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Development of an Implicit Physical Influence Upwind Scheme for Cell-Centered Finite Volume Method

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Abstract : An essential component of a finite volume method (FVM) is the advection scheme that estimates values on the cell faces based on the calculated values on the nodes or cell centers. The most widely used advection schemes are upwind schemes. These schemes have been developed in FVM on different kinds of structured and unstructured grids. In this research, the physical influence scheme (PIS) is developed for a cell-centered FVM that uses an implicit coupled solver. Results are compared with the exponential differencing scheme (EDS) and the skew upwind differencing scheme (SUDS). Accuracy of these schemes is evaluated for a lid-driven cavity flow at Re = 1000, 3200, and 5000 and a backward-facing step flow at Re = 800. Simulations show considerable differences between the results of EDS scheme with benchmarks, especially for the lid-driven cavity flow at high Reynolds numbers. These differences occur due to false diffusion. Comparing SUDS and PIS schemes shows relatively close results for the backward-facing step flow and different results in lid-driven cavity flow. The poor results of SUDS in the lid-driven cavity flow can be related to its lack of sensitivity to the pressure difference between cell face and upwind points, which is critical for the prediction of such vortex dominant flows.

Keywords : cell-centered finite volume method, coupled solver, exponential differencing scheme (EDS), physical influence scheme (PIS), pressure weighted interpolation method (PWIM), skew upwind differencing scheme (SUDS)
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