論文 / 著書情報
Article / Book Information

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Type(English)	Summary

（博士課程）
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論 文 要 旨

THESIS SUMMARY

専攻： Department of	Nuclear Engineering 専攻	申請学位（専攻分野）： Academic Degree Requested	博士 （ Engineering ） Doctor of
学生氏名： Student's Name	DUONG Thanh Tung	指導教員（主）： Academic Advisor(main)	Hiroshige KIKURA
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The High Level Radioactive Wastes (HLWs) are vitrified in a glass melter. In Japan, Liquid Fed Joule-heated Ceramic glass melter (LFCM) has been developed. It applies a constant AC voltage between the main electrodes in order to generate the volumetric heating of molten glass. However, the glass melter is sometimes shut down presently due to the sudden change of the temperature in glass melter. Thus, the understanding the flow behavior in glass melter is important. In the glass melter, the homogeneous Joule-heating of the volume generates a complicated flow. Correspondingly, the stable operation of glass melter is difficult to be maintained. Computational Fluid Dynamic (CFD) can be applied to predict the flow behavior. The flow behavior in glass melter is combined of three fields: flow field, thermal field and magnetic field. Hence, GSMAC-FEM (Generalized Simplified Marker and Cell- Finite Element Method) which can solve the coupled analysis models of three fields is applied. However, GSMAC-FEM is confirmed before applying for Joule-heating flow. The experiment with molten glass is difficult to be conducted in Laboratory scale due to high temperature and opaqueness of molten glass. Therefore, at first, a simplification of the glass melter using a cubic Joule-heating cavity is executed in order to investigate the fundamental flow phenomena induced by internal heat source. Consequently, Joule-heating induced flow in a cubic cavity with glycerol-water solution is examined qualitatively and quantitatively for confirmation of GSMAC-FEM calculation.

The measurement of Joule-heating flow is executed in a cubic cavity (0.1m×0.1m×0.1m) using glycerol-water solution as a working fluid. The flow behavior is very unstable. To understand the flow characteristic, the instantaneous velocity profile needs to measure. Thus, Ultrasonic Velocity Profiler (UVP) method is applied to observe the Joule-heating flow characteristics. The advantages of this method are non-intrusive, applicable in opaque fluids and high temperature fluid such as molten glass. UVP method has some difficulties such as the UVP analysis uses the sound speed in the medium. Therefore, the study on the effect of temperature-dependent speed of sound on the accuracy of the measurement is examined first. Accordingly, a comparison of velocity measurement between UVP method and Particle Image Velocimetry (PIV) is executed. As a result, the comparison of vertical velocity profile presents a good agreement and the discrepancy is less than 5%. Consequently, the frequency spectrum of velocity fluctuation is analyzed from the time-series velocity data. A slope close to -5/3 of frequency spectrum is observed. This slope value is expected in theory for homogeneous isotropic turbulence.

GSMAC-FEM is applied to simulate Joule-heating flow in a cubic cavity using glycerol-water. Using experimental data, GSMAC-FEM is confirmed qualitatively and quantitatively. As a results, GSMAC-FEM can reproduce the chaotic flow in a cubic cavity using glycerol-water. The frequency spectrum is also observed as homogeneous turbulence flow. Moreover, a comparison of temperature history shows a good agreement between GSMAC calculation and experiment data. The applicability of numerical analysis for Joule-heating flow is confirmed.

In glass melter, there are many parameters which affect the chaotic flow, such as cooling condition of electrode plates (due to high temperature) top cooling temperature. Therefore, these effects should be investigated experimentally and numerically using glycerol-water solution. As a result, cooling condition of electrode plates has a strong effect on the Joule-heating flow behavior that the vortex area existed in the upper part of cavity. On the other hand, the condition of the top surface is changed to partly cooling and partly adiabatic in order to investigate the cold cap boundary condition effect. The top cooling wall is covered partly or all (50%, 75% and 100%, respectively). A stable flow is observed with a main vortex which has a diameter of about 90mm for both 50% cooling and 75% cooling. However, when the top wall is cooled on 75% of the surface, variation in width of main vortex is observed. Accordingly, the qualitative and quantitative comparison between GSMAC calculation and experimental data is executed. The effect of mentioned boundary condition is also revealed by numerical results.

Finally, the flow behavior of molten glass is numerically investigated by GSMAC-FEM. The shape of a glass melter is simplified as a cubic cavity (0.7m×0.7m×0.7m) which has a similar dimension of TVF (Tokai Vitrification Facility). TVF is the prototype of glass melter developed for reprocessing of the vitrified waste. A chaotic flow behavior of molten glass is observed by numerical calculation. The average force profiles such as buoyancy force, diffusion force, convection force and Lorentz force are calculated. It is observed that the Lorentz force has significant impact on the flow behavior. Therefore, the magnetic fields should be considered to reveal the flow behavior in the glass melter. These results contributed to reveal the flow behavior in glass melter by a numerical analysis.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
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