Reflections on the Shape of a Turbomachine

Paul Gostelow

Emeritus Professor, Department of Engineering, University of Leicester

Abstract

A taxonomy of turbomachines is firstly presented, permitting turbines of widely varying geometry and layout to be identified and classified. The process is illustrated with reference to different configurations of hydraulic and free flow turbines. The author's background is in research and design on enclosed flow turbines for aircraft propulsion and the framework employed for analysis and design of these devices is introduced. Although the traditional approach to the design of enclosed turbines uses intersecting two dimensional planes it is recognized that all turbomachinery flows are three dimensional and unsteady. The use of advanced RANS and LES computational procedures is routine but these effects are still not well-predicted, even for enclosed flow turbomachinery. This often results in serious efficiency penalties which directly impact on fuel costs and have adverse environmental consequences. A good example of this is the extensive collaboration between universities and industry in the last two decades to produce highly-loaded low pressure turbines. These were eventually deployed in commercial aircraft and major savings in engine weight and cost were achieved, but with a significant penalty in turbine efficiency. Research is now aimed at regaining the lost efficiency whilst retaining the hard-won weight and cost advantages. The difficulties presented by secondary flow vortices and three dimensional flows are discussed. A recent discovery is that of organized fine-scale streamwise vortical structures on turbine blading. This has aerodynamic and heat transfer implications and raises questions of leading edge bluntness, surface curvature and blade sweep. The sweep question seems particularly relevant for most approaches to the design of free flow turbines. These issues are canvassed but largely remain as questions to be resolved. For progress to be maintained it is essential for analytical, computational and experimental work to proceed in a balanced, collaborative and interactive manner. This would best be achieved by the relaxation of traditional disciplinary barriers in universities and industry.

CV

Paul Gostelow was awarded doctoral degrees by Liverpool University in 1965 and 1988. From 1965 to 1968 he was a Senior Compressor Engineer at GE, Evendale, Ohio. From 1968 to 1975 he served as Assistant Director of Research at Cambridge University and Deputy Director of the Whittle Laboratory. From 1975 to 1994 he was Professor of Mechanical Engineering and Dean of Engineering at the University of Technology, Sydney, Australia. He has been a Professor of Engineering at Leicester University since returning to the U.K. in 1995 and has recently returned from Canada having spent two enjoyable years with the National Research Council.