# THERMOPHYSICAL PROPERTIES OF DISPERSION-HARDENED NICKEL

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The thermophysical properties of dispersion-hardened nickel were measured over the following temperature ranges: thermal conductivity and electrical resistivity from 20 to 1300°C, integral hemispherical emissivity and spectral emissivity ($\lambda = 0.65\ \mu$) from 1000 to 1300°C.

This is a continuation of a systematic study concerning nickel [1] and nickel alloys [2] widely used in practice for applications in the 800-1200°C temperature range.

A special feature of dispersion-hardened alloys is that such a hardening is achieved by a uniform distribution of stable oxide inclusions in the metal matrix, the overall concentration of these inclusions amounting to 2-3% vol. and their average size remaining within the 0.02-0.03 $\mu$ range [3]. After deformation these inclusions are spherical with a structure extraordinarily resistant to recrystallization [4], which can affect their kinetic properties.

These studies were made on extruded specimens containing 2.5% vol. hafnium dioxide as the hardening phase. The total impurity content did not exceed 0.15% wt. The density of the specimen material was 8.92 g/cm$^3$ at 22°C. The material had been produced metallurgically by a process analogous to that described in [5].

The thermophysical properties of dispersion-hardened nickel were measured with the same apparatus where the properties of pure nickel had also been studied [1], the vacuum level as well as the geometrical dimensions and the measurement error being the same as in [1].

The results have been evaluated with a correction made for thermal expansion according to [6].

The test results are shown rounded off in Table 1.

It is to be noted that the values given in Table 1 represent the properties of dispersion-hardened nickel with the heat treatment not above 1300°C. Heating and holding the material at temperatures higher than that and the attendant recrystallization process produce irreversible changes in the kinetic characteristics, which has been confirmed repeatedly by electrical resistance measurements. As is shown in Fig. 1, the

TABLE 1. Thermophysical Properties of Dispersion-Hardened Nickel

| $T$, °C | 20 | 100 | 200 | 300 | 400 | 500 | 600 | 700 |
|---|---|---|---|---|---|---|---|---|
| $\lambda$, W·cm$^{-1}$(°C)$^{-1}$ | — | 0,77 | 0,71 | 0,63 | 0,59 | 0,56 | 0,57 | 0,59 |
| $\rho$, $\mu\Omega$·cm | 7,8 | 12,5 | 18,5 | 25,1 | 33,7 | 37,8 | 41,4 | 45,5 |
| T, °C | 800 | 900 | 1000 | 1100 | 1200 | 1300 | — | — |
| $\lambda$, W·cm$^{-1}$(°C)$^{-1}$ | 0,62 | 0,64 | 0,66 | 0,68 | 0,70 | 0,72 | — | — |
| $\rho$, $\mu\Omega$·cm | 49,1 | 51,5 | 54,5 | 57,5 | 60,0 | 63,0 | — | — |
| $\varepsilon$ | — | — | 0,19 | 0,195 | 0,2 | 0,21 | — | — |
| $\varepsilon_\lambda$, $\lambda = 0.65\ \mu$ | — | — | 0,37 | 0,375 | 0,38 | 0,385 | — | — |

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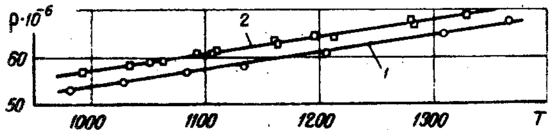


Fig. 1. Electrical resistivity $\rho$ ($\mu\Omega\cdot$cm) as a function of the temperature T (°C): 1) initial heating; 2) cooling and heating after holding at 1350°C for 1 h.

electrical resistivity $\rho$ of dispersion-hardened nickel is, after holding at 1350°C for 1 h, approximately 5 $\mu\Omega\cdot$cm higher than at the initial heat treatment temperature. Furthermore, at room temperature (22°C), after recrystallization, it is equal to 9.5 $\mu\Omega\cdot$cm, while in the initial state it was only 7.8 $\mu\Omega\cdot$cm.

## NOTATION

$\rho$ is the electrical resistivity;
$\lambda$ is the thermal conductivity;
$\varepsilon$ is the integral hemispherical emissivity;
$\varepsilon_\lambda$ is the spectral emissivity;
T is the temperature, °C.

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