Turbulent Simulations of a Rectangular Curved Inlet Duct

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An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

Major Subject: AERONAUTICAL ENGINEERING

The original of the complete thesis is on file
in the Rensselaer Polytechnic Institute Library

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Troy, New York

2009
(For Graduation August 2009)

Abstract

High speed subsonic and transonic flow within an S-shaped duct is simulated with an adaptive grid [17, 18] using a streamline upwind Petrov-Galerkin (SUPG) weighted residual finite element formulation [10]. Turbulence models compared in this study include two variants of the Spalart-Allmaras (S-A) models; the original S-A one equation model in the form of URANS [24] and Detached-eddy Simulation (DES) [14, 26]. Although S-A models were originally designed for application to incompressible external flows, such as airfoil analysis, the current analysis will investigate its accuracy of predicting separation within an S-shaped duct, which is similar to what Kandula et al [11] considered. The simulations were performed with different inflow Reynolds numbers varying from 0.5-1 x 10^6. The S-shaped duct has been augmented with slits (flow control inlets) prior to the curves where separations would occur. Within the simulations the inlets will be modeled in two ways: without forcing in flow and steady blowing. These inlets are used to control the main flow separations [1, 2]. This simulation effort is part of a simultaneous experimental effort. The focus of this paper is not on the experimental portion [30, 31, 32], but on a comparison of the two turbulence models within an anisotropic/boundary layer adaptive simulation effort. A particular novelty of this effort is the study of the interplay of anisotropic, adaptive grid methods with turbulence models which change their character based on grid anisotropy. The results of the simulations show, not only how URANS over-predict separations, but how DES along with adaptation provides a solution close to experimental findings.