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Prediction and Prevention of Segregation in Large Ingots by Numerical Solidification Analysis

(Minoru Yao) (Akihiko Nanba) (Kenji Saito)
(Yutaka Sinsyo) (Kyoji Nakanishi) (Toshio Kato)

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Synopsis :

Solidification simulation technique for large ingots with various shapes has been developed. This technique is superior in computational accuracy and speed, because the basic difference equation is derived from heat balance at the outer nodal region in each element. Characteristic parameters obtained from the simulation results can reasonably predict formation of cavity, inverse V segregation, and macro segregation of carbon. The prediction methods have been applied to the designs of casting plans of roll ingots, large hollow ingots, and uni-directionally solidified ingots. These results made it clear that the simulation technique was effective for producing sound ingots.

数値解析による大型鋼塊の偏析予測とその防止技術*

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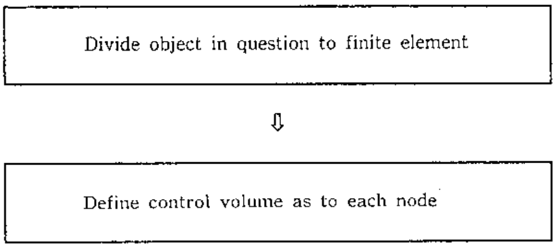
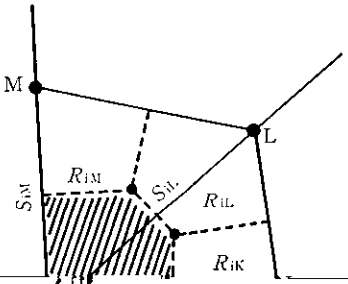
要旨

種々の形状の大型鋼塊に適用し得る凝固シミュレーション方法を，直接差分法（改良外節点法）に基づき開発した。本法は要素の


Divide object in question to finite element
⇩
Define control volume as to each node


M
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における熱伝達項を付加して考慮する（**Fig. 4** のフローチャート参[illegible]

向の凝固速度の比を考慮するものであり（**Fig. 5**），加速凝固域の[illegible]

に，温度勾配に対する冷却速度の平方根の比についても検討した。

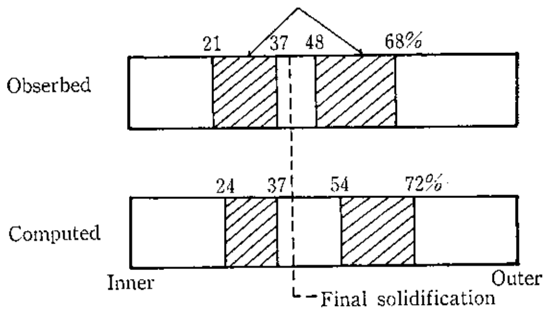
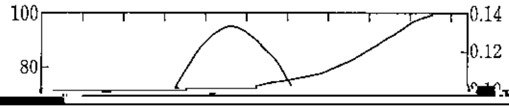


Fig. 11 Comparison between prediction and measurement for the region of inverse V segregation

Table 2 Casting conditions of hollow ingots and their results obtained

Ingot	A	B	C	D	E	F
Ingot weight (t)	20	30	45	90	140	226
Ingot thickness (cm)	45	50	58	70	129	129
Hot top ratio (%)	20	18	17	17	18	18
C_{max}/C_0	1.13	1.15	1.08	1.12	1.35	1.47
Solidification rate (mm/s$^{1/2}$)	1.95	0.98	0.98	1.95	0.98	0.98

ことが確認された。本図から分るように中空鋼塊では中子からの冷却を強化することにより，最終凝固位置とその両側の逆V偏析発生



よび A は同一鋼種での鋼塊破断によるマクロ偏析調査結果と一致するように決定したが，ここでは低合金鋼で $k_0=0.7$, $A=0.0071$ と

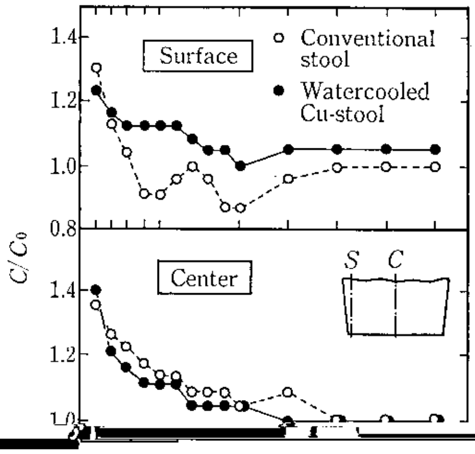
鋼塊底部から上方に向かって指向性凝固を行わせるためにV偏析な

[illegible]

定盤水冷には Fig. 17 のように 30 mm 角の鉄製パイプを通常定

[illegible]

逆V偏析発生域の予測を　通常定盤（非水冷）を用いた一方向凝固



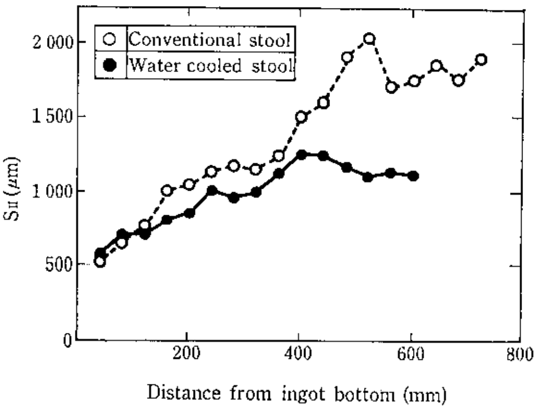


Fig. 22 Comparison between secondary

Fig. 21 Comparison between distribution of C segregation ratio with conventional stool and that with water cooled

ことにより，大型中空鋼塊での発生位置を予測し得るようにな