16. Effect of Aspect Ratio on the Flow Past a Spinning Cylinder

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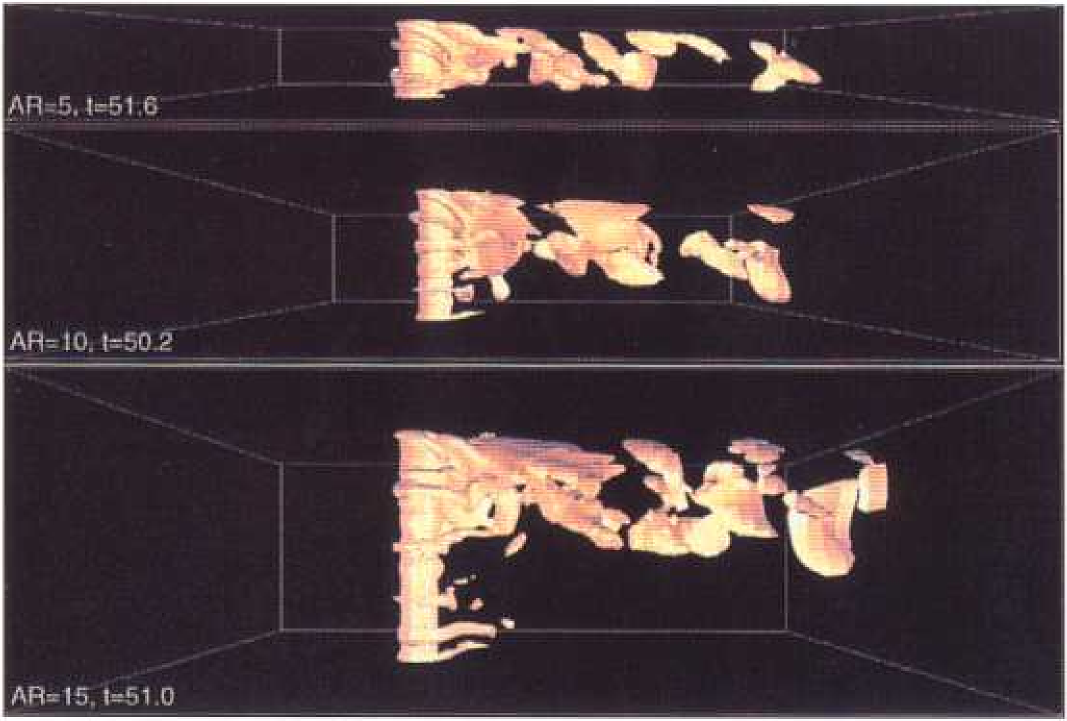
The figure shows the $Re = 200$ flow past a cylinder spinning about its axis. The tip speed of the cylinder is five times the free-stream speed of the flow. Shown are the iso-surfaces for the span-wise component of vorticity for various aspect ratios ($AR = 5$, 10 and 15) of the cylinder. The aspect ratio (AR) of the cylinder is the ratio of its length along the span to its diameter. To save on the computational effort, only one half of the domain along the span is simulated. The top wall in the figure is a solid wall and a no-slip condition is assigned to the velocity. Symmetry conditions are assigned on the lower wall. While the 2D simulations predict a steady flow for such high rotation rates, 3D computations result in unsteady flow due to end-effects and centrifugal instabilities along the span of the cylinder. Separation of the flow on the top wall can be seen in all the three cases. It is responsible for loss in the sectional lift coefficient near the cylinder end. It is observed that the aspect ratio of the cylinder has a significant effect on the magnitude of lift generated by the spinning action (Magnus effect). The lift coefficient increases with the aspect ratio of the cylinder. A stabilized finite-element formulation is utilized to compute this 3D, unsteady flow. The computation for $AR = 15$ utilizes a mesh with $284,199$ nodes and $270,000$ hexahedral elements. At each time step, approximately, 1.1 million non-linear equations are solved implicitly using the Generalized Minimal RESidual (GMRES) Method.



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