INTRODUCTION TO THE EFFECTS OF ROTATION ON TURBULENCE MODELLING - II

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1. Introduction

In the previous lecture, the effects of rotation on the mean and fluctuating flow motion have been pointed out for a number of applications, mostly related to the cooling of gas turbine blades, different types of turbulence models have been introduced and some comments were made on their suitability for the prediction of rotating flows.

Here the objective is to put some of these hypotheses to the test by considering a range of rotating flow case studies and discussing the predictive effectiveness of the models tested.

2. Fully Developed Flow in a Rotating Channel

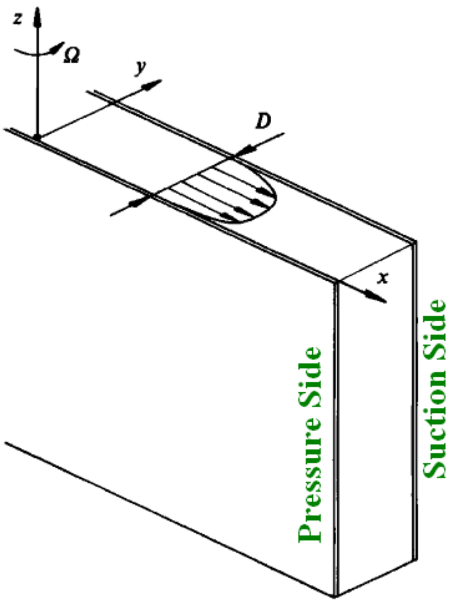

Figure 1. Flow in a rotating channel, Launder et al (1987).

This is essentially an one-dimensional flow. It is of particular interest, because it is only influenced by rotation, through the direct effects of rotation on the turbulence field. It therefore provides a good test for turbulence models.

Using the notation of Figure 1, the mean flow equations, equations (1) and (2) of Lecture 1, are reduced to:

$$0 = -\frac{1}{\rho}\frac{dP^*}{dx} - \frac{d}{dy}\overline{uv} + \nu\frac{d^2U}{dy^2}. \qquad (1)$$

Note that there is no rotation effect in the above equation. Laminar flow will consequently be unaffected by rotation and turbulent flow computations using an effective viscosity model will also show no rotation effects.

If look at the generation rate of the Reynolds stresses, using equation (17) of Lecture 1, with x_1=x, x_2=y, U_2=V=0, U_3=W=0 gradients in x_2 and x_3 are zero and $\Omega_1=\Omega_2=0$ with $\Omega_3=\Omega$ these become:

$$P_{\overline{u^2}} = -2\overline{uv}\frac{dU}{dy} + 4\overline{uv}\Omega \qquad P_{\overline{v^2}} = -4\overline{uv}\Omega \qquad P_{\overline{uv}} = -\overline{v^2}\frac{dU}{dy} - 2\left(\overline{u^2} - \overline{v^2}\right)\Omega \qquad (2)$$