Analyses of Levitation Force in Induction Heating Furnace using 3D Edge Finite Element Method

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1. INTRODUCTION

Induction heating is a very common procedure for melting metals and alloy especially where all other heating procedures are not applicable or advisable. But, design process of such a complicated induction heating devices usually results with extensive use of computer job, time and cost. Not only magnetic flux density and eddy current density distributions inside the furnace have to be analyzed, but also the distribution and intensity of electromagnetic forces, especially levitation force has to be researched and optimized.

In this paper recently developed edge finite element method [1], [2] with its short computational time and low memory requirements, is applied for analyses and optimization of shape and parameters of induction heating furnace. Special attention was paid to the spatial distribution and intensity of the levitation force of the molten metal, for different coil positions, shape of the cold crucible and frequency of the excited current. Method of analysis together with comparison between computed and measured ones that show good agreement are also presented.

2. ANALYZED MODELS

In order to determine the influence of coil position on the levitation force of molten metal, two models shown on Fig. 1 with short and long crucible and each with three different coil positions were considered: $l = 0\ mm$, $l = 30\ mm$ and $l = 60\ mm$. The analyses were performed for two frequencies of excited current: $f = 2kHz$ and $f = 4kHz$.

3. OBTAINED RESULTS AND COMPARISON WITH MEASURED ONES

At the beginning numerically obtained results for magnetic flux density distribution were compared with measured ones. Since the results were in a good agreement, we proceeded the analyses with computation of eddy current distribution and electromagnetic forces using the *volume force density method.* Integrating partial electromagnetic forces over entire area of molten metal enables computation of levitation force acting on molten metal.

Obtained results are presented in Figs. 2 and 3. Fig. 2 shows the influence of the coil position (distance l in Fig. 1) for frequency $f = 2kHz$, and for long crucible. The numerically obtained results are in good agreement with measured once. From the results it is evident that changing coil position and its parameters (frequency and current intensity) enable optimization of spatial distribution and intensity of levitation force. Fig. 3 shows a

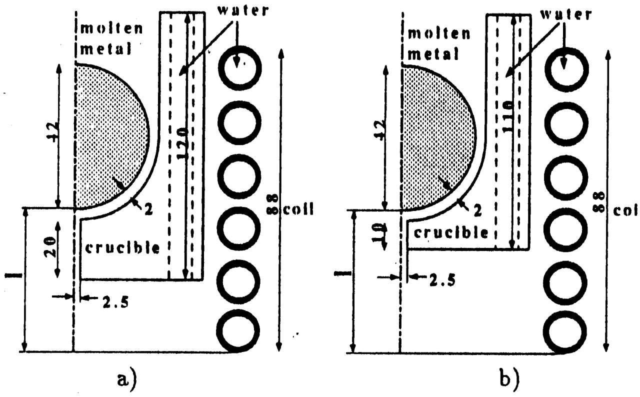

Fig. 1 Analyzed models a) Long crucible b) Short crucible.

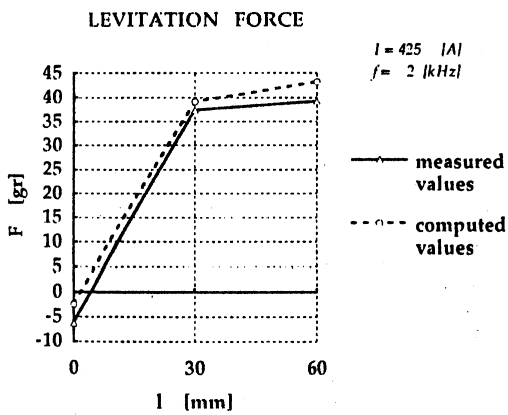

Fig. 2 Comparison between measured and computed levitation force.

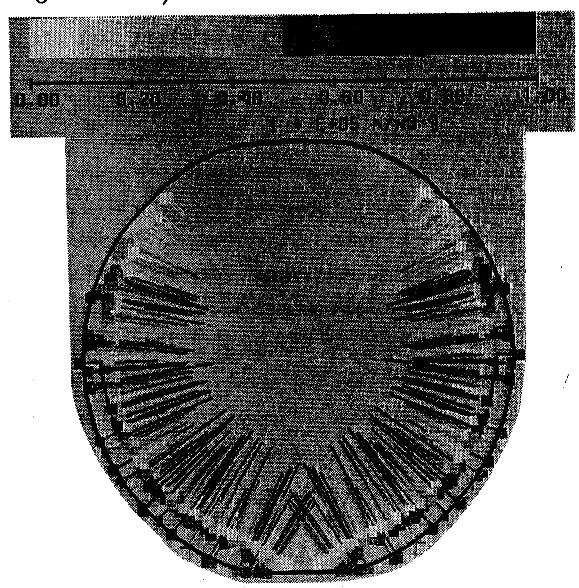

Fig. 3 Typical distribution of electromagnetic forces.

typical distribution of electromagnetic forces in molten metal. The influence of the length of the crucible and frequency of the current source will be discus in details in the full paper.

4. CONCLUSIONS

Levitation force acting on the molten metal is strongly effected by the coil position. Better results are observed using short cold crucible, while increasing the frequency results with decreasing the levitation force. It is possible to optimize the coil position, the value of the excited current and its frequency in order to achieve desired amount and distribution of levitation force.

REFERENCES

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