Flow and Mixing Characteristics of Confined Impinging and Opposing Jets

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The opposing jet configurations have attracted appreciable research efforts over the past fifteen years. Similar to impinging jets, opposing jets create zones of high heat and/or mass transfer rates in the impingement or collision region and its vicinity. Thus the opposing jet techniques have found a wide range of industrial applications, e.g. extraction, chemical reaction, absorption and desorption, dust collection, evaporative cooling, drying of high moisture content particles, total cavopulmonary connection (TCPC) Fontan operation, mixing, reaction injection molding, and side-dump combustion.

In this project, the flow and mixing characteristics in a novel in-line mixer using the opposing jets technique are studied experimentally and numerically using air, water and liquid solution (NaCl) as the working fluids with either temperature or concentration as the passive tracer to characterize mixing performance. The objectives of this project are as follows:

The first objective of this project is to theoretically explore the effects of temperature- or concentration-dependent fluid properties on the flow structure and mixing characteristics of confined laminar opposing jets in a novel in-line mixer without mechanical assists under large temperature difference between opposing jets. Some approaches, viz. unequal momentum of opposing jets and addition of baffles inside a mixer, to improve the mixing effectiveness in such a mixer are investigated numerically.

The second objective is to utilize a low-Reynolds-number k-ε turbulence model to study the flow and mixing characteristics of three-dimensional confined turbulent opposing slot jets in a novel in-line mixer using concentration of the sodium chloride (NaCl) solution as a passive tracer to characterize mixing performance.

Third, the flow and mixing characteristics of three-dimensional confined turbulent opposing round jets are studied experimentally and numerically for a novel in-line mixer and its variants. The effects of thermophysical fluid properties, jet Reynolds number, jet-to-main-chamber diameter ratio, dome height, nozzle geometries, injection angle, multiple opposing jets, and multi opposing jet injection with/without offset on mixing are investigated theoretically.

The outcome of this study could be useful to further understand the flow and mixing characteristics in a novel in-line mixer without cross flow operated at various geometric parameters and operating conditions, and to design such a mixer. Also, this research displays the possibility and importance of CFD in understanding the mixing mechanisms, design as well as optimization of a novel in-line mixer using opposing jets.

Publications

1. **S. J. Wang, S. Devahastin and A. S. Mujumdar**,A Numerical Investigation of Approaches to Improve Mixing under Laminar Confined Impinging Streams, ***Applied Thermal Engineering***, Vol. 25, 253-269, 2005.
2. **S. J. Wang and A. S. Mujumdar**, A numerical study of flow and mixing characteristics of three-dimensional confined turbulent opposing jets: unequal jets, ***Chemical Engineering and Processing***, Vol. 44, 1068-1074, 2005.