Unsteady Internal Flow Methods

While the details are beyond the scope of this book, it is nevertheless of value to conclude the present chapter with a brief survey of the transfer function methods referred to in section (Nrh). There are two basic approaches to unsteady internal flows, namely solution in the time domain or in the frequency domain. The traditional time domain or *water-hammer* methods for hydraulic systems can and should be used in many circumstances; these are treated in depth elsewhere (for example, Streeter and Wylie 1967, 1974, Amies *et al.* 1977). They have the great advantage that they can incorporate the nonlinear convective inertial terms in the equations of fluid flow. They are best suited to evaluating the transient response of flows in long pipes in which the equations of the flow and the structure are well established. However, they encounter great difficulties when either the geometry is complex (for example inside a pump), or the fluid is complex (for example in a multiphase flow). Under these circumstances, frequency domain methods have distinct advantages, both analytically and experimentally. Specifically, unsteady flow experiments are most readily conducted by subjecting the component or device to fluctuations in the flow over a range of frequencies and measuring the fluctuating quantities at inlet and discharge. The main disadvantage of the frequency domain methods is that the nonlinear convective inertial terms cannot readily be included and, consequently, these methods are only accurate for small perturbations from the mean flow. While this permits evaluation of stability limits, it does not readily allow the evaluation of the amplitude of large unstable motions. However, there does exist a core of fundamental knowledge pertaining to frequency domain methods (see for example, Pipes 1940, Paynter 1961, Brown 1967) that is summarized in Brennen (1994). A good example of the application of these methods is contained in Amies and Greene (1977).