High speed coating of optical fibers

Optical fibers are used to transfer optical signals for telecommunications. From several kilometers in 1973, their production boosted to several thousand kilometers in 1983 and is expected to reach several million kilometers by 1993. On October 4, 1991 John Abbott from Corning Incorporated described how optical fibers are made, and then concentrated on the problem of coating the fibers. He presented some models and posed mathematical problems.

2.1 Optical fiber manufacturing

(a) soot deposition, (b) sintering, (c) fiber drawing.

FIGURE 2.1
2.1. Optical fiber manufacturing

Figure 2.1 from [1] sketches the overall process for making optical fibers. The process, called outside vapor deposition, consists of three steps. In the first step fine glass particles (0.2μm diameter) are formed in a combustion reaction and are deposited on a rotating target. The particles motion may be viewed as Brownian motion enhanced by a thermal gradient; this preferential Brownian motion in a thermal gradient is call thermophoresis. The resulting porous soot preform is then sintered in a furnace, shrinking it to a solid glass blank. Finally, the blank is drawn at a higher temperature into fiber; the fiber is solid inside.

The mechanism of soot deposition was studied by J. Abbott [2] and Shen [3], among others. The basic equations are the fluid flow equations (Navier–Stokes), the continuity equation, and the heat equation; the velocity and temperature are coupled.

Sintering was studied by Scherer [4] [5]. The model involves shrinkage, deformation and stresses.

The process of drawing fiber from the preform involves heat transfer (convection and radiation) and diameter control, and it gives rise to instabilities. Meyers [6] introduced a model for analyzing the diameter variations; it is based on radiation-dominated heat transfer.

2.2 Coating of optical fiber

After the fiber is drawn, it is immediately coated with polymeric material to protect the pristine glass surface and the strength of fiber. The diameter of the fiber is 125μm, and with the coating it is approximately doubled to 250μm. Figure 2.2, adapted from [7], shows a generic coating. The fluid, with flux Q covers a portion of the fiber; two free surfaces are formed: the upper meniscus and the lower meniscus.