(373) On the Melting of Scrap and Sponge Iron (2)[*1,2)]

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1. Introduction

The melting of pure solids in their own melt can be described by simple formulas (1,2).
In the more applied case of melting and dissolution in a multi-component-system heat- and mass transport are studied.
For the melting of sponge iron in a Fe-C alloy the influence of the carbon content on the transport phenomena is explained thermodynamically.

2. Some principals of melting

A solid that is immerged in a melt will form a shell.
If two samples of same mass and surface area but different heat conductivity are dipped into a melt, a thick shell will freeze on the sample with high heat conductivity. But actually this formation of a thick shell improves melting as can be seen at $t = t_2$ in Fig. 1.

3. Melting in a binary system

During the melting process in a binary system, heat and mass have to be transported. Assuming thermodynamic equilibrium at the phase boundary, no heat and mass transport inside the sample and corresponding heat and mass transfer, a connection between carbon concentration x_l and temperature T_P at the phase boundary shown in Fig.2 can be derived. x_l and T_P are estimated from the liquidus line of the phase diagram. Furthermore it is assumed that the equilibrium state at the melting front is reached without any interference by the concentration x_C of the solid[2,3].

4. Heat- and mass transfer coefficients α and β of sponge iron in an Fe-C alloy

The melting time t_E of pressed iron powder samples of mass M_C, surface F_C and initial temperature T_C has been reported to depend highly on the carbon content x_B of the bath with temperature T_B (Fig.3).
Using the formulas mentioned above, one can calculate the heat- and mass-transfer coefficients α and β. It can be seen that the heat- and mass-transport coefficients do not depend on the carbon content of the bath (Fig.4).

5. Conclusion

The great influence of the carbon on the melting time is therefore not a reason of kinetics, as some authors have assumed, but of thermodynamics.

References:
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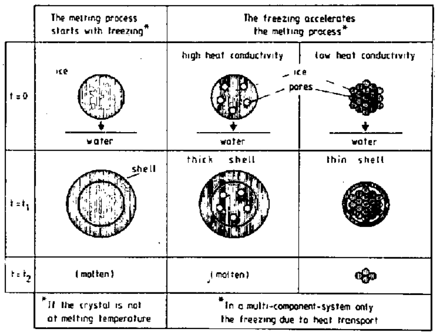

Fig.1: Some principles of melting

$$\frac{\ln(1+\frac{x_B-x_l}{x_l-x_C})}{\ln(1+\frac{\Delta H_\delta}{\Delta H_P})} = (\frac{a_l}{D})^{1/2}$$

$$\alpha = \frac{1}{t_E}\,\frac{c_{pl}M_C}{F_C}\cdot\frac{1}{\ln(1+\frac{\Delta H_\delta}{\Delta H_P})} \quad , \quad \beta = \frac{\alpha}{c_{pl}\,\varrho_l}\,(\frac{D}{a_l})^{1/2}$$

$$\Delta H_\delta = c_{pl}(T_B - T_P) \quad ; \quad \Delta H_P = H(T_P) - H(T_C) + \Delta H_m$$

Data used for the calculation of the transfer coefficients shown in Fig.4:

Thermal diffusivity of the liquid:	$a_l = 0{,}07\ cm^2/s$
Diffusion coefficient of carbon:	$D/(cm^2s^{-1}) = (1+0{,}24\ \frac{x_l-x_B}{2\%})\ 10^{-4}$
Specific heat of the solid:	$H(T_P)-H(T_C) = (1240+0{,}7(T_P-1420\,°C))(\frac{J}{g})$
Specific heat capacity of the liquid:	$c_{pl} = 0{,}71\ J/(g\,K)$
Heat of fusion:	$\Delta H_m = 250\ J/g$
Density of the liquid:	$\varrho_l = 7{,}1\ g/cm^3$

Fig.2: Formulas for the concentration x_l and temperature T_P at the phase boundary and for the transfer coefficients α and β.

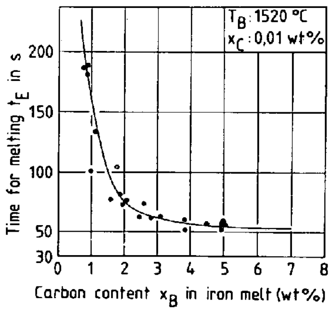

Fig.3: Reported values for the melting time t_E of pressed iron powder slabs (4)

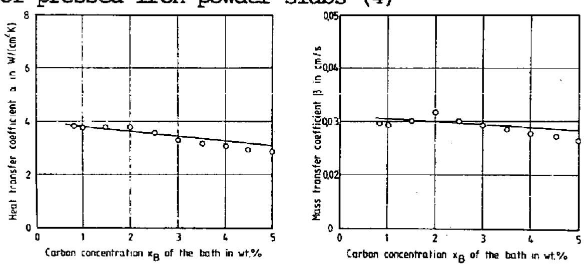

Fig.4: Calculated heat and mass transfer coefficients α and β according to Fig.3 as functions of the carbon content x_B of the bath