Solidification Microstructure and Columnar-to-equiaxed Transition of Fe-C Alloy by Cellular Automaton

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A Cellular Automaton (CA)-Finite Difference (FD) coupling model was developed to analyze the development of solidification microstructure and the columnar-to-equiaxed transition (CET) in Fe-C alloy. Kobayashi's microsegregation equation [1] was adopted to describe the solute diffusion in solid phase, and a "decentred square" growth algorithm with coordinate transformation [2] was performed to describe the grain growth and the entrapment of neighbor cells.

Through the examination on the effects of operation parameters and nucleation parameters on solidification morphologies, it was found that length of columnar grains is controlled by the dendrite tip growth kinetics, and that width of columnar grains is controlled by the implicit relationship between nucleation density and cooling rate at ingot surface. It was also found that size of equiaxed grains is controlled by the competition of the nucleation and the grain growth. By using the control ability of nucleation density in the bulk of liquid for equiaxed grain size, the nucleant and its nucleation density in actual Fe-C alloy was estimated.

Both of the CET criteria on the solidification path by the CA-FD coupling model and the curves of the critical temperature gradient conditions by Hunt's model [3] were strongly dependent on nucleation undercooling and C concentration. The good agreement was obtained between the two.

KEY WORDS: Fe-C alloy; solidification microstructure; grain size; nucleant; CET; Cellular Automaton

Fig. 1. Comparison between CET criteria on the solidification path by the CA-FD coupling model and critical temperature gradient conditions by Hunt's model in Fe-C alloy.

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