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The role of initial conditions on mixing efficiency for convective flows

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Mixing is measured by comparing the gain in potential energy with respect to the immiscible situation with the initial available potential energy of a top-heavy brine resting on a gel. The experimental setup generates a discrete number of forced turbulent plumes whose behavior and interaction result in the mixing process. In this experiment our principal aim is the study of the properties of the mixed fluid during the transient turbulent mixing process. The fluid system consists of three homogeneous fluids with different densities that are initially at rest. The fluids are inside a cubic glass container of sides 270 mm (figure 1a). At the bottom of the container there is a fluid with lower density ρ_L making a layer designated as the "light layer" with a height h_L. On top of this layer, a sodiumcarboximethyl celulose gel stratum, or CMC gel, is placed with density ρ_G and a height of h_G. Finally, a system made of two metacrylic boxes, one fitting inside the other is placed at a height Ho from the CMC gel layer. The bottoms of the boxes are pierced with orifices that have apertures that can be regulated. A convective unstable front is generated by the evolution of an array of forced turbulent plumes. The corresponding qualitative conclusions and the quantitative results based on measures of the density field and of the height of the fluid layers are described. The partial mixing process is characterized and analyzed, and the conclusions of this analysis are related to the mixing efficiency and the volume of the final mixed layer as functions of the Atwood number,(Taylor1950, Sharp 1984) which ranges from 0.010 to 0.134. An exponential fit is used for the mixing efficiency versus the Atwood number which explains 98% of the mixing efficiency variability. Similarly, a linear fit is proposed for the mixed volume versus the Atwood number. The mixing efficiency increases with the Atwood number but decreases as the viscosity of the CMC gel is increased. The values of the mixing efficiency are less than 0.30 , slightly lower than in Redondo and Linden (1990) and also tend toward an asymptotic behavior when the Atwood number tends to its maximum experimental value. The mixing efficiency is strongly influenced by the size of the initial plume array and depends directly on the external volume of the mixing cones. The limiting case of RT has to consider that when the stable stratification in the mixed layer increases, more energy is consumed to work against the buoyancy forces. The mixed layer height increases as the Atwood number grows, and also diminishes as the viscosity of the CMC gel increases, confirming the importance of the initial conditions on global mixing efficiencies.

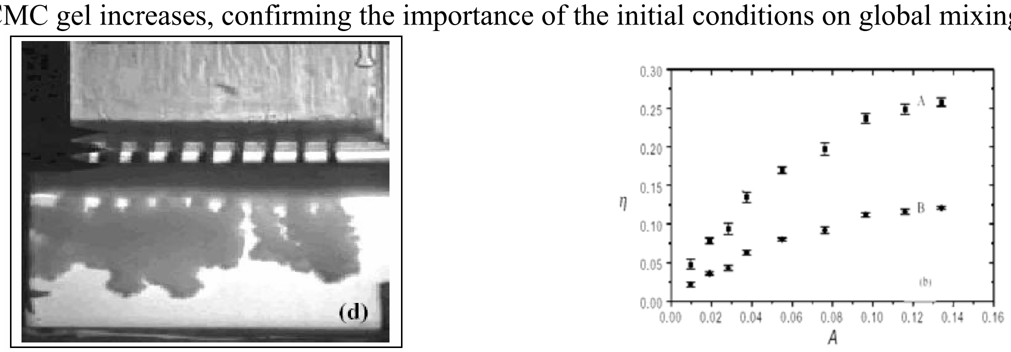

Figure 1. Structure of the Plume array -RT front and the global mixing efficiency for Low A, and high B viscosity gel layers.

References

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