NSAERO APPLICATION NOTE
External-Internal Flow: S-Duct RAE M2129

Introduction

This application note demonstrates the capability of NSAERO to compute the external and internal flow in the S shaped duct. NSAERO is a multi block computational fluid dynamics software package available from Analytical Methods, Inc. The current application is the S-Duct RAE M2129 featuring high and low mass flow regime (LMFR and HMFR) at Reynolds number 777,000.

Problem Description

The M2129 S-Duct is a diffusing offset intake that exhibits complex secondary flow, causing a mal-distribution of pressure at the engine face. Secondary flow is challenging to predict, turbulence models play a critical part of the prediction.

Problem Setup

The computational domain was broken into 66 structured zones (provided by G. Barakos [1]). Free-stream Mach number is 0.21 and back pressure ratio of 1.043 and 1.232 at the fan face is imposed to simulate the two flow regimes, LMFR and HMFR, respectively. The Spalart-Allmaras and K-ω turbulence models are considered for this application

Results

The runs are summarized in Table 1. Figure 1 shows extractions of pressure from the starboard and port sides for the LMFR case with the Spalart-Allmaras turbulence model. Good agreement is obtained. Due to the adverse pressure gradient, small separation is captured as shown in Figure 2. For the HMFR case, the K-ω turbulence model gives the best result, the pressure profile along the duct compares well with the scattered data from ARA and BAE [2] (Figure 3). The predicted pressure recovery is under-predicted for both cases (see Table 2). The secondary flow for the HMFR case is clearly shown in Figure 4, whereas it is weak for the LMFR case.

Surface mesh points	10,300
Off body points	435,000
CPU time 4 2.2 Ghz AMD	KW 6.3 hours SA 5.15 hours
Memory	410 MB

Table 1 Mesh size, CPU time and memory requirement

Case	Pressure Recovery
LMFR SA/KW/Exp	0.9913 / 0.9909/0.9897
HMFR SA/KW/Exp.	0.9511 / 0.9447/0.9280

Table 2 Pressure recovery for LMFR and HMFR

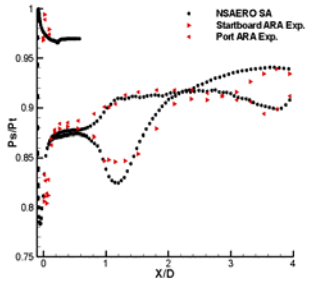

Figure 1 Cp Profile Along the Duct (LMFR)

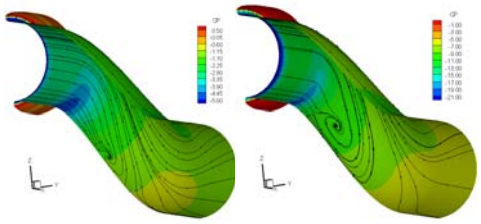

Figure 2 Calculated Cp contour with surface streamlines LMFR (left) and HMFR (right)

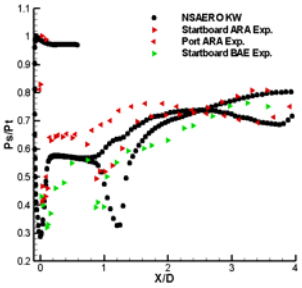

Figure 3 Cp Profile Along the Duct (HMFR)

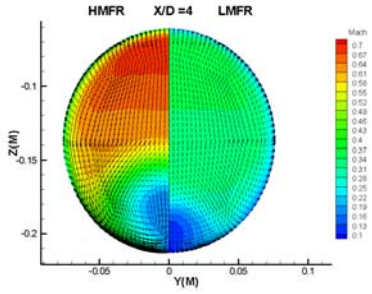

Figure 4 Calculated Mach number contours with vector plots at the fan face.

[1] CFD Group, Department of Aerospace Engineering, Univ. of Glasgow.

[2] Fluid Dynamics Panel Working Group 13. Test case 3 - subsonic/transonic circular intake. AGARD, Advisory Report 270, 1991.