electrical resistivity of liquid zirconium are being made at the United Institute of High Temperature, Russian Academy of Sciences under the leadership of A. Savvatimskii. These measurements will provide the temperature dependence of the electrical resistivity of liquid zirconium near the melting point, which may be used to determine the temperature dependence of the thermal conductivity. The above recommendation will be reassessed when results of these measurements are available.

In their review of thermal conductivities of liquid metals, Mills et al. also provide a recommendation for the thermal conductivity of the solid at the melting point. For zirconium, they recommend:

$$\lambda(s,m) = 38\ W{\cdot}m^{-1}{\cdot}K^{-1}; \qquad \textbf{(2)}$$

where $\lambda(s, m)$ is the thermal conductivity of solid zirconium at the melting point. This value was also calculated from electrical resistivity measurements using the Weiderman Franz Lorentz rule. The electrical resistivity measurements by Desai et al. [3] and by Korobenko and Savvatimskii [2] at the melting point gave 39.5 and 37.7 $W \cdot m^{-1} \cdot K^{-1}$, respectively, for the thermal conductivity. Mills et al. [1] note that these values are in good agreement with the value (37.5 $W{\cdot}m^{-1}{\cdot}K^{-1}$) obtained from extrapolation of the 1973 high-temperature zirconium thermal diffusviity data of Filippov [4].

Measurements of the thermal conductivity of solid zirconium from 1951 through 1992 have been reviewed by Fink and Leibowitz [5]. From their analysis of these data, they recommend an equation for the temperature range 298 through 2000 K. Extrapolation of their equation to 2128 K, the melting point of zirconium, gives 36.8 $W{\cdot}m^{-1}{\cdot}K^{-1}$. Fink and Leibowitz comment the standard deviation is 9.5% at high temperatures because of large scatter in the data. The value of the solid thermal conductivity at the melting point calculated by Mills et al. is only 3% higher than the value obtained from the equation of Fink and Leibowitz. Thus, it is well within the standard deviation of thermal conductivity data.

References

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3. P. O. Desai, H. M. James, and C. Y. Ho, *Electrical Resistivity of Vanadium and Zirconium*, J. Phys. Chem. Ref. Data **13**, 1097-1130 (1984).

4. L. P. Filippov, *Untersuchung der Thermischen Eigenschaften im Stoff an der Moskauer Universitat*, Int. J. Heat Mass Transfer. **16**, 865-885 (1973).

5. J. K. Fink and L. Leibowitz, *Thermal conductivity of zirconium,* J. Nucl. Mater. **226**, 44-50 (1995).