FLUID STRUCTURE INTERACTIONS RESEARCH GROUP

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Numerical simulation of interfacial fluid flows by an anti-diffusive VOF method

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Background & Aims

•The numerical simulation of free surface flows remains a challenging problem in ship hydrodynamics. The flow around ships and surface piercing marine structures is influenced by free surface phenomena and these fluid-structure interaction systems involve in nonlinear dynamics.
• For solving free boundary problems a good scheme should be capable of accurately preserving the sharpness and shape of the interface while involving in violent fluid motions such as interface rupture and coalescence.
• Aim to develop computational fluid dynamics methods to deal with nonlinear free surface problem involving gas-liquid two phase flow assuming both fluids incompressible or compressible.

Numerical method

- An anti-diffusive Volume of Fluid (VOF) method is developed by combining a first-order limited downwind scheme with the higher order Essentially Non-Oscillatory (ENO) schemes.
- The proposed VOF technique has been integrated into a flow solver for computing two-fluid flows.
- Some features of new approach
  1. Reduce numerical diffusion near the air-water interface
  2. Avoid the geometrical reconstruction of the interface
  3. High order accuracy in a smooth region and eliminating spurious oscillations in the vicinity of large gradients

Calculated results for two selected cases

1. Dam breaking flow

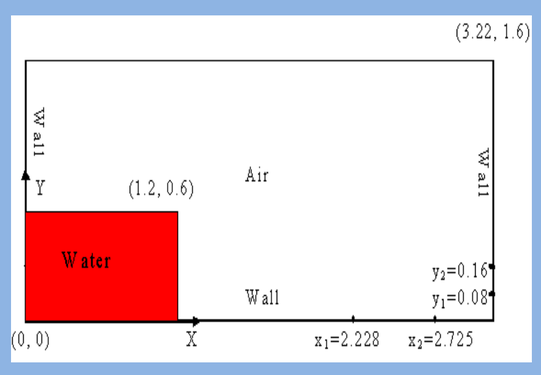
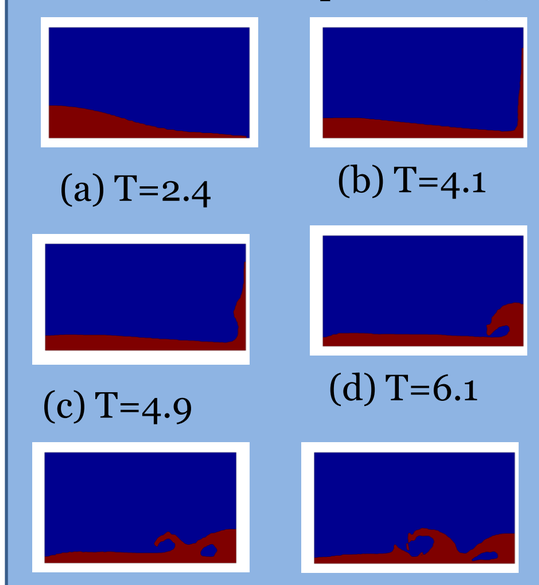


Fig. 1 Layout of dam breaking problem and measurement positions (Units: m)



(a) T=2.4 (b) T=4.1 (c) T=4.9 (d) T=6.1 (e) T=7.1 (f) T=8.1

Fig. 2 Dam breaking flow against a wall at several different non-dimensional times; H: initial water height (air and water assumed incompressible) $(T = t/\sqrt{H/g})$

Chen, Y., Price, W.G. & Temarel, P. (2010)
An anti-diffusive VOF method for interfacial fluid flows, Int. J. Numerical Methods in Fluids.

2. Two-dimensional free falling jet impacts

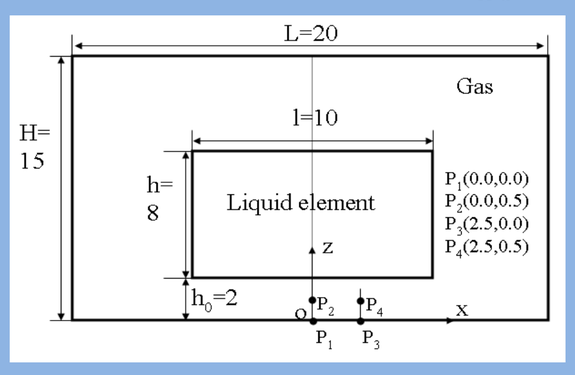


Fig. 3 Layout of free falling liquid and measurement positions (Units: m)

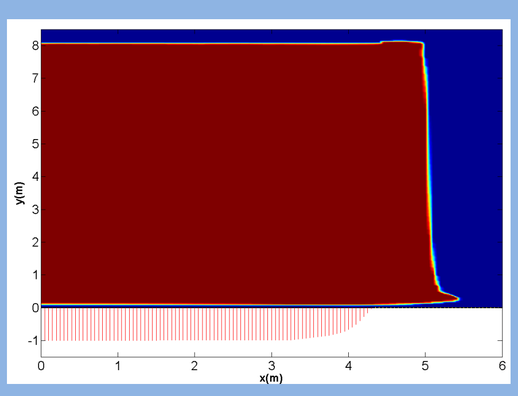


Fig. 4 Snapshot of the calculated density distribution when the pressure at P1 is maximum (gas assumed incompressible)

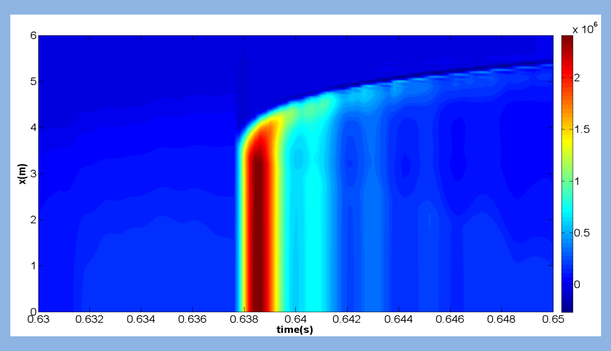


Fig. 5 Contour plot of bottom wall pressure as a function of time (gas and liquid assumed incompressible)

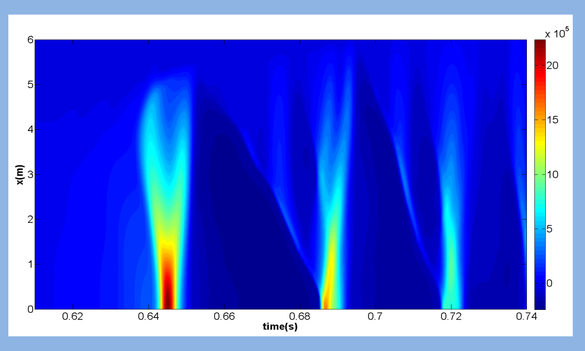


Fig. 6 Contour plot of bottom wall pressure as a function of time (gas and liquid assumed compressible)

Conclusions

- An anti-diffusive VOF method is developed to examine two-fluid flows with a separated interface.
- The method developed here proved to be robust and gives good results for dam breaking flow and free falling jet impact involving the effects of gas compressibility.

Acknowledgement
This project is supported by funds from The Lloyd's Register Educational Trust, through the Lloyd's Register University Technology Centre.

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