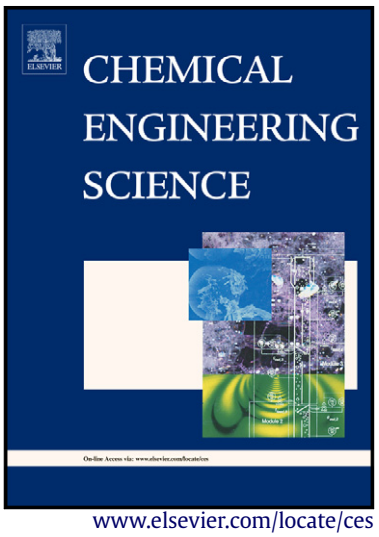

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Chaotic mixing by longitudinal vorticity

Charbel Habchi[1,*], Jean-Luc Harion[2,3], Serge Russeil[2,3], Daniel Bougeard[2,3], Farouk Hachem[1], Ahmed Elmarakbi[4]

[1]*Energy and Thermo-Fluids Group ETF, School of Engineering, Lebanese International University LIU, PO Box 146404 Mazraa, Beirut, Lebanon*

[2]*Mines Douai, EI, F-59500 Douai, France*

[3]*Université Lille Nord de France, F-59000 Lille, France*

[4]*Department of Computing, Engineering and Technology, Faculty of Applied Sciences, University of Sunderland, Sunderland SR6 0DD, United Kingdom*

Abstract

In this paper, scalar mixing by several arrays of vortex generators mounted inside a circular pipe is investigated using numerical simulations. Two flow configurations are studied in which the arrays are in-line and rotated periodically by an angle of 90°, respectively. Each vortex generator creates a pair of streamwise vortices which enhances the mixing process in the flow cross section. It is shown that the alternate configuration, in which the vortex generators are rotated periodically by an angle of 90°, enhances the mixing process relative to the in-line one due to the generation of chaotic advection flow, while in the in-line configuration the flow is regular and the mixing process is only caused by the convective motion of the longitudinal vortices. Both Eulerian and Lagrangian analysis are used to investigate the chaotic behavior. From the Poincaré sections, the alternate rotation of the vortex generators is found to better disperse the fluid particles in the flow cross section, while in the in-line array the particles are trapped into the vortex core. The Lagrangian study shows that initially close fluid particle paths exhibit an exponential remoteness in the alternate configuration, a sign of chaotic advection flow. This chaotic advection enhances the stretching and folding of the fluid particles which are responsible for mixing in laminar flows. The proposed flow configuration can be used as a multifunctional heat exchanger/reactor for industrial applications such as in chemical reaction and food processing.

Keywords: vortex generator; chaotic advection; chemical reactors; static mixer; laminar flow; mixing.

[*]Corresponding author: Tel.: +961.1.70.68.81; Fax: +961.1.30.60.44
E-mail address: charbel.habchi@liu.edu.lb