INTRODUCTION TO THE EFFECTS OF ROTATION ON TURBULENCE MODELLING - I

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1. Introduction

1.1. Background

Flows affected by rotation, are encountered in a variety of applications which involve rotating machinery, but also include large-scale atmospheric and oceanic flows. For the computation of flows within rotating components, in other words flows enclosed by solid boundaries which are in solid-body rotation, it is often necessary to express the equations of fluid motion in a rotating frame of reference, with zero-velocity wall boundary conditions. One such example is that of internal cooling flows of gas-turbine blades, see Figure 1, a type of flows in which the author has had some research experience. In the computation some cases, such as those of flows in axi-symmetric rotating cavities, see Figure 2, it is not necessary to employ a rotating frame of reference. The flow equations can be expressed in a stationary frame of reference, with the wall boundaries at solid body rotation. What both these types of flows have in common, is that the fluid motion includes a substantial sold-body-rotation component. This solid-body-rotation component influences the development of both the mean and the fluctuating motion. Both these effects of rotation, either directly, or indirectly influence the turbulence field of rotating flows and consequently need to be taken into account in the modelling of their turbulence fields.

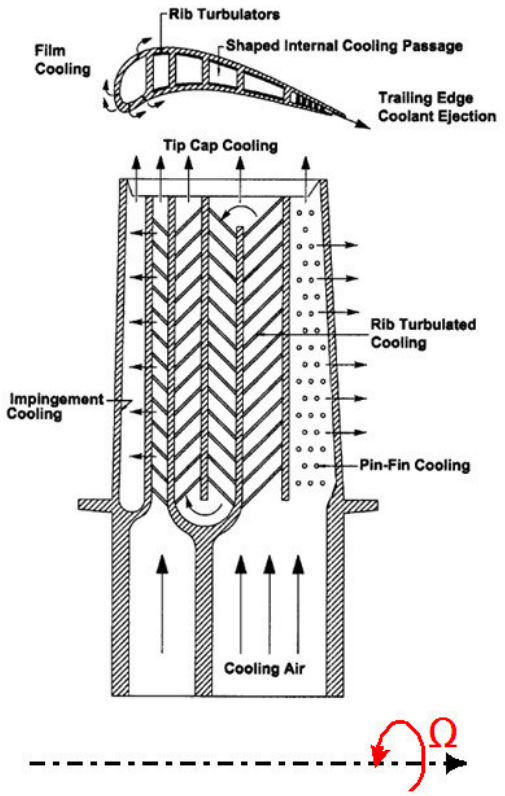

Figure 1 Typical internal blade-cooling arrangements. From Fu et al. (2005)

Even though, as pointed out above, the use of a rotating frame of reference is not always necessary, nevertheless, all the subsequent discussion on the effects of rotation will be based on the flow transport equations expressed in a rotating frame of reference. The conclusions, however, are equally relevant to all types of rotating flows.