NON-AXISYMMETRIC COMPLETE FLOW CONDITIONING GAUZES

Alejandro Castillo Pardo
Whittle Laboratory
Department of Engineering
University of Cambridge
Cambridge, UK

James V. Taylor
Whittle Laboratory
Department of Engineering
University of Cambridge
Cambridge, UK

ABSTRACT

This paper presents a novel methodology for the design of a gauze that produces the distributions of total pressure, swirl angle and turbulence intensity tailored in both the radial and circumferential directions. The distortion gauze is designed using 1D correlations and full annulus 3D CFD simulations. The resulting design is additively manufactured as a single thick sheet and tested in a low-speed fan rig. The device controls the flow with a large number of small scale circumferential and radial vanes with tailored thickness and camber distributions. These are controlled independently in the radial and circumferential directions to generate the target distortion pattern.

In this paper the method has been used to simulate the flow distortion seen at the aerodynamic interface plane of an aft-mounted boundary layer ingesting (BLI) fan. The flow in this application comprises large variations in both total pressure and swirl angle caused by the upstream fuselage, wings and fin. The gauze is able to replicate the structures of this target flow in an experimental test. These kind of flow structures would be extremely difficult or impossible to replicate in an experiment in any other way.

INTRODUCTION

With the advent of tighter engine-intake-airframe integration, increasing levels of swirl and total pressure distortion are ingested by the low-pressure compression system. In order to replicate these complex inflow conditions in an experimental setup, distortion generation devices are required. Traditionally, total pressure distortion is generated by a combination of distortions screens or grids, whilst swirl is generated with inlet guide vanes. The combined and controlled generation of total pressure and swirl generation remains a challenge with these current technologies, especially for non-axisymmetric inflow with large gradients in both the radial and circumferential directions. The present paper presents a novel methodology for the design of a coupled total pressure and swirl distortion gauze. The distortion gauze is designed using 1D correlations and full annulus 3D CFD. The resulting gauze, shown in Fig. 1, is 3D printed in a single thick sheet and tested in a low-speed fan rig.

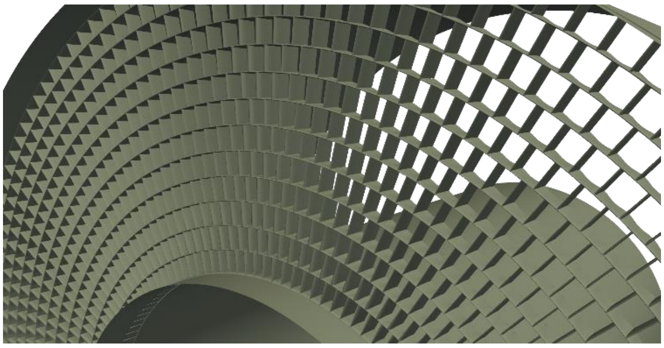

Figure 1 Render of the distortion gauze.

RESULTS AND DISCUSSION

Within the paper, the effectiveness of the proposed methodology is assessed experimentally. The inflow generated by the designed gauze is shown to reproduce the main flow structures of the target BLI inflow. In addition, the capability of the method to generate larger local gradients in the radial and circumferential direction is presented. The proposed methodology is proved to offer a large potential in the generation of complex inflow patterns, enabling more comprehensive experiments of fans/compressors subjected to inlet flow distortion.

This research is part of the CENTRELINE project, which has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 723242.