# MEASUREMENT OF HIGH-TEMPERATURE ACCOMMODATION COEFFICIENTS FOR ALKALI METAL VAPORS ON NICKEL

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Measurements on the temperature step have given the accommodation coefficients for cesium, rubidium, and sodium vapors on nickel for the range 685-1095°K.

The literature carries no values for the accommodation coefficients for alkali metal vapors; here we report values derived from measurement of the temperature differences for cesium, rubidium, and sodium vapors. The measurements were made with an apparatus for determining the thermal conductivity of alkali metal vapors by the coaxial-cylinder method, the cylinders being made of nickel [1-3].

The dimensions (mm) of the cylinders were as follows: diameter of inner cylinder 10.70, diameter of outer cylinder 11.10, gap 0.20, length of working part 78.7, and length of cylinders 230.

The radial heat flux was set up by an internal heater, which had a main winding and two guard windings; the walls of the inner and outer cylinders carried three platinum–platinum/rhodium thermocouples each over the working part. The temperature difference between the cylinders was in the range 25-40°K. The temperature nonuniformity along the working part was not more than 0.1-0.2°K. The cylinders were in a thermostat providing automatic temperature control.

The vapor pressure was determined from the pressure curve [4-6] derived from measurements of the temperature in the evaporator made with a platinum–platinum/rhodium thermocouple at the surface of the liquid metal.

The temperature step was measured for cesium vapor at 685, 785, 945, and 1085°K at pressures from 2 to 140 mm Hg; for rubidium vapor the temperatures were 925 and 1075°K and pressures were from 3 to 65 mm Hg; for sodium vapor the pressure range was from 8 to 40 mm Hg at 1095°K.

The temperature step was determined from the standard relation [7]

$$\Delta T_p = \Delta T_{\text{gas}} + B\left(\frac{1}{p}\right),$$

where $\Delta T_p$ is the difference for the given pressure, $\Delta T_{\text{gas}}$ being the value for $p \to \infty$; in determining $\Delta T_p$ we applied a correction for the contact thermal resistance of the thermocouple, which ranged from 2 to 10%, as well as a correction for the dissociation of diatomic molecules, which did not exceed 8%.

During the measurements, the proportion of the heat carried by radiation $W_{\text{rad}}$ in relation to the total heat flux $W_{\text{tot}}$ varied somewhat, and, consequently, $W_\lambda$ was not constant. Therefore, for each isotherm we calculated the reduced temperature difference

$$\Delta T_{\text{red}} = \Delta T_p \frac{W_{\lambda\max}}{W_\lambda},$$

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TABLE 1. Data for Determining Accommodation Coefficients for Alkali Metal Vapors on Nickel

| $T_{vap}$, °K | $W_{tot}$, W | $W_\lambda$, W | p, mm Hg | $\Delta T_{red}$, °K | $\Delta T_{vap}$, °K | $\alpha$ |
|---|---|---|---|---|---|---|
| | | | Cesium | | | |
| 685 | 2,341 | 1,993 | 10,7 | 33,6 | 31,5 | 0,98 |
| 685 | 2,372 | 2,018 | 10,7 | 33,7 | | |
| 685 | 1,638 | 1,362 | 4,0 | 38,4 | | |
| 685 | 1,629 | 1,287 | 1,5 | 48,8 | | |
| 785 | 2,711 | 2,174 | 35,7 | 29,8 | 29,0 | 0,99 |
| 785 | 2,672 | 2,102 | 13,7 | 30,9 | | |
| 785 | 2,730 | 2,118 | 8,7 | 32,3 | | |
| 785 | 2,721 | 2,066 | 4,6 | 34,9 | | |
| 945 | 3,483 | 2,429 | 144 | 27,5 | 27,6 | 1,05 |
| 945 | 3,484 | 2,389 | 36,5 | 28,9 | | |
| 945 | 3,450 | 2,313 | 15,2 | 29,6 | | |
| 945 | 3,449 | 2,243 | 6,7 | 32,6 | | |
| 945 | 3,437 | 2,145 | 3,7 | 36,0 | | |
| 1085 | 4,662 | 2,730 | 139 | 27,7 | 27,5 | 0,99 |
| 1085 | 4,384 | 2,543 | 71 | 28,1 | | |
| 1085 | 4,479 | 2,564 | 27,4 | 28,6 | | |
| 1085 | 4,432 | 2,489 | 16,0 | 30,0 | | |
| 1085 | 4,414 | 2,207 | 4,0 | 37,9 | | |
| | | | Rubidium | | | |
| 925 | 4,634 | 3,335 | 5,1 | 37,9 | 30,6 | 1,03 |
| 925 | 4,638 | 3,397 | 9,1 | 35,0 | | |
| 925 | 4,639 | 3,515 | 29,1 | 31,4 | | |
| 925 | 4,348 | 3,330 | 66,7 | 31,3 | | |
| 1075 | 4,836 | 2,688 | 2,5 | 41,1 | 25,2 | 0,98 |
| 1075 | 4,959 | 3,099 | 6,5 | 30,9 | | |
| 1075 | 4,965 | 3,227 | 10,8 | 27,5 | | |
| 1075 | 4,813 | 3,230 | 62,9 | 25,6 | | |
| | | | Sodium | | | |
| 1095 | 12,550 | 10,276 | 8,5 | 32,1 | 24,5 | 1,01 |
| 1095 | 12,577 | 10,430 | 13,7 | 29,9 | | |
| 1095 | 12,662 | 10,585 | 16,0 | 28,5 | | |
| 1095 | 12,686 | 10,663 | 17,3 | 27,6 | | |
| 1095 | 12,687 | 10,823 | 42,6 | 25,8 | | |

