論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Study on Joule-heating Flow and Diffusion Flow in Glass Melter Models
著者(和文)	ZhouJiaju
Author(English)	Jiaju Zhou
出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第10969号, 授与年月日:2018年9月20日, 学位の種別:課程博士, 審査員:木倉 宏成,竹下 健二,赤塚 洋,筒井 広明,相樂 洋
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第10969号, Conferred date:2018/9/20, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

専攻： Department of	原子核工学　　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（　工学　）
学生氏名： Student's Name	ZHOU JIAJU	指導教員（主）： Academic Supervisor(main)	木倉　宏成
		指導教員（副）： Academic Supervisor(sub)	赤塚　洋

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This thesis describes studies of Joule-heating flow and diffusion flow in LFCM process melter shape models used experimental model and numerical model. Chapter 2 observes Joule-heating flow behavior in a 2-D glass melter shape model cavity named slopping bottom cavity to understand characteristics of Joule-heating flow in the glass melter. Chapter 3 is devoted to develop GSMAC-FEM code applying on Joule-heating calculation in the slopping bottom cavity and the code was verified by experimental result written in the chapter 2. Chapter 4 describes diffusion flow of high viscosity fluid in a cylinder tank which is the validate results for HLLW diffusion simulation in the glass melter. Simulation of high viscosity fluid diffusion is reported in Chapter 5, followed by the overall conclusion in Chapter 6.

In the Chapter 1 “Introduction”, background of research about the vitrification technology of High Level Radioactive Wastes (HLLWs) using Glass melter is presented.

In the Chapter 2 “Experimental investigation of Joule-heating flow in a glass melter model”, the flow behavior of Joule-heating flow in a 2-D glass melter shape model cavity named sloping bottom cavity is observed. This chapter presents the characteristics observation of Joule-heating flow occurs in the sloping bottom cavity using glycerol-water solution as working fluid. For flow measurement, the instantaneous velocity profile is needed to understand the flow characteristic. In the chapter, the flow profile on the center vertical line is observed by the UVP method, and the PIV method is applied to observe the flow behavior two-dimensionally. The temperature profile is obtained by thermocouple measurements. In the sloping bottom cavity without the electrode cooling, chaotic flow occurred just in the upper part, only a small flow was in the sloping bottom part. In the condition with the electrode cooling, the chaotic flow also occurred in the upper part of the cavity. The Joule-heating area was similar to that without the electrode cooling.

In the Chapter 3 “Numerical investigation of Joule-heating flow in a glass melter model”, the simulation analysis of Joule-heating flow by computational codes is presented. The flow behavior in glass melter is too complicated by interfering of flow field, thermal field and magnetic Field. Hence, finite element analysis code, GSMAC-FEM, which applies coupled solution of temperature field, flow field and magnetic field, is utilized to simulate the molten glass. To validate the GSMAC code, experimental results reported in the Chapter 2 is used to compare the numerical result. As a results, a comparison of history of temperature measured at center of cavity shows good agreement between experimental data and numerical results. Moreover, Fast Fourier Transform (FFT) was used to investigate quantitatively the Joule-heating flow from the time-series velocity data. The same slop of FFT analyses of numerical data and experimental data could be observed. After the validation, the molten glass was applied as a working fluid in the real scale sloping bottom cavity model in the GSMAC method to predict the flow in the glass melter.

In the Chapter 4 “Experimental investigation of feeding flow diffusion led by concentration and density difference”, the flow behavior of diffusion flow by flow feeding in a cylinder tank modeled HLLW feeding is observed. To understand the flow diffusion, the injected fluid concentration was measured using an Electric Resistance Tomography (ERT) technique at the top, middle and bottom levels in the cavity. A vertical velocity component was also measured using an Ultrasound Velocity Profiler (UVP) technique. The concentration profiles of the injected fluid at different levels in the cavity were found to change with the viscosity of the injected fluid, and the velocity was found to depend on the density of the injected fluid. As a result, after injection into the cavity, the injected fluid formed a ball at first, and the liquid ball flowed down by gravity with the diameter increasing slowly. However, the liquid ball did not fall downward in a straight path due to the shape deformation and the drag force from the surrounding liquid changing its direction. As the liquid ball falls, a thin long stream of liquid was left behind by the ball. After the liquid ball reached the bottom of the cavity, some residual flow could still be measured in the surrounding fluid.

In the Chapter 5 “Numerical investigation of feeding flow diffusion led by concentration and density difference”, the simulation analysis of diffusion flow by computational codes is presented. A commercial CFD code fluent using Volume of Fluid (VOF) model was applied to calculate the flow diffusion after injected into a cylinder tank. To validate the model, experimental results reported in the Chapter 4 was used to compare the numerical result. The diameter of injected flow had a good agreement between the experimental data and the numerical data.

In the Chapter 6 “Conclusion”, insights the chapter 2 to chapter 5 are summarized in this chapter.