KAWASAKI STEEL TECHNICAL REPORT

No.12 (July 1985)

Special Issue on Hot-and Cold-rolled Steel Sheets

Effects of Heat Cycle and Carbon Content on the Mechanical Properties of Continuous-annealed Low Carbon Steel Sheets

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Synopsis :

Effect of the continuous-annealing heat cycle and carbon content on the mechanical properties of continuous-annealed low carbon steel sheets is discussed. The metallurgical basis of the continuous annealing process for producing deep drawing quality cold rolled steel sheets consists of the following: (1)Lowering carbon content to increase grain sizes,(2)high temperature annealing followed by slow cooling, (3)rapid cooling and (4)holding around 400 , all the four factors combined contributing to softening and decreasing solute carbon. Increasing grain sizes by decreasing carbon content is necessary not only for softening but also for enhancing the surpersaturation of solute carbon resulting in the dense cementite precipitation. The solute carbon profile in grain during cooling can be estimated on the assumption that a ferrite grain is of a spherical shape and the carbon diffusion to grain boundaries is the rate controlled

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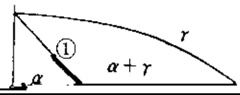
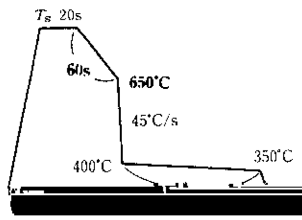
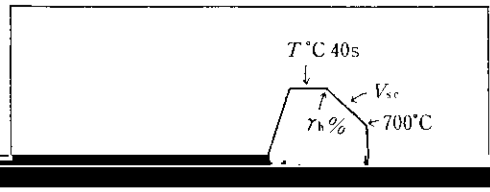
Effect of the continuous-annealing heat cycle and carbon content on the mechanical prop-



(a)

ing can easily be understood. Since the cooling rate is very slow in the case of box annealing, solute carbon





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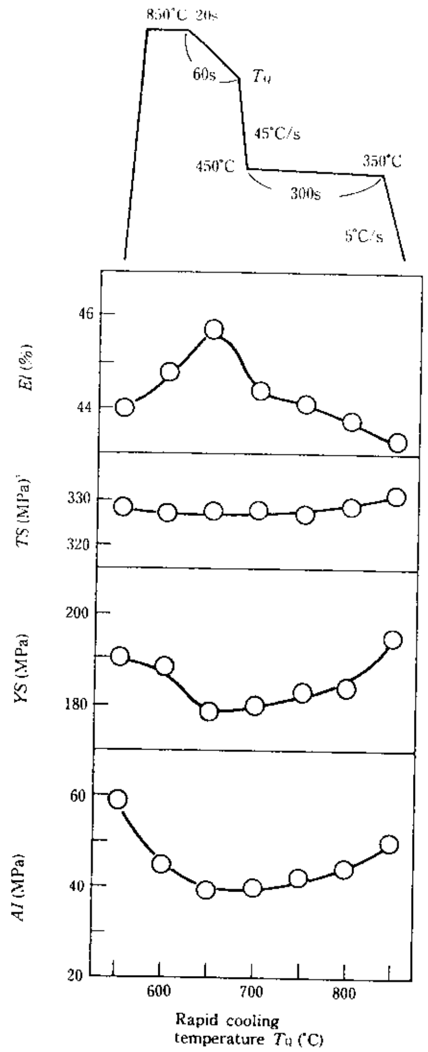