Note. $T_{vap}$ denotes alkali metal vapor temperature, $W_{tot}$ denotes total heat flux, $W_\lambda$ denotes conducted heat flux, p denotes vapor pressure, $\Delta T_{red}$ denotes reduced temperature difference, $\Delta T_{vap}$ denotes temperature difference for $p \to \infty$, and $\alpha$ denotes the accommodation coefficient.

where $W_{\lambda max}$ is the maximal heat flux transmitted by thermal conduction for the given isotherm and $W_\lambda$ represents the values for the other points on that isotherm.

The accommodation coefficient was calculated as in [8] from

$$\alpha = \frac{2.74\,\lambda_1 \sqrt{TM}}{1.37\,\lambda_1 \sqrt{TM} + ph(\delta T_{st})}, \tag{1}$$

where $\alpha$ is the accommodation coefficient, $\lambda_1$ is the coefficient of thermal conductivity of the monatomic vapor in W/(m · deg), $T = (T_1 + T_2)/2$ is the vapor temperature in °K, M is the molecular weight in kg/kmole, p is vapor pressure in N/m$^2$, h is the gap between the cylinders in m, and $\delta T_{st} = (\Delta T_p - \Delta T_{gas})/\Delta T_{gas} = \Delta T_{st}/\Delta T_{gas}$ is the temperature step expressed in %.

Table 1 gives values calculated from (1) for the vapors of these three elements on nickel; calculations also indicate that the error in determining $\alpha$ was ±10%.

The result $\alpha \approx 1.0$ for the alkali metal vapors indicates that there is complete energy transfer between these vapors and nickel.

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# THERMOPHYSICAL PROPERTIES OF COBALT AT HIGH TEMPERATURES

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Measured values of the thermal conductivity, total hemispherical and spectral ($\lambda = 0.65\ \mu$) emittances, resistivity, and coefficient of linear expansion of cobalt are presented.

Cobalt is widely used as a basis of a large group of alloys capable of successful operation over a wide temperature range [1, 2], but its thermophysical properties have been inadequately investigated, particularly at temperatures above 1200°K.

The known investigations of the thermal conductivity of cobalt at high temperatures [3] are based on calculations using experimental values of the thermal diffusivity.

Data on radiative properties of cobalt are meager and highly contradictory [4].

The present work was undertaken to determine the thermophysical properties of cobalt at high temperatures.

The properties of cobalt were measured in the 300-1700°K range using samples made of a single bar having the following composition (wt. %): Co, 99.4; Fe, 0.4; Si, 0.15; C, 0.035; Mn, 0.01; remainder $\leqslant 0.005$.

The technique for measuring the thermal conductivity and the total hemispherical emittance is based on a solution of the steady-state energy-balance equation for an element of length of the central part of the sample heated by an electric current in a vacuum [5]:

$$\frac{d^2t}{dx^2} - Lt - K = 0, \tag{1}$$

where

$$L = \frac{P\varepsilon_0\sigma}{\lambda S}\, 4T_e^3 + \frac{P\varepsilon_0\sigma}{\lambda S}\, \gamma T_e^3 - \frac{I^2\rho_0}{\lambda S^2}\, \beta, \tag{2}$$

$$K = \frac{I^2\rho_0}{\lambda S^2} - \frac{P\varepsilon_0\sigma}{\lambda S}\, T_e^4. \tag{3}$$

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