【別紙２】

論文名：A Study in Volumetric Receiver under Beam-Down Concentrated Irradiation
（ビームダウン集光照射を受ける体積型レシーバの研究）（要約）

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Porous media are characterized by extremely large specific area. Their huge interface area between solid and fluid phases enhances heat transfer and chemical reaction. Porous material such as foam device and honeycomb often encounters thermal radiation. Application of irradiated porous prevails to laser welding for metal powders, laser operation to human tissue, high temperature solar receivers for concentrated solar heat utilization, solar reactors and solid oxide fuel cells. These applications involve mutually interacted three-styles of heat transfer: radiation; convection; conduction. Optimization and control are challenging for engineers due to difficulty of predicting interactive transport processes. Some porous material has complex structures, to make the problem even harder to solve. This is because thermal dispersion is encouraged by hydrodynamic mixing of flow. Moreover, when the incident radiation enters to the porous media, their multifaceted geometry causes the volumetric effect making transport process quite complex.

Especially, series of this study focus on volumetric solar receiver under beam-down concentrated irradiation. The beam-down optics will increase the effectiveness of solar field utilization and enhance the thermal efficiency because of homogeneity of irradiation. The present study selected this new technology as a next generation reflector, and considers combination of the beam-down optics and volumetric solar receiver. This thesis consists of seven following chapters:

Chapter 1 introduced background of irradiated porous structure applications, which involve radiation, convection and conduction heat transfer. Especially, volumetric solar receiver for concentrated solar heat usage was treated as a focused area. The current technology and novel numerical methods were described for solar receivers. Moreover, it was explained that the major objectives were experiment, simulation and analysis of vertical oriented receiver for high-temperature solar absorption. The target temperature is 1000–1500°C.

In Chapter 2, SiC honeycomb receiver is experimentally evaluated using 30 kW_{th} beam-down solar simulator in Niigata University. This experiment successfully collected data of vertically installed honeycomb receiver irradiated by beam-down concentrated irradiation. Measurement was made for the air temperature at receiver outlet and thermal power by convective air flow in various operating conditions.

Chapter 3 described continuum modeling and simulation of honeycomb receiver. The numerical model reproduced the entire area of the flow and temperature fields in the receiver and the upstream and downstream area. The experimental data acquired above were used for confirmation of numerical validation. The simulation investigated the macroscopic heat transfer performance of the receivers with different sizes. Additionally, it was examined how the buoyant flow affected the receiver performance.

In Chapter 4, the numerical simulation focused on direct simulation of the unit channel of honeycomb receiver. Numerical method was developed for conjugate heat transfer problem at the receiver channel. Discrete Ordinates radiation model was applied to solve radiative transfer equation. Thus, the radiative heat transfer could be fully coupled with CFD solver. This chapter described the fundamental validation of the method changing number of mesh and angular discretization to compare the results with the experiment. Moreover, this chapter introduced and evaluated cut-back channels, which are fabricated by removing part of solid wall from simple channel's inlet.

In Chapter 5, heat transfer mechanisms of simple and cut-back channels were discussed in more detail. The receiver efficiency and energy loss analysis were conducted for wider operating conditions of air mass flow rate and incident beam width. Energy balance on the inner walls of channel was examined to explain the performance enhancement of cut-back channels.

The simulation of Chapter 6 examined the heat transfer and hydrodynamic characteristics of the simple channel at very high temperature conditions in the range of 1000–1500°C. This operating temperature was assumed for the application for solar fuel reactors. The effects of cell sizes and air mass flux were analyzed at certain level of POM (irradiation power over air mass flow rate). There were optimized conditions showing maximum receiver efficiency and minimum re-radiation loss for high temperature solar concentration.

Finally, concluding remarks are summarized in Chapter 7.