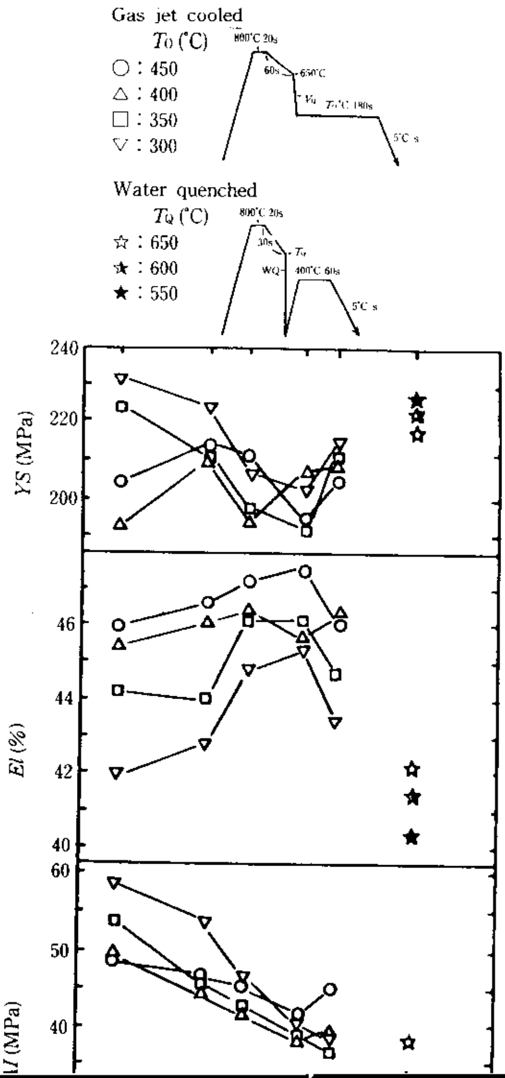
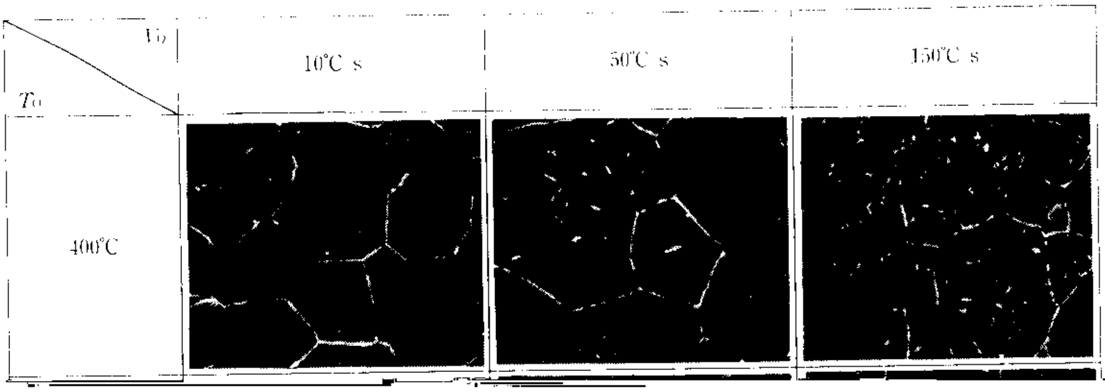
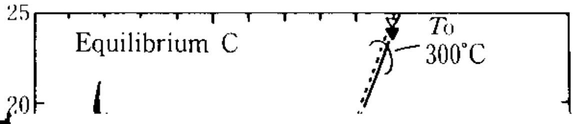


Fig. 5 Effect of

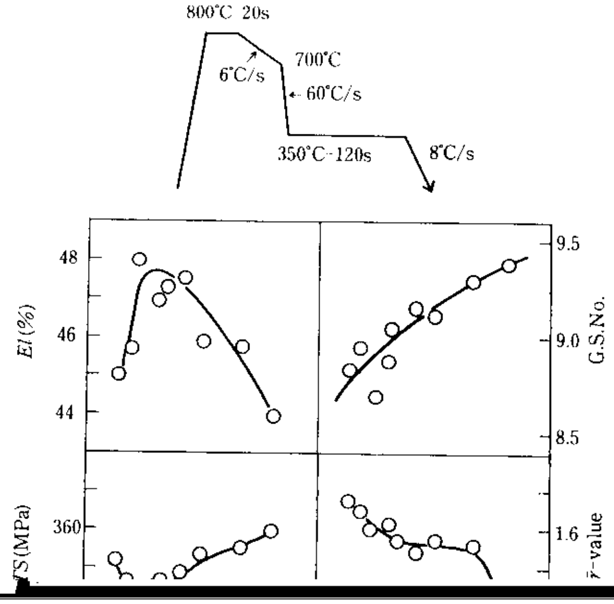


V_0
T_0
10℃/s
50℃/s
150℃/s
400℃

In general, grain boundaries are preferential nuclea- carbon content in the [illegible]



This indicates that the overaging temperature should be determined by examination from two viewpoints, that is, the nucleation and the growth of cementite. Recently an attempt has been made to give a generalized expres-



