A free element method for solving incompressible fluid flow using a pressure correction method

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Abstract

Based on pressure correction method, a new type of meshfree collocation method, free element method (FECM), is proposed to numerically solve incompressible Navier-Stokes equations. In the proposed method, the upwind scheme is utilized to calculate convective terms, and, a generalized momentum interpolation method is applied to avoid the decoupling of velocity and pressure. The governing equations are collocated at internal points with each point being located inside an independently formed collocation element, and as a result all elements are overlapped with each other. In this way, we can simplify the element generation. The proposed method uses only one isoparametric element to approximate the physical fields at each collocation point, and the derivatives of velocity or pressure can be obtained by taking the derivatives of the element shape functions. The propose FECM is quite simple and robust. There is no need to evaluate the domain integration. Since the elemental shape functions satisfy the so-called Delta property, the intrinsic boundary conditions can be easily imposed. Two cases are tested with different nodal configurations. The first case is lid-drive cavity problem and the other is the backward facing step flow. The results demonstrate that the proposed method is accurate and robust.

Keywords: Free element method; free element collocation method; CFD; pressure correction method; finite element method; mesh free method.