

Enthalpy and Heat Capacity of Zr-1% Nb

Preliminary Recommendation

The recommended equations for the enthalpy and heat capacity of Zr-1%Nb are based on the linear equations for the heat capacity determined from measurements by Peletsky and Petrova [1].

For the α -phase (500-1100 K)

$$C_p (J \cdot g^{-1} \cdot K^{-1}) = 0.2375 + 15.91 \times 10^{-5} T \quad (1)$$

$$H(T) - H(298) (kJ \cdot kg^{-1}) = -74.53 + 0.2375 T + 7.955 \times 10^{-5} T^2 \quad (2)$$

For the β -phase (1250-2000 K)

$$C_p (J \cdot g^{-1} \cdot K^{-1}) = 0.2813 + 6.625 \times 10^{-5} T \quad (3)$$

$$H(T) - H(298) (kJ \cdot kg^{-1}) = -15.35 + 0.2813 T + 3.313 \times 10^{-5} T^2 \quad (4)$$

Recommended values are given in Table 1 and shown in Figures 1 and 2.

Uncertainty

Peletsky and Petrova report a 3.5% inaccuracy in the heat capacity determinations except for the phase transformation zone. The uncertainty in the phase transition region is higher and estimated as 10%.

Discussion

The recommended equations for the α -phase are identical with those recommended in the IBRAE Material Property Database on the world wide web and the Russian Academy of Science Nuclear Safety Institute Report by Ozrin et al. [2], which are from 1993 measurements by Lusternik,

Peletsky, and Petrova [3,4]. For the β -phase, the 1997 heat capacity equation of Peletsky and Petrova [1] is preferred to the equations of Lusternik, Peletsky, and Petrova [3,4] that were available at the time of the IBRAE report and are recommended in the IBRAE Material Property Database because Eq.(3) is based on experimental data to 2000 K whereas the earlier equations were based on data only to 1600 K. The enthalpy change for the α to β phase transition is the same for Eq.(2) and Eq.(4) as for the 1993 equations of Lusternik et al. [3,4] as evident from the enthalpy increments shown in Figure 2. For the phase transition region, Ozrin et al.[2] recommend using tabulated experimental values for the heat capacity and enthalpy increments. Values for the 1000 K/s heating rate have been included in Table 1. Both the fast (1000 K/s) heating rate and the slow (0.2 K/s) heating rate heat capacity data of Lusternik et al. have been included in Figure 1. Table 1 gives evenly spaced values from Eqs. (1-4) and experimental values from 1100 to 1250 K.

References

1. V. E. Peletsky, and I. I. Petrova, *Investigation of the thermophysical properties of the alloy Zr-0.01Nb by a subsecond pulse-heating technique*, High Temp.-High Pressures **29**, 373-378 (1997).
2. V. T. Ozrin, V. Yu Zitceman, V. M. Gefter, and V. F. Bajbuz, *Material properties for International Nuclear Safety Data Base*, Russian Academy of Sciences Nuclear Safety Institute (IBRAE) report **NSI-SARR-34-96** (September 1996).
3. V. E. Lusternik, V. E. Peletsky, and I. I. Petrova, *Experimental study of caloric properties of reactor materials on the base of zirconium alloy E-110*, Teplofiz. Vys. Temp. **31** (no. 4), 560-564 (1993) [in Russian]; High Temperature **31**, 509-513 (1993) [English translation].
4. V. E. Lusternik, V. E. Peletsky, and I. I. Petrova, *High temperature calorimetric measurements of Zr-1%Nb alloy at various heating rates*, High Temp.-High Pressures **25**, 539-543 (1993).

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Table 1 Enthalpy and Heat Capacity of Zr-1%Nb

Temperature K	C_P J g⁻¹ K⁻¹	H(T) -H(298.15 K) kJ kg⁻¹
298	0.285	0
300	0.285	3.9
350	0.293	18.3
400	0.301	33.2
450	0.309	48.5
500	0.317	64.1
550	0.325	80.2
600	0.333	96.6
650	0.341	113.5
700	0.349	130.7
750	0.357	148.3
800	0.365	166.4
850	0.373	184.8
900	0.381	203.7
950	0.389	222.9
1000	0.397	242.5
1050	0.405	262.5
1100	0.476	339.8
1150	1.240	352.8
1200	0.480	369.8
1250	0.364	388.0
1300	0.367	406.3
1350	0.371	424.8
1400	0.374	443.4
1450	0.377	462.2
1500	0.381	481.1
1550	0.384	500.3
1600	0.387	519.5
1650	0.391	539.0
1700	0.394	558.6
1750	0.397	578.4
1800	0.401	598.3
1850	0.404	618.4
1900	0.407	638.7
1950	0.410	659.2
2000	0.414	679.8

