STUDY ON DENDRITIC GROWTH OF FE-0.82WT%C ALLOY

*Weiling Wang, Sen Luo, Miaoyong Zhu**
School of Materials and Metallurgy, Northeastern University, Shenyang, China
[*]Corresponding author: myzhu@mail.neu.edu.cn

Abstract. A series of mathematical models and codes are developed to investigate the dendritic growth of Fe-0.82wt%C alloy. It is found that the small columnar dendrites are growing under the restriction of neighboring bigger ones and will be eventually combined to form the stronger columnar dendrites. With the decrease of cooling intensity, the primary dendrite arm spacing increases, and the secondary arms become undeveloped. The melt flow influencing the solute distribution around the solid dendrites promotes the asymmetrical growth of equiaxed dendrites, and generally inhibits columnar dendritic growth except at downstream side under weak flow intensity. The growth behavior of dendrites under melt flow is determined by the competition between bringing in solute enriched melt from upstream side and carrying away solute rejected at local interfaces.

1. Introduction

In traditional research and industrial production, the solidification defects are directly correlated with the processing parameters. The optimization of the process and its parameters relies on the experience and by trial and error. Obviously, it cannot meet the new challenge emerging with the development of high quality steel and the demand of the low cost. Fortunately, the as-cast structure of steel strands provides a bridge to connect the solidification defects and the processing parameters. So, the formation and the development of defects can be fully understood. The as-cast structure including the mesoscopic grain and the microscopic dendrite gives us some important information, such as grain size, equiaxed ratio and DAS. Our group has been devoted to the investigation of the solidification structure of continuously cast steels and focused on the development and the application of models with CA approach and the experimental tests of strands from steel plants. In the present paper, our simulation works on the dendritic growth of Fe-0.82wt%C alloy are briefly introduced. Moreover, their details can be found in the published papers[1,2].

2. Our works

Firstly, the columnar dendritic growth of Fe-0.82wt%C alloy predicted by our models is discussed, as well as the effect of the cooling intensity on the primary dendrite arms spacing (PADS). Fig. 1 shows the solute distribution and columnar dendrite morphology at 1.25 s with cooling intensity of 1.0, 0.8 and 0.6 relative to the mold cooling intensity of SWRH82B billet during continuous casting. With the solidification proceeding, the solute is gradually enriched in the liquid between dendrites and distributes as layers from dendritic roots to tips.

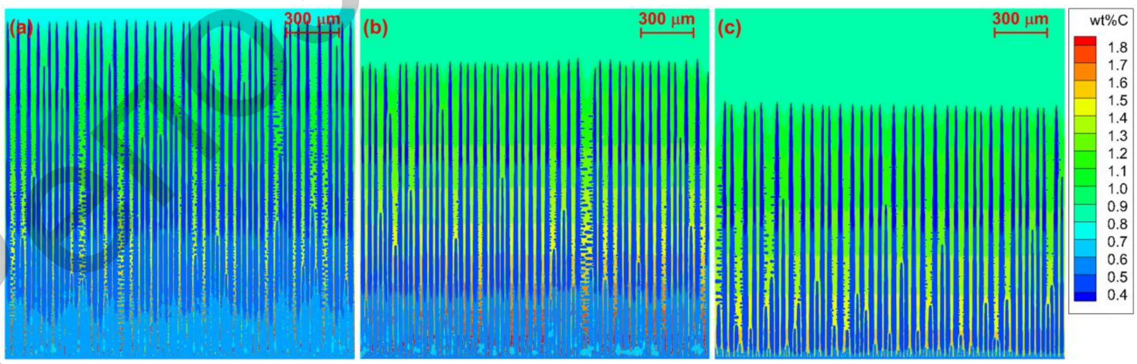

Fig. 1. Solute distribution at 1.25 s under cooling intensity relative to the mold cooling of billet (a) 1.0, (b) 0.8 and (c) 0.6[1]

The disturbance induced by temperature field and solute field is gradually intensified and causes the formation of secondary dendrite arms. Moreover, the secondary dendrite arms of strong dendrites will eventually hinder the progressing of neighboring thin and tiny columnar dendrites. However, before the growth of thin and tiny columnar dendrites is confined, the secondary dendrite arms of strong dendrites are undeveloped because the distance between dendrites is too small. Thin and tiny columnar dendrites will be eventually captured and devoured by neighboring strong dendrites. With the relative cooling intensity reducing from 1.0 to 0.6, PDASs increase from 51.0-130.0 μm (50% below 100 μm) to 62.0 μm to 169.5 μm (33% above 120 μm).

Secondly, the effect of the melt flow on the dendritic growth is focused on. As the melt flow is introduced, the four fold symmetrical morphology is destroyed, and changes into symmetry in horizontal direction, since the left (upstream) arm is promoted and the right (downstream) arm is restrained. The tendency becomes more significant with the increase of the inlet velocity and the decrease of the melt undercooling. It is also found that with the introduction of the vertical flow, the formed oblique flow near the dendritic tip at the downstream side will weaken the inhibited growth, especially at the low undercooling. With the introduction of the melt flow, the symmetry of columnar dendrites is also changed. The melt flow blows up the solute enriched at the root of the dendrite at the upstream side to the dendritic tip, which causes the growth of columnar dendrites is inhibited in sequence. However, as the inlet velocity is low, the columnar dendrites at the downstream side can easily break through the blocking of the melt with enriched solute. The melt flow can also promote the development of secondary arms far from the upstream side.

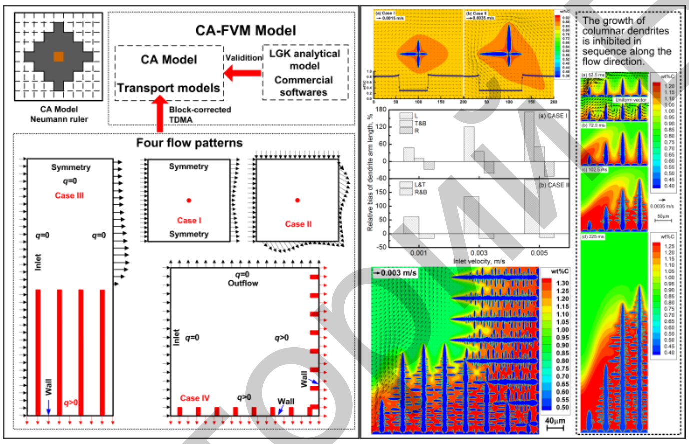

Fig. 2. The effect of melt flow on dendritic growth[2]

3. Conclusions and prospects

The main conclusions of our works can be summarized as follows:

(1) The coarsening behavior of columnar dendrites is observed. With the increase of cooling intensity, columnar dendrites become more compact, and PDASs decrease, moreover secondary dendritic arms become developed.

(2) The asymmetrical growth caused by the introduction of the melt flow is reinforced with the increase of inlet velocity and the decrease of melt undercooling. Due to the oblique flow near the dendritic tips at the downstream side, the growth there gets less inhibited, especially at the lower melt undercooling. The growth of the columnar dendrite is inhibited in sequence along the flow direction. However, under the weaker melt flow, columnar dendrites near the outlet can easily break through the blockage of the melt flow and achieve better developed structures.

1. Wang W, Luo S, Zhu M. Numerical simulation of dendritic growth of continuously cast high carbon steel [J], Metallurgical and Materials Transactions A, 2014: 1-11.
2. Wang W, Luo S, Zhu M. Dendritic growth of high carbon iron-based alloy under constrained melt flow [J], Computational Materials Science, 2014, 95: 136-148.