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(122) Relationship between Mould Heat Extraction and Shell Growth

(On Solidification in Continuous Casting Moulds - Part I)

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1. Introduction: Prediction of shell growth in the mould is most vital to breakout safety and surface quality. As shown earlier[1], growth behaviour also in moulds can be reasonably defined by the parabolic function $d = kt^{0.5}$---(1) with shell thickness, d, in mm, solidification time, t, in min, and the solidification constant, k, in mm $min^{-0.5}$. In order to monitor shell growth in the actual casting operation by the extent of mould heat extraction, a relationship between these two quantities must be established accordingly.

2. Investigation Procedure: In one part of a recent study on solidification in continuous casting moulds[2], plant observations on mould heat extraction of 24 casters - comprising machine radius from 4.0 to 12.5 m(including three straight-mould machines), strand number between 1 and 8, and section sizes ranging from 100 x 100 up to 310 x 2500 mm - were evaluated, totally 56 different sets of conditions.

3. Results and Discussion: As one important result, a parabolic relationship is found between the average heat extraction(related to mould surface), $\bar{H}_m$, and dwell time in the mould, t_m(Fig. 1). Thereby, billet sections with oil lubrication give higher values than powder-cast slab sections but also the difference in range of C-content is of influence (cf. Part II). Now, heat extraction can be simply linked with shell thickness and temperature(neglecting superheat): $H_s \sim 10^3 d\varrho[0.5E + C(T_i - T_s)]$---(2) with heat extraction (related to strand surface), H_s in kcal m^{-2}, specific density, $\varrho(= 7.4\ 10^{-3} g mm^{-3})$, melting enthalpy, $E(= 62\ cal\ g^{-1})$, specific heat, $C(= 0.17\ cal\ g^{-1}K^{-1})$, interface and surface temperature, T_i and T_s, respectively. Using the relationship between shell growth and shell temperature established earlier[1], the parabolic solidification constant can be derived from heat extraction at the "standard" dwell time of t_m= 0.6 min: $k \sim 0.225\ H_s^{0.5}$---(3). Accordingly, for the average conditions in Fig. 1 the resultant $\bar{k}$-values are (a) 29.8 and (b) 26.1 mm $min^{-0.5}$.

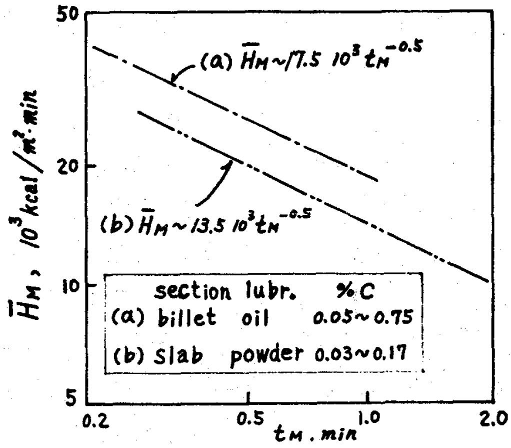

Fig. 1 Empirical relationships between mould heat extraction and dwell time for billet and slab sections.

4. Conclusion: As shown, not only shell growth but also heat extraction follows a parabolic function of time, thus, heat extraction measured at one casting speed can be used for prediction at others. Furthermore, the simplified approach by eq.(3) allows to derive the solidification constant from heat extraction. This provides a basis for effective control of the solidification process in the mould.

5. References: 1)M. Wolf, W, Kurz: Sheffield-Conf. 1977, 2)M. Wolf: Dr. sc. thesis, ETH Lausanne 1978