Study on Bubbler Position Optimization of Cold Crucible Induction Melter

Seokju Hwang*, Young Hwan Hwang, and Cheon-Woo Kim

KHNP CRI, 70, 1312-gil, Yuseong-daero, Yuseong-gu, Daejeon 34101, Republic of Korea

*hsjhhhhh@khnp.co.kr

1. Introduction

In the cold crucible induction melter(CCIM), bubblers are installed to efficiently mix wastes such as dry active waste and resin with motlen glass to obtain high-quality stable glass solid. In this study, the thermal flow field is visualized in the CCIM according to the position of the bubbler, and the influence of the position of the bubbler on the flow of the molten glass in the CCIM is examined. Previously, study was the thermal- flow analysis inside the CCIM.[1]

2. Thermal-Flow Analysis

2.1 Analysis strategy

Thermal-Flow Analysis in the FLUENT 15.0 is used. Under the presumption of abnormal state and incompressible flow, the volume of fluid(VOF) model, and standard k-ε turbulence model were applied to simulate the bubble behavior, molten glass, and interface.

2.2 Initial Conditions

The physical properties and boundary conditions used in this study are shown in Table 1 and Table 2. [2] The cooling conditions outside the CCIM are evaluated by calculating the thermal transfer coefficient according to the given temperature, which influences the thermal flow simulation.

Table 1. Physical properties of the air and glass

	Density (kg/㎥)	Cp (j/kg·K)	Thermal Conductivity (W/m·K)	Viscosity (kg/m·s)	Molecular Weight (kg/kgmol)
Air	1.225	1006.23	0.0242	1.7894e-5	28.966
Glass	2350	1290	3	4.278	69.62

Table 2. Boundary conditions for interfaces

	Interface	Bottom Wall	Side Wall Air	Side Wall Glass
Heat Transfer Coefficient	80 W/m^2·K	300 W/ m^2·K	80 W/ m^2·K	30 W/ m^2·K
Free Steam Temperature	30℃	24℃	30℃	30℃

In order to investigate the thermal flow phenomenon of the molten glass with respect to the position change of the bubbler, the bubbler position was changed to 4 positions based on the center. The bubbler position for each analysis case is shown in Fig. 1.

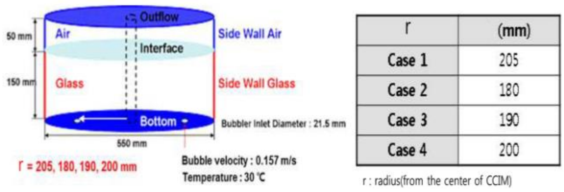

Fig. 1. Dimensions and boundary conditions of CCIM.

2.3 Analysis results

Fig. 2 shows the temperature distribution of the central section with respect to time in the case of Case 1.

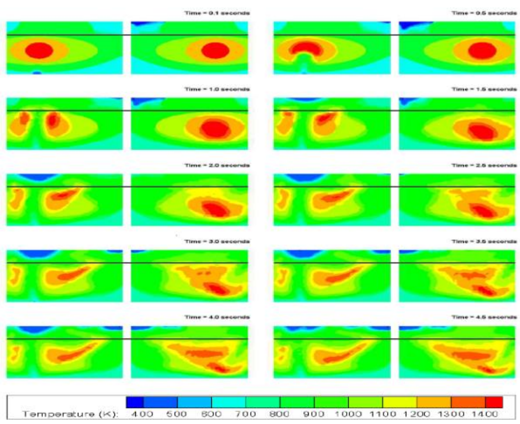

Fig. 2. Temperature distribution. (Case1)

Fig. 3 shows the temperature distribution with respect to time when the bubbler's position is 0.18m from the center.

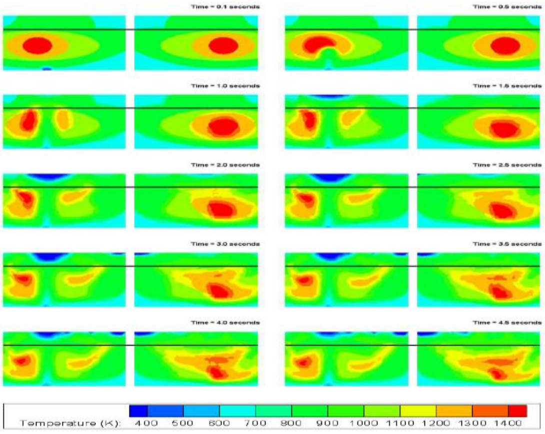

Fig. 3. Temperature distribution. (Case2)

Fig. 4 and 5 show the temperature distribution of the central section with respect to time when the position of the bubbler is 0.19m and 0.2m from the center.

