Symposium on Fluid Mechanics in the Spirit of Tony Perry

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ABSTRACT

Calculation and prediction of turbulent boundary layers are among the most challenging tasks of present fluid mechanics. A strong demand exists for robust, easy-to-handle and in terms of computing effort cheap algorithms which can be used for technical applications. From an engineering point of view zonal methods and RANS are among the most useful tools for solution of fluid mechanical problems. It is known that zonal methods which use integral approaches for the description of the boundary layer can be used successfully in manifold forms. One way to improve zonal methods further is the development of advanced integral methods.

Basically three different types of integral algorithms - entrainment, momentum of momentum and dissipation integral method - can be derived from the three-dimensional boundary layer equations. If one compares the usual entrainment integral method with the dissipation integral method it turns out that the latter has the following physical advantages. While the entrainment method considers information about the shear stress distribution only at the outer edge of the boundary layer, the dissipation integral method uses the whole distribution. Apart from the integral momentum balance, the dissipation integral method satisfies a second major balance with the integral balance of mechanical energy. The shear-stress distribution needed for this balance can be derived from the boundary layer equations directly.

The talk gives an overview over the dissipation integral method and shows its extension to three-dimensional boundary layers. The general integral equations for the three-dimensional case are derived. It is shown using two different sets of mean velocity profiles that dissipation integral method has a hyperbolical character. It is found that for a practical calculation the integral momentum equation and the integral energy equation are most useful.

The results of sixteen two-dimensional experimental test cases with none-zero pressure gradients are presented. These results show that the averaged relative deviation between the measured and the computed values for the skin friction coefficient is about 5 % and about 3 % for the shape parameter. Two three-dimensional fully turbulent boundary layers approaching an obstacle are discussed. The agreement between experimental results and the calculation is reasonably good. The calculation allows the prediction of the velocity distributions. Flow angle and flow gradient angle distributions being additional results.