21st Applied Aerodynamics Conference
23-26 June 2003, Orlando, Florida

AIAA 2003-4088

SURGE WAVE PROPAGATION MODELLING USING COMPUTATIONAL FLUID DYNAMICS

R. D. D. Menzies*, K. J. Badcock†, G. N. Barakos‡, and B. E. Richards§
CFD Group, Department of Aerospace Engineering,
University of Glasgow, Scotland G12 8QQ, United Kingdom.

Flows in the s-shaped intake (Royal Aircraft Establishment intake model 2129 - M2129) have been simulated and analysed using Computational Fluid Dynamics (CFD). Steady throughflow for validation and verification was initially studied and then the unsteady flow of surge wave propagation following the application of a surge signature at the engine face was modelled. Reynolds Averaged Navier-Stokes (RANS) simulations have been considered using the SST turbulence model. The freestream Mach number (M) was fixed at 0.21 and the Reynolds number (Re) based on the non-dimensional engine face diameter was 777,000. It was found that the propagation of the surge wave through the duct following the application of the surge signature demonstrated a complex flow with an interaction with the natural separation of the flow from the starboard side first bend. The duct offsets induce an over-pressure on the port side of the duct at the first bend that can peak at a value of around 2.7 with respect to the downstream boundary steady-state pressure in extreme cases.

Introduction

THE flow in the RAE intake model 2129 (M2129) is complex. The flow accelerates into the intake from a stagnation point on the outer cowl surface. There is further acceleration of the flow around the starboard side first bend of the intake - Fig. 1 - where separation occurs. The faster moving core stream is acted upon by centrifugal and pressure forces which cause it to move towards the outside of the bend (port side). Here the flow meets an adverse pressure gradient. Energy deficient near wall fluid approaches this adverse pressure gradient but cannot pass through it. Instead the flow moves around the outside curve of the wall towards the lower static pressure on starboard side. This action of the low energy region towards the inside bend combined with the movement of the core flow towards the outside bend sets up two cells of contra-rotating secondary flow.

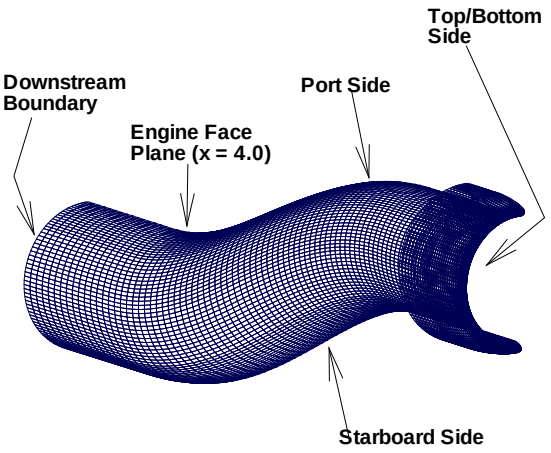

Fig. 1 M2129 intake geometry showing surface grid and intake definitions.

Intakes are a very important component of an aircraft. The efficiency of such devices is crucial in that they make major contributions to the performance and handling attributes of the aircraft. At least as important is the need for intake and engine compatibility. Engine surge can be induced if factors such as cowl lip shape and subsonic diffuser shape are not considered in the design process. Engine surge is a complicated phenomenon that can occur at the compressor face. The causes of surge can be wide ranging, especially when considering the engine systems as a whole (nozzle, turbines, combustion chamber, and compression systems) as each individual

*Research Student, corresponding author.
†Senior Lecturer.
‡Lecturer.
§Mechan Professor, AIAA Associate Fellow.