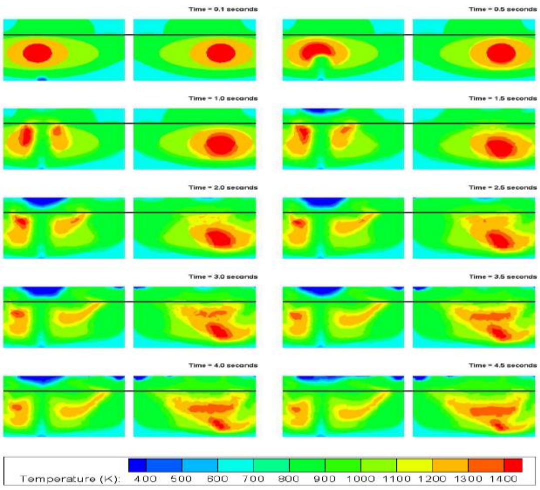

Fig. 4. Temperature distribution. (Case3)

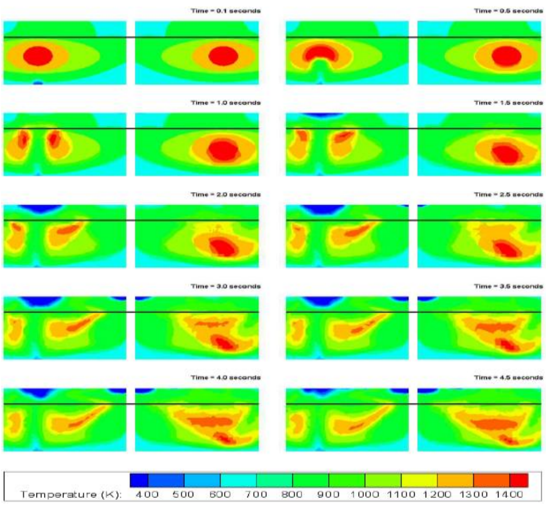

Fig. 5. Temperature distribution. (Case4)

It can be seen that the temperature of the wall of case 2~4 is lower than the wall temperature of case 1. This is because of the flow of fluid generated by bubbles, less active around the wall than in case 1.

In order to analyze the flow inside the CCIM, the streamline was identified in the middle section. Fig. 6 shows the streamline of the central section with respect to time when the position of the bubbler is 0.205m from the center (case 1). In the early stage of the bubble generation, it can be seen that the internal melt flow path rises due to the momentum generated by the bubble generation. As the bubble rises, it is observed that the molten glass circulates thanks to the vortex generated near the wall surface and the central position inside the CCIM. According to the analysis, the size of vortex only differed from the central part and wall surface according to the position of the bubbler.

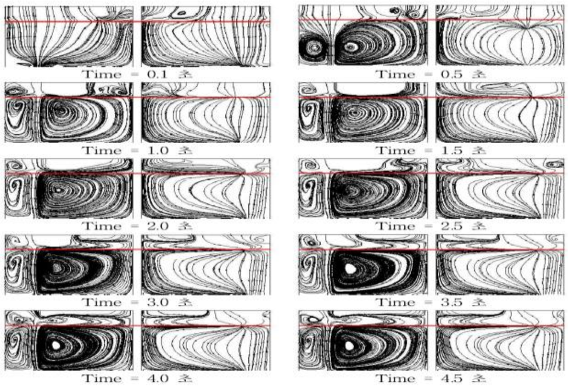

Fig. 6. Streamline inside the CCIM. (Case1)

3. Conclusion

The effect of the position of the bubbler on the flow of the molten glass inside the CCIM was analyzed by visualizing the thermal-flow field according to the position of the bubbler. It was confirmed that the flow the fluid did not flow toward the wall as the position of the bubbler became closer to the center. As a result, it is found that case1 is the optimal position.

REFERENCES

[1] KHNP CRI, "Thermal fatigue life evaluation of the CCIM chamber.", Technical Report (2013).

[2] Seokju Hwang, Young Hwan Hwang, Cheon-Woo Kim, "Study on Thermal-Flow Analysis of Cold Crucible Induction Melter", Proc. Of the KRS 2017 Spring Conference, 15(1) May 24-25, 2017, Busan.