A First Course

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FLUID FLOW

in Fluid Mechanics

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through a rapidly expanding duct—the reverse of the flow in Fig. 6-1a. Here, because of the large and rapid increase of pressure required of the low energy boundary layer (it has a lower kinetic energy than the main stream), it cannot regain pressure together with the main stream to fill completely the downstream duct. Instead the main flow, while remaining more or less unaffected by viscosity, does not follow the wall but continues into the channel as a jet. The region between the jet and the wall is filled with fluid of lower velocity that churns and eddies in an irregular way. In this way the boundary layer

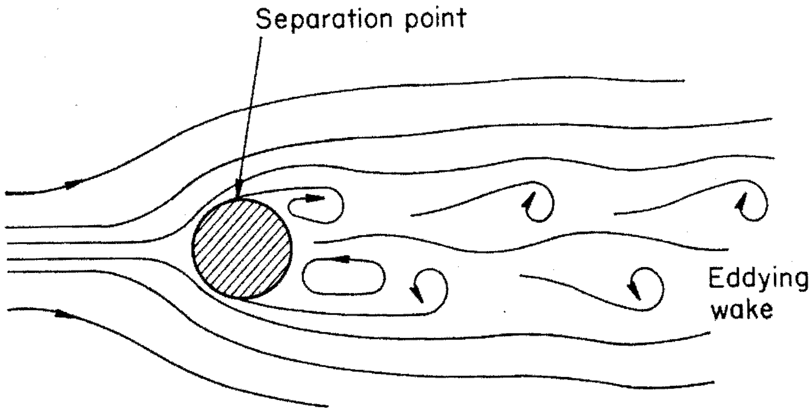

Fig. 6-1d *Separation behind a cylinder. In this particular instance the wake formed is nonsteady.*

has brought about a rather severe alteration of the flow picture. When the main stream (that portion unaffected by viscosity) does not follow the walls of the surrounding duct or adjacent solid surface, it is said to *separate* or *break-away*. A similar situation is observed for the flow around a cylinder (Fig. 6-1d). The main flow separates at a position near the maximum height; behind the cylinder there is an eddying wake which extends for many diameters downstream. On the forward portion of the cylinder a relatively thin boundary layer develops (at fairly large Reynolds numbers), and the flow exterior to this and to the wake may be considered to be inviscid.

These examples illustrate two features of recurring importance in fluid mechanics: the development of viscous regions and the occurrence of the separation phenomenon. Because of the possibility of separation one cannot always assume that the inviscid portion of the flow will conform to the shape of solid boundaries in the flow. In the absence of separation and at sufficiently high Reynolds numbers, however, the actual boundaries may be taken as the boundaries for the inviscid flow, because of the thinness of the boundary layer. In general these conditions are fulfilled in the forward portions of blunt bodies or along airfoil-like shapes, particularly in regions where the pressure decreases in the direction of flow.