Mixing flow in a multiflux static mixer

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Published: 01/01/1997

Document Version
Accepted manuscript including changes made at the peer-review stage

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Link to publication

Citation for published version (APA):
Introduction
The most efficient way to make thin layers is the baker transformation (fig. 1). Material is stretched, cut and stacked, thereby doubling the number of layers each time.

Fig. 1 The bakers transformation

A device that mimics the bakers transformation in a continuous process is the multiflux static mixer (fig. 2). The material flow is continuously stretched, cut and stacked.

Fig. 2 Two elements of the multiflux static mixer: outer view; cross-sections; ideal case of layer distribution (full wall slip)

However, since there is no plug flow in the channels the actual layer thickness distribution will differ from the ideal case.

Flow field analysis
Using a spectral element method, the flow field is computed. The mesh (fig. 3) is built out of 680 elements of tenth order (totalling 1493120 d.o.f.). Using this flowfield, an analysis on periodicity of the flow and layer thickness can be performed. Assuming two newtonian fluids that are rheologically identical, this is reduced to a post-processing computation.

Fig. 3 Spectral element mesh of the multiflux mixer

A grid of 100x100 points is tracked for 1 period (from the bottom of the first element to the top of the second). Then the displacement of a particle in the XY-plane is computed (fig. 4a). This gives an indication if the point is periodic or not. Simultaneous, the layer thickness is determined by coloring the gridpoints.

Fig. 4a) Displacement in the XY-plane (dark colors = small displacement); b) Layer thickness in the multiflux mixer

The fact that not all layers show equal thickness (fig. 4b) within the flow channel does not mean that this is the case at outflow. In order to get an equal layer thickness at outflow, the fluxes of every colored region should be equal.

However, the velocity profiles in the channels are not equal (fig. 5) and thus no uniform layer thickness distribution results. The difference in velocity profiles is explained by a preferred direction of flow induced by differences in flow resistance.

Conclusions
Spectral methods are capable to accurately track particles in complex flows. The fluxes through all channels of the multiflux should be equal to guarantee an equal layer thickness. This can be accomplished by design adaptations.

References
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