growth and homogenization (Brooks, 1992).The kinetics of austenitization mainly depends on microstructure and chemical composition of the parent phase, soaking time, soaking temperature, as well as the magnitude of the appropriate carbon diffusion coefficients (Bain and Grossman, 1964; Akbay *et al.*, 1994; Judd and Paxton, 1968; Reed *et al.*, 1998; Atkinson and Akbay, 1996; Wert, 1950; Mclellan and Dunn, 1969; Capdevila, 2001; Smith, 1946; Wells, 1950; Smith, 1964; Miloud, 2005) .The majority models predicting the kinetics of austenite formation are based on these steps, although some neglect the nucleation step, as the nucleation of austenite in a Fe — C steels takes place just above the eutectoid temperature, and the nucleation sites are quickly saturated. After this saturation, the following austenitization process is dominated by the grain growth and homogenization (Brooks, 1992).

Alloy additions to low carbon micro-alloyed steels play important roles in the different mechanisms of austenitization. Normally, the presence of soluble particles, such as boron carbide in boron steel, may resist the growing austenite grain boundary movement by changing the surface energy of the particle and austenite grain boundary system, and reduce the mobility of the austenite grain boundaries by their diffusion ( Maazi and Rouag, 2001; Thelning, 1984). They may also delay the phase transformation of ferrite, pearlite or bainite in the subsequent cooling process (Thelning, 1984; Bain and Grossman, 1964). In this research, a set of schematic diagrams are designed to show the mechanism of the austenitization process for steels and basic theory for modelling of austenitization has been reviewed.

## 2. Mechanisms of austenitization of steels

Formation of austenite depends very much on the parent phase prior to heating for austenitization. Austenite grain growth and homogenization is a carbon diffusion controlled process, which is significantly depends on microstructure, chemical composition, soaking temperature and soaking time (Brooks, 1992; Thelning, 1984; Speich and Szirmae, 1969; Bain and Grossman, 1964; Akbay *et al.*, 1994; Judd and Paxton, 1968; Reed *et al.*, 1998; Atkinson and Akbay, 1996; larsson and Karlsson, 1975; Jacot and Rappaz, 1997; Jacot and Rappaz, 1999; Jacot *et al.*, 1998; Karlsson and larsson, 1975).

### *2. 1. Nucleation of austenite*

From the relationship of the amount of formed austenite with austenitizing time for eutectoid steel (Grossman and Bain, 1964), it is shown that there is an incubation period for the formation of the first austenite nucleus, after which more nuclei are developed and grown at a much higher rate. The incubation time is required in order to satisfy the thermodynamic condition for the nucleation of austenite (Christian, 1975). The eutectoid reaction of ferrite + carbide → austenite occurs when austenite nucleates. Therefore, the austenite is expected to nucleate at carbide-ferrite interfaces. As the driving force of heterogeneous grain nucleation, is determined by thermodynamics and geometry, surface energy at the interfaces of parent and product phases has to be taken into account. When the temperature increases to that at which austenitization occurs, the free energy change increases with the increasing temperature, resulting in the increasing rate of austenite nucleation, therefore, the starting and completion of austenitization will be earlier at a higher temperature than at a lower one for an isothermal case, as shown in Figure 1.

Geometrically, the surface energy is a function of the lattice mismatch between crystals, thus a high angle parent grain boundary would be more favorable for austenite nucleation (Speich and Szirmae, 1969; Roberts and Mehl, 1943; Samuels, 1980). Figure 2 schematically illustrates the preferred nucleation sites for austenite formation from the parent phase of ferrite, ferrite with spheroidized cementite and lamellar pearlite.

Figure 3 shows the evidence of austenite nucleation at interfaces of a pearlite matrix and a primary ferrite matrix.

### *2. 2. Grain growth of austenite*

Nucleation of austenite in Fe-C steels is a fast process (Haworth and Parr, 1965) and the preferred sites are quickly saturated. After nucleation of austenite, austenitization will be determined by the austenite grain growth. For a Fe-C steel, the grain growth of austenite is controlled by the diffusion of carbon at the $\theta / \gamma$ interface and the $\gamma / \alpha$ interface, as shown in Figure 4.