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# (213) On the Melting of Scrap and Sponge Iron [*1,3)]

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## 1. Introduction

The melting of scrap and sponge iron has been described in many papers (1,2). Except in a few cases all experiments have been carried out in small furnaces.

This work will show results of melting down isothermally scrap and sponge iron in electric arc and induction furnaces.
The second part of the work will compare the different existing mathematical models and introduce a revised model giving limiting cases for melting down particles in their own melt.

## 2. Formation of a shell on cold cylinders

During the first period of "melting down" a cold sample will become thicker. The formation of a shell depends among other factors on the different thermal conductivity of the particle (Fig.1).

## 3. Determination of the heat transfer coefficient α

Heat transfer and conduction are studied by melting down particles in their own melt. The melting time of scrap and sponge iron of different initial temperature is measured (Fig.2, dots).

In the case of maximum preheat of the solid the process is determined by the heat transfer from liquid to solid only.

Thus by "separating" the heat conduction from the heat transfer it is possible to determine a mean heat transfer coefficient (Table 1 Case 1).

## 4. Revised mathematical model for melting in an industrial furnace

The existing model for melting down a particle in its own melt (4) is revised for the industrially important case of super heating. The main cases to describe the melting process are shown in Table 1 along with the electrical analogue.

By knowing the heat transfer coefficient it is possible to calculate the minimum and maximum melting times of a particle in a bath at different temperatures (Table 1 Case 4 and 5).

Comparing the calculated and measured melting times (Fig. 2) it can be seen that the heat transfer coefficient is a function of temperature.

References:

1) Mori,K.;Nomura,H.:Tetsu-to-Hagané 55 (1969) p. 347/54
2) Sato,A. et al: Tetsu-to-Hagané 67 (1981) p. 79/88
3) Rademacher,P.K.: Dr.-Ing.thesis,RWTH Aachen, to be published
4) Friedrichs,H.A.et al.: Arch.Eisenhüttenwes.44 (1973) p. 879/86

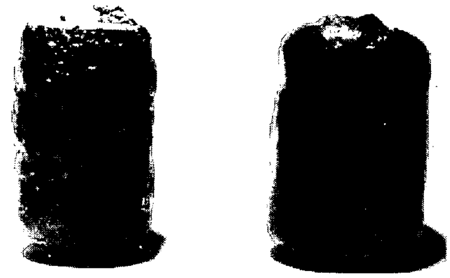

Fig.1: Forming of a shell on particles of different thermal conductivity λ.
Sponge iron (left) and pure iron (right)

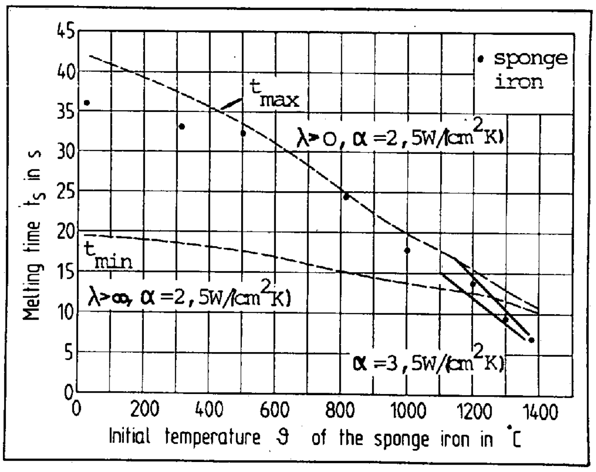


Fig.2: Total melting time of sponge iron at different initial temperatures (3)

| | Case 1 | Case 4 | Case 5 |
|---|---|---|---|
| Temperature of solid $T_s$ | Below melting point $\Delta h_s << \Delta h_m$ | Far below melting point | |
| Temperature of bath $T_B$ | Constant but above melting point $\Delta h_s << \Delta h_m$ | | Far above melting point |
| Equivalent connection | $T_B - T_m$ ⊢[ w ]⊣ $T_m$ | | |
| Heat flow | $I = \frac{T_B - T_m}{w} = \frac{\Delta H_m}{t_E}$ | | |
| Heat resistance | $w = \kappa \frac{n}{\alpha F_o}$ | | |
| Melting time | $t_E = \kappa \frac{n}{\alpha F_o (T_B - T_m)} \Delta h_m \rho V_o$ | | |
| Connector | $\kappa = 1$ | $\kappa_{min} < \kappa < \kappa_{max}$ | |
| | | $\kappa_{min} = (1 + \varphi_s)^{1/n}$ | $\kappa_{min} = (1 + \frac{\varphi_s}{1+\varphi_l})^{1/n} \frac{\varphi_l}{\ln(1+\varphi_l)}$ |
| | | $\kappa_{max} = 1 + \varphi_s$ | $\kappa_{max} = \frac{\varphi_l}{\ln(1+\varphi_l / 1+\varphi_s)}$ |
| Ratio of enthalpy | | $\varphi_s = \frac{\Delta h_s}{\Delta h_m}$ | $\varphi_l = \frac{\Delta h_l}{\Delta h_m}$ |
| Symmetry number | n for a plate (1), cylinder (2) and sphere (3) | | |

Table 1: Melting times for particles at different temperatures with electrical analogues (3)