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APPLICATION OF THE GENERALIZED-α TIME INTEGRATION SCHEME IN PFEM FOR SOLVING THE INCOMPRESSIBLE NAVIER-STOKES EQUATIONS

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Despite the increasing use of the Particle Finite Element Method (PFEM) in fluid flow simulation [1] and the outstanding success of the Generalized-α time integration method [2], very little discussion has been devoted to the performance of both methods. This work contributes in this regard by presenting a detailed implementation that combines these methods. In addition, the Generalized-α is compared against the conventional time integration schemes of the PFEM literature, i.e., the Backward Euler and Newmark.

The implementation is developed for the incompressible Navier-Stokes equations and a monolithic PFEM formulation stabilized with the Pressure-Stabilizing Petrov-Galerkin (PSPG) method. To extend the analysis, equations are developed for velocity-pressure and displacement-pressure based formulations. The study is carried out using four benchmarks, the flow around a rigid cylinder, sloshing of water in a tank, single wave propagation and dam break problems.

The work shows that different implementation approaches are possible for the Generalized-α method, which differ mainly in the terms that are α-interpolated (state variables or equilibrium forces) and in whether or not the pressure is considered in the time integration scheme [3]. Whatever the approach, the Generalized-α scheme demonstrates superiority in agreement with the observations of the literature, i.e., it does not suffer from excessive numerical dumping for large time steps and exhibits less spurious oscillations that the compared schemes.

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