A 4OEC scheme for the biharmonic steady Navier-Stokes equations in non-rectangular domains

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Abstract

Recently the biharmonic form of the Navier-Stokes (N-S) equations have been solved in various domains by using second order compact discretization. In this paper, we present a fourth order essentially compact (4OEC) finite difference scheme for the steady N-S equations in geometries beyond rectangular. As a further advancement to the earlier formulations on the classical biharmonic equation that were developed for cartesian co-ordinate system this scheme is capable of numerically solving the two-dimensional N-S equations using body fitted co-ordinate system. Despite the presence of the extra derivative terms in the quasi-linear form of the biharmonic equation, our extended formulation continues to maintain its fourth order accuracy on a nine-point compact stencil. A spectral analysis on the scheme reveals its superior resolution properties. The formulation has been tested on fluid flow problems of varied complexities on different geometries which includes flow past an impulsively started circular cylinder and elliptic aerofoil with angles of attack. We present our numerical results and validate them with established numerical and experimental observations available in the literature; excellent comparison is obtained in all the cases.

Keywords: Compact, biharmonic, non-rectangular, N-S equations, polar cavity, constricted channel, circular cylinder, elliptic aerofoil.

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