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Quantitative Evaluation of the Joint Segregation Characteristics of Two Alloying Elements

Graduate School, Nagoya University. ○Alireza RADJAI

Faculty of Engineering, Nagoya University. Shigeo ASAI and Iwao MUCHI

I. Introduction: Some statistical functions are employed to develop a new method for quantitative evaluation of the joint segregation characteristics of two alloying elements. A new index is proposed which is a measure of the extent to which the two elements segregate at positions close to each other or in the form of a compound. The proposed method and the index are used to evaluate the efficiency of calcium treatment in suppressing the formation of MnS in commercial continuously cast steel slabs. The combination of S with Ca in preference to Mn and P in a Ca-treated slab is quantitatively verified.

II. Theory: Let X_n and Y_n (n=1,2,3..,N) be the concentration-distance records corresponding to the distributions of two alloying elements. Then, a plot of the coherence function between them ($\gamma_{XY}^2(f)$) vs. spatial frequency (f) will give information about their common segregation spacings. On the other hand, the plot of phase angle between them (θ_{XY}) vs. spatial frequency (f) informs the extent to which their segregates are separated from each other at a specific spacing. Therefore, a combination of these two functions can be used to study the joint segregation characteristics of two elements. Based on this principle, an index is proposed which is called the overall joint segregation index and is defined as: $J_{XY}=(1/f_c)\int_0^{f_c}\{\gamma_{XY}^2\cos(\theta_{XY}/2)\}df$, where f_c is the cutoff frequency.

III. Application and Results: The specimens sampled from a calcium treated slab (A) and an untreated one (B) were scanned by an electron beam of 20 μm diameter for distributions of S and Mn. The plots of γ_{MnS}^2 and θ_{MnS} given in Fig. 1 show that the coherency between S and Mn in slab (A) is much lower than in slab (B). These plots quantitatively inform the efficiency of Ca-treatment in suppressing the segregation of MnS.

Moreover, to evaluate the extent to which S is combined with Ca in preference to other elements, slab (A) was scanned by a 5 μm electron beam for distributions of S, Ca, Mn and P. Table 1 gives the values of (J) for different combinations of the elements. It is quantitatively shown that S is combined more with Ca than with the other elements.

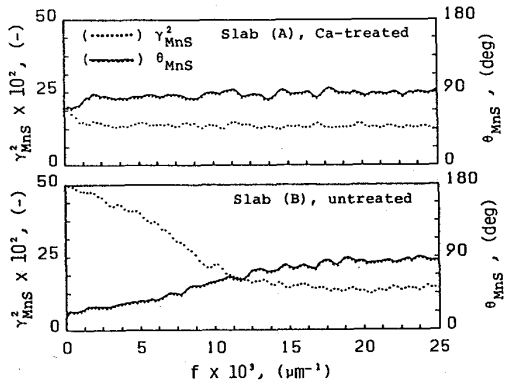

Fig. 1. Effect of Ca-treatment on γ^2_{MnS} and θ_{MnS} vs. f.

Table 1. Values of index (J) for some elements in slab (A).

Elements	Ca-S	Mn-S	P-S	Mn-Ca	Mn-P	Ca-P
J	0.328	0.149	0.111	0.239	0.182	0.141

IV. Conclusion: 1). A quantitative method for evaluating the joint segregation characteristics of two alloying elements is developed. 2). Efficiency of Ca-treatment is quantified. 3). The extent to which S is combined with Ca in preference to other elements in a Ca-treated slab is evaluated.