INTEGRAL EMITTANCE OF ALLOYS OF THE IRON—ALUMINUM SYSTEM AT HIGH TEMPERATURES

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Experimental data on the integral emittance coefficients of alloys of the iron—aluminum system in the temperature range from 80 to 1700°C are given.

The integral emittance in the normal direction ε_T of iron alloys (99.98% Fe) with aluminum (99.95% Al) was investigated by comparing the emission intensities of a specimen and a standard (polished monocrystalline tungsten) by means of the apparatus described in [1]. A device [2] was added to this apparatus in order to effect alloying of the melt in the course of an experiment, which improved considerably the sensitivity of the method in determining the effect of the chemical composition on the integral emittance value. The specimens were melted and heated in a vacuum, and the operating chamber was subsequently filled with a mixture of hydrogen at 0.3 kPa and helium at 1.0 kPa. It was thus possible to obtain specimens with a clean surface, free from oxide films, which contained aluminum in amounts from 0 to 30 at. % and from 75 to 100 at. %. We did not succeed in obtaining a mirror surface for the other alloys. The error in measuring the value of ε_T with a confidence coefficient of 0.95 amounted to 6% at 1600°C and 13% at 900°C.

Figure 1 shows the experimental polytherms $\varepsilon_T(t)$ for Fe—Al alloys. The curves shown in the diagram were obtained under conditions of cooling specimens. With crystallization, the emittance of iron and of alloys containing up to 5 at. % aluminum diminishes stepwise, while, in the case of the other alloys, it increases as roughness develops and an oxide film forms. The value of the blackness coefficient of such a surface is unstable due to the fact that the thickness of the oxide film varies in time. Therefore, we have used here only data pertaining to a clean metal surface. For such surfaces, it is evident from the $\varepsilon_T(t)$ diagrams in Fig. 1 that the temperature coefficient is $d\varepsilon_T/dt > 0$. Moreover, it follows on the basis of the emittance isotherms given in Fig. 2 that a quantitative relationship between the experimental values of ε_T and $\varepsilon_T(\rho)$, found by means of an expression similar to the Ashkinass—Foot equation (see, for instance, [3, 4]), holds for these melts:

$$\varepsilon_T(\rho) = 5.76(\rho T)^{0.5} - 17.9\rho T + 58.6(\rho T)^{1.5} - 2\pi c\tau\rho^{0.5}T^{1.5},$$

where $\varepsilon_T(\rho)$ are the calculated values of the integral degree of blackness, ρ is the electric resistivity ($\Omega\cdot$m), τ is the relaxation time of conduction electrons, c is the velocity of light (m/sec), and T is the absolute temperature (°K).

The data on the electric resistivity of Fe—Al melts were borrowed from [5, 6], the relaxation time values for conduction electrons in molten iron were obtained from [7], and the corresponding data for aluminum were borrowed from [4]. The value of τ for iron—aluminum at 1600°C was assumed to be $0.6\cdot10^{-15}$ sec, as in the case of iron. It should be noted that the corrections pertaining to the relaxation time are not larger than 6%. The good quantitative agreement between the $\varepsilon_T(\rho)$ and ε_T isotherms (see curves 1 and 2 in Fig. 2) indicates that the model of quasi-free electrons can be used for describing the emissive properties of Fe—Al melts. In conclusion, it should be noted that the detected anomalies of the ε_T isotherm in the 5 at. % Al range as well as the discrepancies between data on the electric resistivity indicate the need for further investigations of the thermophysical properties of this system.

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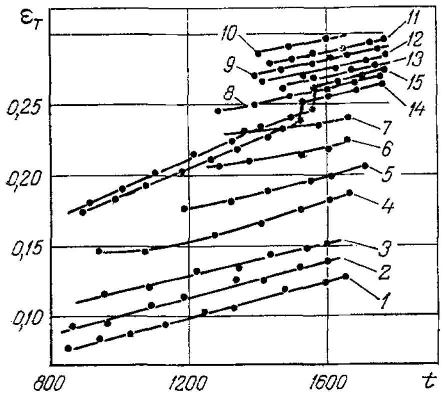

Fig. 1

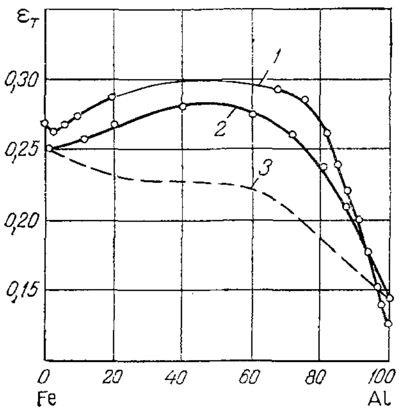

Fig. 2

Fig. 1. Effect of the temperature on the integral degree of blackness of iron—aluminum alloys in the normal direction. The aluminum content is expressed in mass percentages: 1) 100; 2) 98; 3) 96; 4) 92; 5) 89; 6) 86; 7) 84; 8) 82; 9) 73; 10) 68; 11) 19; 12) 10; 13) 6; 14) 4.8; 15) 0 (% Al); t, °C.

Fig. 2. Isotherms (1600°C) of the integral emittance of iron—aluminum alloys. 1) Our data; 2, 3) data calculated by using the Ashkinass—Foot equation and also the results of electrical resistivity measurements [5, 6], respectively (Al, at. %).

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