4 Effects of Rapid-cooling and Overaging on Continuous Annealing of Tinplate

In the past, hard tinplates with a hardness of T4 or over were manufactured on the conventional continuous annealing line (CAL), and soft (low-temper) tinplates of T3 or under were manufactured by box annealing. Similar to the case of drawing quality steel, however, the process of manufacturing low-temper tinplates of T3 or under using CAL, which is capable of rapid-cooling and overaging treatment, has now been developed and incorporated into standard operationing procedure.[14] The Metallurgical changes which occur during continuous annealing of low-temper tinplates are essentially the same as those with drawing quality steel, but are different in the following respects:

(1) High-temperature coiling at hot rolling causes coarsening of cementite grains and deterioration of

Table 2 Chemical composition and hot rolling tem

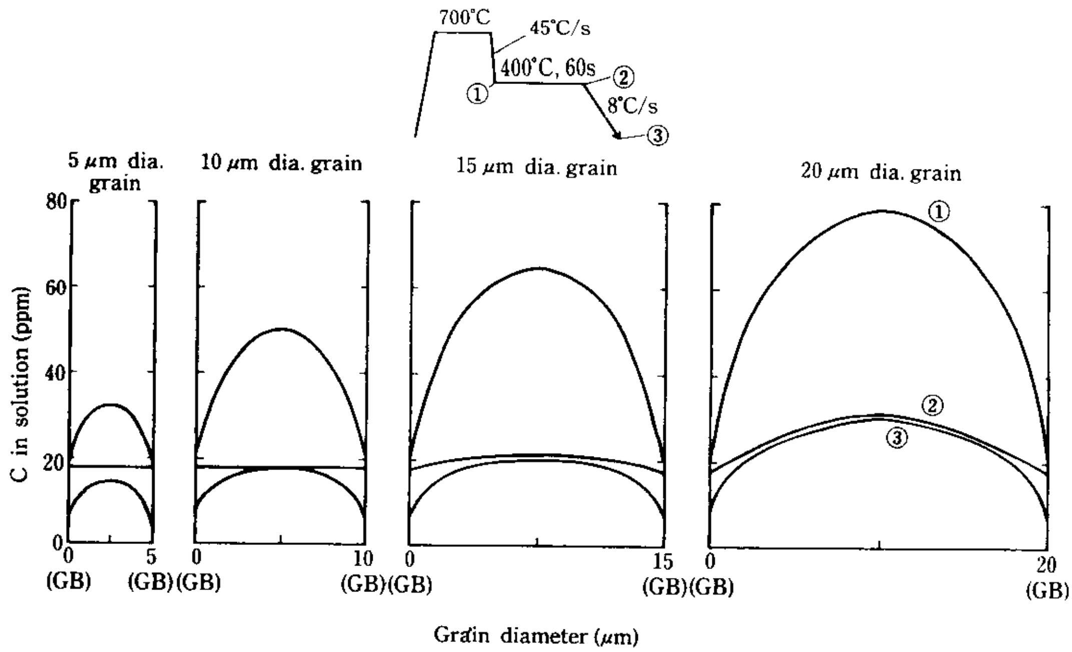
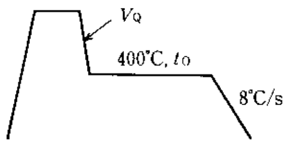
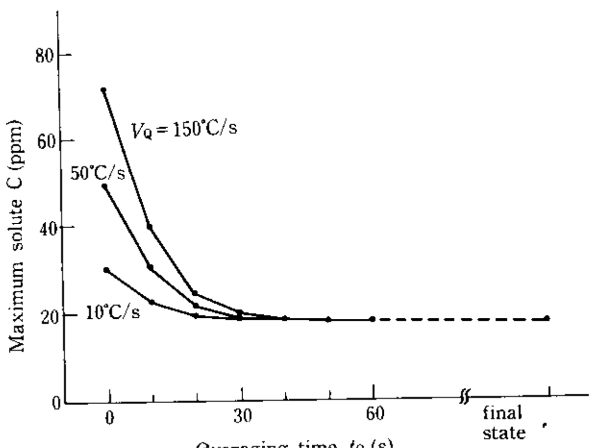


Fig. 15 Effect of grain diameter on the solute C change in a grain during overaging

and a large number of undissolved cementite grains



causes deterioration of corrosion resistance. It differs from deep drawing quality steel in this respect. The grain of annealed low-temper tinplate is of small diameter and contains undissolved cementite. For tinplate, therefore, the effect of cooling rate is



small and it is not a necessarily very important factor. What is important is the effective use of grain boundaries and undissolved cementite, and quick and efficient reduction of solute carbon.

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