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THE ROLE OF BRIAN SPALDING IN THE EARLY DAYS OF TURBULENCE MODEL DEVELOPMENT

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ABSTRACT

The presentation gives a brief account of the development of turbulence models in the research group of Professor D. Brian Spalding at Imperial College in the late 1960's and early 1970's. When in the mid 60's the research in this group shifted from integral methods to numerical field methods solving the Reynolds Averaged Navier-Stokes equations, Brian Spalding recognized the need for sufficiently general models for the turbulent transport terms in these equations. The first calculations in the group carried out for 2D thin-shear flows employed the Prandtl mixing-length model relating the turbulent (or eddy) viscosity to the mean-velocity gradient. Brian Spalding realized soon that this model is not adequate for flows with separation. He therefore started a major research activity on the development and testing of models in which the eddy viscosity is related to the kinetic energy k and the length scale L of the turbulent motion. He recognized that for sufficient model generality both these turbulence parameters need to be determined from a transport equation, i.e. the development concentrated on two-equation models. The model form of the k-equation was already well established in the literature, while various forms of the length-scale determining equation had been proposed, and the choice of the dependent variable for this equation was not obvious. Brian Spalding initiated and carried out research on the development of models using equations for the product kL and for the square of the fluctuation frequency, $W \sim k/L^2$, while in a companion group led by B.E. Launder the use of an equation for the dissipation rate $\varepsilon \sim k^{3/2}/L$ was explored. In an internal note Brian Spalding examined the consequences of the choice of the length-scale equation and came to the conclusion that, when a single set of constants is used, the ε-equation would be best suited for flows both near to and remote from walls. A similar analysis was later published in the seminal 1974 paper by Launder and Spalding and led to the preference given to the ε-equation and to the wide-spread use of the k-ε model.