CHAPTER I

INTRODUCTION

1.1 Background

Flow of fluid in long tubes and ducts has been the subject of extensive study for many decades because the tubes and ducts serve as important component in a wide variety of heat exchange devices. Nevertheless, very little information is available on the hydrodynamic characteristics in flows through short tubes and ducts with abrupt entrance and exit.

The ratio of tube or duct length to its hydraulic diameter, L/D_h is the dimensionless parameter commonly employed as a measure of length for the development of a boundary layer. Another dimensionless parameter is the ratio of area of core-free-flow to frontal area σ, which is commonly refered to as the frontal porosity, a degree of contraction or expansion. The majority of both the theoretical and experimental study for flow characteristics in ducts deal with hydrodynamically smooth entrance and exit. On account of the fact that internal flows with abrupt entrance and exit are more common for industrial applications. For example, the flows into and out of heat exchangers experience abrupt changes in flow cross-sectional areas at the entrance and exit regions. A flow through a flat-edged orifice is another example. Most of heat exchange equipments such as air conditioning units, rocket power plants, gas turbine regenerators, radiators etc., the ducts usually have cross sections that are non-circulars. When the L/D_h ratio is large, the disturbed fluid as a result of an abrupt change in the flow cross-sectional area at entrance has enough downstream distance to readjust its velocity profile even though vortices may have been generated at the entrance region as in the case of moderate to high speed flows. When the L/D_h ratio is small, the fluid is still in the developing region at the exit. The experiments at low Reynolds number are actually more difficult to conduct than numerical works because of the lack of the experimental accuracy. The difficulties involved in obtaining accurate experimental data concerning the detailed velocity, shear, and pressure fields for such complicated flows leads to fully appreciate the value of numerical analysis. Producing a truly planar or axisymmetric separated flow in the laboratory is always difficult. In addition, one must face the equally difficult problem of measuring velocity and/or pressure in such low-Reynolds-number flows. However, experimental investigation is still needed in order to compare the experimental results obtained with those predicted from numerical analysis and to examine whether a correlation between the two is existed.

1.2 Objective of the Research

- To study the characteristics (such as friction factor, loss coefficients, pressure distribution and flow visualization) of laminar flow in parallel ducts with abrupt contraction and expansion for various area ratio, σ and constricted length to hydraulic diameter ratio, L/D_h.

- To compare experimental results with available results obtained through numerical analysis of flow equations.

1.3 Scope of the Research

In the present study, an experimental system is embodied and developed to measure the flow behavior in parallel ducts having sudden entrance and exit. The flow regions immediately upstream and downstream from the passage are also included. The pressure distribution along the duct associated with the presence of the constriction was measured, and flow visualization was employed for observation of certain characteristics of flow field. Relative to the diameter, D_h of the constricted duct, the investigated constriction configurations encompassed the range $2 \le L/D_h \le 100$, respectively for σ = 1/4, 1/2 and 2/3. For each fixed constriction configuration investigated, experiments were conducted for Reynolds numbers ranging from 500 to 4000. These results were compared with Bunditkul's analysis [1,2,3].