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The particle finite element method: a powerful tool to solve incompressible flows with free-surfaces and breaking waves

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SUMMARY

Particle Methods are those in which the problem is represented by a discrete number of particles. Each particle moves accordingly with its own mass and the external/internal forces applied to it. Particle Methods may be used for both, discrete and continuous problems. In this paper, a Particle Method is used to solve the continuous fluid mechanics equations. To evaluate the external applied forces on each particle, the incompressible Navier–Stokes equations using a Lagrangian formulation are solved at each time step. The interpolation functions are those used in the Meshless Finite Element Method and the time integration is introduced by an implicit fractional-step method. In this manner classical stabilization terms used in the momentum equations are unnecessary due to lack of convective terms in the Lagrangian formulation. Once the forces are evaluated, the particles move independently of the mesh. All the information is transmitted by the particles. Fluid–structure interaction problems including free-fluid-surfaces, breaking waves and fluid particle separation may be easily solved with this methodology. Copyright © 2004 John Wiley & Sons, Ltd.

KEY WORDS: particle methods; finite element methods; fractional step; lagrange formulations; incompressible Navier–Stokes equations; implicit time integration; fluid–structure interactions; free-surfaces; breaking waves

1. INTRODUCTION

Over the last 20 years, computer simulation of incompressible fluid flow has been based on the Eulerian formulation of the fluid mechanics equations on continuous domains. However, it is still difficult to analyse problems in which the shape of the interface changes continuously

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