別紙様式８

研　究　主　論　文　抄　録

論文題目　Flow Characteristics in X-Shaped Micro-Channels
（X字型マイクロチャネル内の流動特性）

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主論文要旨
《本文》

Fluid flow and heat transfer in channels and pipes occur in many engineering applications, such as cooling in mechanical machineries, gas and water turbines, and mixing ducts. Understanding the internal flow effects on the fluid flow temperature gradient, velocity and pressure changes, helps to improve the design of those devices. The traditional normal sized channels can be stirred or used in other ways to form the turbulence flow for mixing. However, with very low Reynolds numbers and flow velocity in micro-channels, the flow becomes laminar. Therefore, mixing takes a relatively long and hard time. Designing a highly efficient and stable micro mixer is a critical issue in micro fluid research. In another approach, the fields of biochemistry and biology for example, various types of micro-channels have been designed and demonstrated with the goal of developing microminiaturization devices. The blood system in the human body can be said to be a natural and special micro flow. The study of blood flow can predict many vascular diseases and save a human's life.

In the past, several studies of micro-channels have focused on the mixture characteristics in C-shaped and T-shaped micro-channels with complex flow fields of temperature gradient, velocity vector, and pressure change. However, the purpose of this study is to research the flow transport phenomenon by employing different converging and diverging angles, channel sizing, and channel geometry on the converging, mixing and diverging area in X-shaped micro channels. The main concern of the study of converging, mixing and diverging processes in micro-channels concentrates on enhancing mixing performance such as in stretched and folded fluids to generate chaotic advection and increase the interfacial area or incorporated obstructions within the micro-channel to break up and recombine the flow.

During the last decade, many theoretical and experimental investigations have been conducted to better understand the flow characteristics in micro channel heat sinks designed for use in the thermal control of electronic devices. In the past design work of thermal system, the efficient utilization of energy has been treated as an essential consideration except the analysis from the view point of thermodynamic first-law. Nowadays, the second-law of thermodynamic, irreversibility and entropy generation in the flow field have been adopted as a gauge for evaluating the optimization of thermal system. Entropy generation minimization is a method of modeling real devices that owe their thermodynamic imperfection to heat transfer and velocity distribution. Entropy generation is associated with thermodynamic irreversibility, which is present in all types of heat transfer processes. Therefore, it makes good engineering sense to focus on the irreversibility of heat transfer and fluid flow processes, and try to understand the function of entropy generation mechanism.

The objective of the entropy generation method is to optimize heat transfer in X-shaped micro-channels via both first and second laws of thermodynamics. We analyze the fluid flow transport phenomenon in X-shaped micro-channels both on numerical simulation and experiment. Our goal is to design a mixer by studying the effects of converging and diverging angles, channel sizing, and channel geometry. Therefore the entropy generation method can be a useful tool to confirm a better design.

For apparatus setup, water as a working fluid, is injected to the micro-channel at different mass flow rates. Over a wide range of flow condition, $0.52 < Re < 881$, in X-shaped micro-channels has been tested. The mixture performances of numerical simulation, flow visualization, and temperature distribution were been compared and discussed in this present paper.