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NUMERICAL COMPUTATIONS OF THREE-DIMENSIONAL FLOWS IN CURVED AND ROTATING DUCTS

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ABSTRACT

The early 1970s can be considered as the golden period of research in computational methods at Imperial College. It gave birth to the SIMPLE algorithm and the method to compute three-dimensional parabolic flows in ducts. After the first paper on the algorithm, numerous applications of the method to complex flows were demonstrated by a number of Prof. Spalding's students. Among these, duct flows with additional forces arising from duct curvature and duct rotation are two examples. In ducts with mild curvature, the flow could be computed by the parabolic procedure, and successful predictions of the flow and temperature fields in laminar and turbulent flows were published. These were subsequently pursued by study of flow in transversely rotating ducts. In both geometries, the generation of secondary flows was successfully predicted. In ducts of strong curvature however, the parabolic procedure is not applicable. Professor Spalding proposed a novel algorithm with consideration of only pressure ellipticity, and named it as partially-parabolic procedure. This was applied successfully to predict flows in strongly curved ducts without flow separation. The pressure ellipticity was accounted by repeated iterations over the flow domain, but with a marching procedure in the streamwise direction. This was optimal in situations where the flow does not separate. This early work on curved ducts was subsequently extended to flows in elbows and T-junctions by other students, employing a fully-elliptic procedure. I will present these developments as well as recent research on mixing and particle transport in curved ducts.