COMPUTATIONAL IMPLEMENTATIONS OF THE DORODNITSYN BOUNDARY LAYER FORMULATION

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1. INTRODUCTION

Conventionally the boundary layer governing equations are discretised by treating the velocity components, u and v, as the dependent variables and the coordinates, x and y in two dimensions, as the independent variables. However there are many advantages in adopting a Dorodnitsyn boundary layer formulation which uses a non-dimensional normal velocity gradient as the dependent variable and x and u as the independent variables.

An immediate computational advantage is that an infinite domain in the y direction is replaced by a finite domain in u; u is scaled to vary between zero and unity in traversing the boundary layer. The scaling of u means that the grid automatically captures the boundary layer growth in the downstream direction. In (x,y) space periodic readjustment of the boundary layer grid at the downstream stations is computationally expensive.

In the Dorodnitsyn formulation is is convenient to specify a uniform grid in the u direction. For the finite element Dorodnitsyn formulation this permits a higher accuracy to be achieved. In contrast in physical space a non-uniform grid is invariably required which implies, for the finite difference or finite element method, a larger truncation error than if a uniform grid is used. The use of a uniform grid in u-space provides high resolution in physical space adjacent to the wall. This is particularly important for turbulent boundary layers.

For two-dimensional flows the Dorodnitsyn formulation offers the additional advantage of avoiding the explicit appearance of the normal velocity component, v. Although it can be recovered if required. Consequently only one equation is solved with the Dorodnitsyn formulation.

By choosing the non-dimensional velocity gradient as the dependent variable the shear stress is computed accurately. This is particularly important in determining the skin friction behaviour.