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ACCURACY EVALUATION OF VOLUME TRAKING METHODS FOR FREE SURFACE FLOWS

*** Jesús Castro[1], Carles Oliet[1]**

[1] Centre Tecnològic de Transferència de Calor (CTTC)
Universitat Politècnica de Catalunya (UPC)
ETSEIAT, C. Colom 11, 08222 Terrassa (Barcelona), Spain
cttc@cttc.upc.edu, http://www.cttc.upc.edu

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ABSTRACT

Free surface flows are common in many phenomena involved in thermal engineering: i. e. evaporation, condensation, absorption, etc. The development of reliable and robust codes for the detailed simulation of these phenomena is of big interest for a better understanding of the processes involved and, in the near future, for having a numerical tool capable of making realistic simulations in order to obtain expressions of friction or factors heat and mass transfer coefficients, and substituting experimentation.

Volume Of Fluid (VOF) are one of the most common techniques for the simulation of free surface flows. In two-phase flows these techniques are based in a colour function (F) that has the value of 1 in the control volume is filled of liquid phase and 0 for no fluid or vapour phase. They have the advantage of robustness, even in situations of coalescence of vapour or liquid dechatchments. The main disadvantage is the low accuracy in the reconstruction of sharp interfaces.

The main question of these techniques is an adequate algorithm for calculating the advection of the colour function F in order to avoid numerical smearing of F and having interface reconstructions as sharp as possible. From the different techniques used for calculating this advection, there are the volume tracking methods, based on the calculation of the F fluxes according to a previous information of the volumes of each phase (given by the F function), and a surface reconstruction e.g., [1][2][3].

This paper is the continuation of the work developed by Leal et al. [4], where the performance of the Youngs' method developed [2] was compared with the results of other researchers [5]. Several benchmark tests where the velocity field was given were carried out with similar results. Finally, the procedure of Richardson extrapolation [6][7] was used in order to determine the order of accuracy of the velocity field in a benchmark case (Broken Dam Problem) where the Youngs' method was employed for the advection of F coupled with the resolution of the Navier-Stokes equations.

In this work the procedure of surface reconstruction with the volume tracking method described by Rider and Kothe [3] has been implemented. This procedure, in comparison with other previously used [1][2], requires of more information of the interface position, therefore is more accurate. It has the advantage of be valid also for unstructured meshes [8]. The same comparison with several advection tests

with given velocity field in two dimensions performed at [4] is carried out for the three volume tracking methods mentioned: i) piecewise constant, stairstepped, from Hirt and Nichols [1]; ii) piecewise linear, from Youngs [2]; iii) piecewise linear, from Rider and Kothe [3] with two different reconstruction algorithms of first and second order of accuracy. The results are also compared with other researchers [5].

In a similar manner as performed at [4], the Broken Dam Problem is used as benchmark in order to apply the procedure of Richardson extrapolation for comparing the three volume tracking algorithms implemented. In this case, the Navier-Stokes equations are solved coupled with the resolution of the free surface location. The procedure is adapted for a complete determination of the order of accuracy of all the relevant variables including F, that is dependent of the mesh used. Finally, a validation with experimental tests reported at [1] for the Broken Dam Problem is also reported.

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