Figure 1 Heat Capacity of Zr-1% Nb

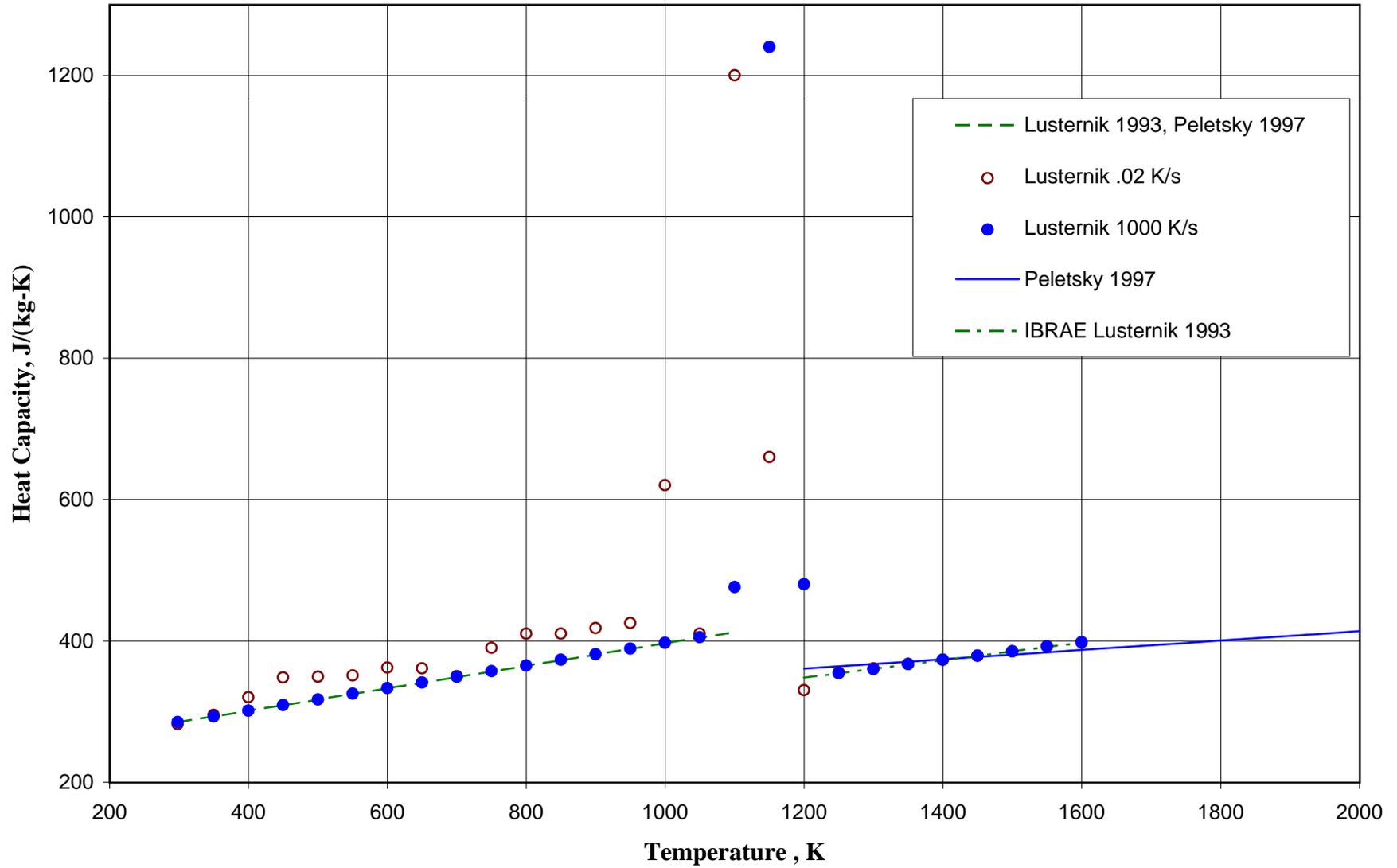


Figure 2 Enthalpy of Zr-Nb

