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Transitional Separation Bubble over a Rounded Backward Facing Step Due to a Temporally Applied Very High Adverse Pressure Gradient Followed by a Slow Adverse Pressure Gradient Applied at Inlet of the Profile

Authors : Saikat Datta

Abstract : Incompressible laminar time-varying flow is investigated over a rounded backward-facing step for a triangular piston motion at the inlet of a straight channel with very high acceleration, followed by a slow deceleration experimentally and through numerical simulation. The backward-facing step is an important test-case as it embodies important flow characteristics such as separation point, reattachment length, and recirculation of flow. A sliding piston imparts two successive triangular velocities at the inlet, constant acceleration from rest, 0≤t≤t0, and constant deceleration to rest, t0≤t<t1. The temporal and spatial pressure gradient is varied by a controlled motion of the piston. The flow visualization and PIV data on a water channel where water flows from right to left reveal the locally separated region on the rounded backward-facing step is filled with much vortex-flow structure, which grows during the deceleration phase of the piston motion. The reattachment of the outer shear layer forming a separation bubble has also been discussed. The development of vortices has a wave-like pattern within the separated region, and the bubble depicts an open bubble topology. The maximum pressure gradient point where the first vortex is formed is confirmed through numerical simulations. The flow visualization data also shows a distinct growing vortex at the maximum pressure gradient point. Secondary vortices of opposite signs grow in the inner layer due to adverse pressure gradients induced by the primary vortices. The boundary layer thickness at the point of separation is used to quantify the type of wall-bound vortex formed inside the outer shear layer of the separation bubble.

Keywords : laminar boundary layer separation, rounded backward facing step, separation bubble, unsteady separation, unsteady vortex flows
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