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An Approximate Analytical Solution for Backward-Facing Step Flow ISMAIL CELIK, DON PARSONS, ERTAN KARAISMAIL, JAGANNATH NANDURI, West Virginia University — Flow past a backward facing step is a classical bench mark for both laminar and turbulent flow calculations. Due to the near-singular behavior arising from the presence of the sharp step, it is very difficult to predict the size of the recirculation region and the reattachment length. This difficulty, in turn, manifests itself as a significant discrepancy between predicted and measured velocity profiles. The aim of the current work is to formulate an analytical solution to the 2D, steady flow in question that satisfies the Navier-Stokes equations with a source term. The proposed solution is a superposition of two stream functions, one being a semi-potential solution that satisfies all the boundary conditions for real incompressible fluids, and another composed of rotational vortices (e.g. Rankine vortices) which enable flow separation. The location and distribution of the vortices is selected to emulate the Reynolds number dependence of the re-attachment length, while other parameters in the model are used to minimize the additional source term that is needed. The proposed solution can be primarily used in code-verification, and quantification of discretization errors in CFD (Computational Fluid Dynamics). It can also be used to assess modeling errors, by adding additional source terms that represent the spatial variations in turbulent-eddy viscosity, the key quantity used in Boussinesq-type turbulence models.

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