FM25L_10683

XXI International Congress of Theoretical and Applied Mechanics
Warsaw, Poland, August 15–21, 2004

New Means of Vortex Breakdown Control

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It is shown that an additional near-axis swirl, temperature gradients, and their combination can help to efficiently control vortex breakdown (VB). The numerical analysis of a flow in a cylindrical container driven by a rotating bottom disk reveals the underlying mechanisms, explains the experimental observations of control co- and counter-rotation with no temperature gradient (Husain et.al. 2003, Phys. Fluids, 15, 271), and reveals some flaws of dye visualization. Co- (counter-) rotation diminishes (enhances) the unfavorable axial gradients of pressure and thus suppresses (stimulates) VB. A moderate negative (positive) axial gradient of temperature enforces the effects of the additional swirl, e.g., significantly stimulates (suppresses) VB. A strong positive temperature gradient induces the centrifugal instability and time oscillations in the flow with counter-rotation. These results indicate that an additional co-rotating cold (counter-rotating hot) swirling jet can help to suppress (enhance) VB in practical flows, e.g. over delta-wing aircraft and vortex burners.

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