

Temperature Dependent Spectral Emissivities of Metals

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Emissivities of metals are used for many high-temperature plants as thermophysical data for calculation of heat transfer, for process modeling and simulation, and for process control by optical temperature measurements. Emissivities can not be calculated with sufficient accuracy based on other properties of the metals. Theoretical formulas are not sufficient and the needed material properties (n , k) are not known. Therefore, the emittance of metals must be determined experimentally. At the University of Duisburg-Essen an apparatus was developed for measuring the temperature-dependent spectral emissivity of metals in the temperature range from 200°C up to 1200°C and in the wavelength range from 0.8 μm up to 25 μm . The measurements are performed in the direction normal to the surface. To prevent oxidation at higher temperatures, the metal samples are heated up and investigated in atmospheres of protective gases. Under technical conditions, most of metals are heated in high-temperature furnaces for heat treatment and in reheating furnaces before metal forming. For example, there is no car in the world without heat treated metallic components. On the other hand, there are also many high-temperature plants in which metals are used as construction materials. These metals must be resistant against temperature and oxidation. At the University of Duisburg-Essen a large number of radiation investigations of different metals were carried out to get emissivity data of metals for all these heating processes. The following results should be presented in the paper:

- temperature-dependent spectral emissivities of different steel qualities, nonferrous metals, and powder metals with bright, oxidized, and heat-treated surfaces,
- spectral emissivities of heat resistant steel grades and nickel alloys;
- spectral emissivities of coated metals,
- spectral emissivities of steel during oxidation, with measured interferences caused by the growing oxide layer,
- investigation of different parameters influencing the spectral emissivities (roughness, grain size, crystal transformations),
- investigation of the X-point of metals,
- investigation on the suitability of technical pure iron ("Armco" iron) as a radiation standard,
- in-situ measurements of the spectral emissivities of metals during heat treatment, and reheating processes with parameters of temperature and heating time corresponding to real practical conditions.

For the radiation of metals, knowledge of the chemical composition of the surface layer is of great importance. GDOS-analysis is a useful tool for that. For example, it can detect thin oxide layers on the surface of metals which were found by radiation measurements too. Therefore, this method was used for the interpretation of the results of the emissivity determinations. The investigations at the University of Duisburg-Essen have led to extensive new results on radiation of technically important metals. This means that now for many processes of heat treatment and reheating sufficient data of the spectral emissivities of metals are available. For heat transfer calculations of high-temperature plants in many cases temperature-dependent total emissivities are required. For temperature measurements with optical pyrometers band-emissivities are required as correction values in the spectral working ranges of the pyrometers. Finally it is shown, that these emissivities of the metals can be calculated based on their measured spectral emissivities.