Part III

Coating

A coating flow is a fluid flow that is used for covering a surface area. Coating flows are associated, for example, with painting by a brush or a roller, or in withdrawing a flat sheet or a web immersed in paint bath. Photographic film is a polymeric surface (the film base) that has been coated by several layers of photographic emulsion. Each layer is deposited in a fluid phase by a coating process; it is then dried, after which another layer is coated. (Recent technologies allow simultaneous coating of several layers.) One basic coating method for photographic film is *curtain coating*, which is illustrated in Fig. 10.1: A liquid curtain issues from a slot and falls under the influence of gravity onto the film surface which moves in a uniform speed. Several different configurations are used to guide the falling liquid onto the moving surface. The points where the fluid first makes contact with the moving surface form the *contact line*, or *wetting line*, or for 2-dimensional configurations, the *contact point*. The angle between the surface and the wetting line, at the contact points, is called the *dynamic contact angle*; see Fig. 10.2. It is known from experiments that this angle depends on the velocity of the substrate, although the precise formula for such dependence has not been established. When the substrate is at rest, the dynamic contact angle is referred to as the *static contact* angle.

A high quality coating requires not only that a uniform thickness of coverage, but also maintaining uniform velocity field within the coating flow so as to achieve uniform consistency of the covering fluid. However, near the contact points the velocity field is not uniform due to the abrupt contact with the surface. In order to increase productivity, manufacturers would like to increase the speed of the moving film base, but this tends to cause increased instability near the contact points. Hence there is a need for careful analysis in order to determine the optimal design parameters for high-speed coating which does not cause disruption near the wetting line.

For most purposes the fluids being coated can be assumed to be Newtonian. Sometimes, they can be assumed to be ideal. In Chap. 10 we deal with Newtonian coating flows, we introduce a mathematical model, and then describe what is known about the behavior of the fluid near the contact line. In Chap. 11 we deal with various coating configurations and, using an ideal flow approximation, we explain how to determine design parameters for coating devices. In Chap. 12 we consider the effect of surfactants on curtain coating and the effect of air pressure applied to curtain coating. Finally, in Chap. 13 we describe a non-Newtonian approach to colloidal dispersions based on Brownian dynamics.