

Is there an alternative to Euler-Euler?

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Abstract

In a way comparable to the Reynolds Averaged Navier-Stokes (RANS) treatment of turbulent single-phase flows, the Euler-Euler approach of two-phase flows, or the so-called Two Fluid Model (TFM), aims at producing an averaged representation of the two-phase flow fields. This is accomplished by overlooking a great deal of the complex mutual interaction of the two interpenetrating continuous phases, *i.e.* by modeling features of the flow which remain unresolved by the CFD simulation.

Just like the popular CFD-RANS approach of turbulent flows, TFM based CFD offers industry a useful tool for 'quick and dirty' evaluations of two-phase process options. This paper assesses the physical models used in and the limitations of TFM's. In addition, we comment on some aspects of the numerical tools exploited. Eventually we conclude that it is a miracle that TFM based CFD is capable of arriving at meaningful results anyway.

Hence, this paper is a provocative plea for focusing on more promising CFD options, more or less in line with my view (Van den Akker, 2006) that single-phase Large Eddy Simulations (LES) make RANS-simulations redundant in cases the details really matter. The idea is illustrated by the striking difference between the smooth pattern of Fig. 1a and the abundant presence of coherent two-phase structures in Fig. 1b. An obvious drawback of the LES/PT-procedure used for Fig. 1b is that the particles have been treated as point particles: this ignores how the real particles not only respond to the turbulence of the carrier phase but also affect that turbulence in return. Rather, one should allow for the details of the mutual interaction between turbulent eddies and particles, their rotation and deformation inclusively, as well for potential break-up and coalescence of bubbles and drops. Direct Numerical Simulations (DNS) are perfectly capable of resolving such intimacies of two-phase flow (Ten Cate *et al.*, 2004; Derksen & Van den Akker, 2006)

More in particular, the author stands up for a challenging multi-scale approach in which two-phase flow is simulated by means of two-phase LES supplemented and sustained by a limited set of local DNS of two-phase flow in sufficiently small periodic boxes driven by LES resolved effects. Each

local DNS should provide the constitutive relations and coefficients needed locally in the more superficial LES of the full two-phase flow domain. Pros and cons of such a challenging proposition are discussed.

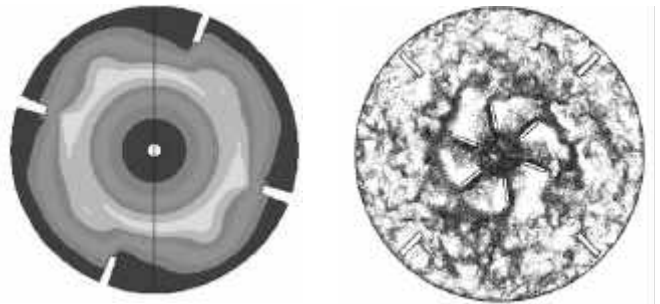


Figure 1a (left): Sample of an Euler-Euler CFD simulation result of an aerated stirred vessel, due to Khopkar *et al.* (2005)

Figure 1b (right): Sample of a LES extended with Particle Tracking (PT) for solids suspension in a stirred vessel, due to Derksen (2003)

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