Study on swirls to optimize contacts between fluids

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Physicists who have studied the mixing between two incompatible fluids have found that it is possible to control the undercurrents of one circulating fluid to optimise its exposure to the other. This work, which is about to be published in *European Physical Journal E*, was performed by Jorge Peixinho from CNRS at Le Havre University, France, and his colleagues from the Benjamin Levich Institute, City University of New York, USA.

The authors compared quantitative experimental observations of a viscous fluid, similar to honey, with numerical simulations. They focused on a fluid, which partially filled the space between two concentric cylinders with the inner one rotating. This system was previously used to study roll coating and papermaking processes. To interpret this seemingly simple system, they factored in interface flows, film spreading, and the formation of free surface cusps - a phenomenon relevant to fluid mixing, but which is not quantitatively captured by conventional numerical calculation.

The authors observed the presence of several flow eddies, stemming from fluid flowing past the inner cylinder, causing it to swirl, and the appearance of reverse currents including one orbiting around the rotating cylinder and a second underneath. They made the second eddy disappear by increasing the fluid filling or its velocity. This is akin to turning a spoon full of honey fast enough to prevent it from draining.

This model is based on a highly viscous oil combined with air as a top fluid. When combined with a light oil containing nutriments as a top fluid, it could also apply to a suspension of bioreactor cells typically used to produce biotech medicines. Ultimately, it could help identify the right parameters and adequate mixing time scales to ensure that nutriments feed all the cells homogeneously without segregation.

More information: Peixinho J., Mirbod M. and Morris J.F. (2012), Free surface flow between two horizontal concentric cylinders, *European Physical Journal E* (EPJ E) 35: 19, DOI 10.1140/epje/i2012-12019-8

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