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The effect of Reynolds number on the drag of a rectangular cylinder ROBERT BREIDENTHAL, JONATHAN WAI, University of Washington — Direct numerical simulations of the flow past a rectangular cylinder at low Reynolds number reveal that the aspect ratio for maximum drag is much less than that measured at high Reynolds number. Nakaguchi et al. (1967) discovered a remarkably sharp peak in the drag coefficient at a cylinder aspect ratio of 0.62 for Re = 20,000. In contrast, our numerical simulations at Re = 500 indicate a maximum-drag aspect ratio of 0.2. This dramatic difference is attributed to the rollup station of the laminar vortex sheet from the separating boundary layer. Essentially inviscid, the rollup process scales with the thickness of the vortex sheet at the separation point, which in turn varies inversely with the square root of the Reynolds number. Consequently, at low Reynolds number, the sheet remains thin and laminar, curving tightly toward the cylinder. On the other hand, at high Reynolds number, the vortex sheet promptly rolls up into a rapidly growing, turbulent shear layer. The thick, turbulent layer has a large displacement thickness, deflecting the outer streamlines and altering its own trajectory so that it curves relatively gradually toward the cylinder. Bearman and Trueman (1972) showed that the peak drag corresponds to the shear layer nearly reattaching to the bluff body and rolling up into vortices very close to the base of the cylinder. The low pressure of the vortex cores is reflected in a low base pressure and thus high drag. The critical aspect ratio is much smaller for the laminar vortex sheet because of its more tightly curved trajectory.

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