PREDICTION METHODS FOR TURBULENT FLOWS

INTRODUCTION

by

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Abstract

The historical development of prediction methods is traced. Examining second order methods in particular, the equations are presented and the nature of the problem made clear. It is shown how a large value of the Reynolds number can be used to simplify the equations. The separation of the pressure correlation into "rapid" and "return to isotropy" parts is discussed, and the construction of good models for the rapid part described. A general formalism is presented for generating successive approximations to the unknown (third rank) terms. A general technique is presented for modeling transport terms.

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an unrelated nature. Such situations are, of course, more the rule than the exception in nature and practice. Despite these problems, (1) is widely used because of its simplicity and many techniques have been devised to predict K in various situations. (See, for example, Monin and Yaglom, 1971, p 364 and 606).

Another type of approach was devised by von Kármán (1921), and others specifically for turbulent boundary layers. This is the so-called integral method. If the mean streamwise momentum equation is integrated across the stream, an equation results relating momentum thickness, displacement thickness and wall shear stress. Assumptions may now be made about the relations among these integral parameters. Such assumptions are not local, but to a certain extent global, and might be expected to be less dangerous then (1); the integrated equations, however, also predict less. Many other integral approaches have been devised, using integrals of the energy equation as well as of the momentum equation - see Kline et al, (1969) for a discussion of some of these. These methods suffer from much the same difficulties as the eddy viscosity methods; although

the assumptions are global, in a sense they still generally relate quantities at a cross section. We may thus expect such methods to break down in rapidly developing situations, since the state at a cross-section is strongly dependent on the upstream history, which may be quite different.

The final class of techniques, the introduction of which defines the beginning of the modern period, consist in keeping the equations for the second order fluxes of momentum and other quantities and making closure assumptions expressing the third or higher order quantities in terms of these second order quantities. A good description of the early development of these ideas is contained in Monin and Yaglom (1971) p. 318. Since we will be discussing many of these ideas in some detail later, we will mention here only a few of the relevant names. Kolmogorov (1942) appears to be the first to suggest characterizing turbulence entirely by its intensity and scale, and using this to simplify the equation, an idea which is characteristic of all these methods. Chou (1945a;1945b;1947) suggested a number of closure