Optimal shape design of a two-dimensional asymmetric diffuser in turbulent flow

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Abstract

An optimal shape of two-dimensional asymmetric diffuser with maximum pressure recovery at the exit is numerically obtained using a mathematical theory based on the variational calculus and gradient algorithm. The initial diffuser is taken to be a two-dimensional asymmetric diffuser for which many experimental and numerical data are available (Obi *et al.* 1993; Buice & Eaton 1996; Kaltenbach *et al.* 1999). The Reynolds number based on the bulk mean velocity and the channel height at the diffuser entrance is 18,000. From this initial shape, we design optimal diffuser shapes for six different geometric constraints such as the streamwise length and height of the diffuser. The optimality condition for maximum pressure recovery is obtained to be zero skin friction along the diffuser wall. The turbulent flow inside the diffuser is predicted using the $k-\varepsilon-v2-f$ model, and optimal shapes are obtained through iterative procedures to achieve the optimality condition. With the shape design, flow separation appeared in the initial diffuser is completely removed or significantly reduced. For one of the optimal diffuser shapes obtained, large eddy simulation is carried out to validate the result of shape design. The wall shear stress, wall pressure, mean velocity and turbulence quantities form large eddy simulation are in good agreement with those from the simulation using the turbulence model, even though the skin friction from large eddy simulation is slightly positive rather than zero.

Keyword: *optimal shape design, maximum pressure recovery, gradient algorithm, zero skin friction.*

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