

will thus delay the formation of ferrite, pearlite and bainite, while more martensite is formed. Hence the presence of boron increases the hardenability of steel (Thelning, 1984).

Hillert (1971) studied the effect of alloying elements on the formation of austenite and the method of calculating the effect of an element on the carbon activity at the front

$$\frac{dl^\gamma}{dt} = \left[\tilde{D}_{FeM}^\gamma \cdot \frac{du_M^\gamma}{dy} - \tilde{D}_{FeM}^\delta \cdot \frac{du_M^\delta}{dy} \cdot \left(\frac{V_m}{1-X_C} \right)^\gamma \cdot \left(\frac{1-X_C}{V_m} \right)^\delta \right] / (u_M^\gamma - u_M^\delta) \quad (7)$$

$$u_M = \frac{X_M}{X_M + X_{Fe}} = \frac{X_M}{1-X_C} \quad (8)$$

where M represents the alloying element, γ and δ are the growing phase of austenite and shrinking phase of ferrite or cementite respectively. \tilde{D}_{FeM}^γ and \tilde{D}_{FeM}^δ are interdiffusion coefficients of Fe and M in γ and δ phases respectively, X_M , X_{Fe} and X_C are the mole fractions of M, Fe and C, V_m is the molar volume of the steel and u_M^γ and u_M^δ are compositions of alloy M such as Mn, Si, Cr, etc. in γ and δ phases. The model was then applied to steels with different carbon concentrations and achieved good agreement with relevant experimental results (Hillert et al., 1971).

5. Conclusions

The austenitization process can be divided into three typical steps which are nucleation, grain growth and homogenization. Starting microstructures, soaking time and temperature, carbon concentration and alloy composition have a great effect on austenitization. Significant study has been carried out on mechanisms and modelling techniques, including the effect of alloying, of austenitization. It is generally accepted that the formation and development of austenite in both plain carbon and alloyed steel, is a diffusion controlled process. According to the austenitization mechanisms studied, pearlite grains can be austenitized more quickly than ferrite grains, and also complete homogenization state can be achieved quicker in original pearlite grains. Most material models for austenitization available so far are based on Fick's second law. Thus partial differential equations are widely used. However, these equations are difficult to solve and

of the growing phase, without detailed information on the ternary phase diagrams (Hillert, 1955). He concluded that the effect of alloying can be accounted for by assuming local equilibrium at all the phase interfaces, and the model of a Fe-C-alloy is entirely rate controlled by diffusion. The growth rate equation of austenite can be calculated from

normally numerical methods are required.

Nomenclature

γ, θ, α (-)	austenite, cementite and ferrite phase in steel.
$C_\gamma, C_\theta, C_\alpha$ (%)	carbon concentration in austenite, cementite and ferrite.
t (s)	time.
r (m)	distance from the centre of the cementite particle.
δ (-)	a single α phase or θ phase.
$D_\gamma, D_\theta, D_\alpha$ (m ² /s)	carbon diffusion coefficient in austenite, cementite, and ferrite.
T (K)	temperature.
n (-)	integer related to the geometry of a austenitization model, where $n=0$ for planar geometry, $n=1$ for cylindrical geometry and $n=2$ for spherical geometry.
$r_{\gamma\theta}$ (m)	instantaneous position of the γ/θ interface.
$r_{\gamma\alpha}$ (m)	instantaneous position of the γ/α interface.
C_γ^{θ} (%)	carbon concentration in austenite at the θ/γ interface.
C_γ^{α} (%)	carbon concentration in austenite at the γ/α interface.
C_α^{γ} (%)	carbon concentration in ferrite at the γ/α interface.
C_d (%)	average carbon concentration in the material.
r_0 (m)	initial radius of the cementite particle or initial interface position.
D_δ (m ² /s)	carbon diffusion coefficient in δ phase.