PROPOSITION DE SUJET DE THESE

Intitulé : Numerical Simulation of Serpentine Air-Inlet (S-Duct) – Compressor Interaction

Référence : **SNA-DAAA-2026-06**
(à rappeler dans toute correspondance)

Lien de candidature *:*
https://emea3.recruitmentplatform.com/apply-app/pages/application-form?jobId=PVOFK026203F3VBQB68LOF6HI-6157

Début de la thèse : 01/10/2026	**Date limite de candidature : 30/04/2026**

Mots clés

Axial compressor, distortion, rotating stall

Profil et compétences recherchées

Master thesis with CFD / turbomachinery / fluid mechanics lectures

Présentation du projet doctoral, contexte et objectif

Whether in the civil sector (BLI and BWB architectures) or in the military sector for stealth reasons, engines are tightly integrated into the fuselage, which implies a serpentine air inlet, also called an “S-Duct.” This type of inlet generates a highly complex and unsteady flow, but above all a distorted one. The distortion can be radial and/or circumferential, with variable amplitude, and can affect the pressure rise, turbulence, and swirl of the flow as seen by the downstream compressor. So far, because of the separation between aircraft manufacturers and engine manufacturers, the interactions have been little studied, limited to an interface plan and without the two configurations (S-Duct and compressor) being examined simultaneously. The two parties mainly discuss the issue through distortion coefficients or indices.

From the engine-manufacturer’s point of view, the goal is then to reproduce the distortion pattern using a distortion generator. Several strategies exist to design such generators, allowing the modulation of distortion amplitude, the combination of several patterns (pressure, swirl) at once, and the spatial modulation of their location. The work of Virginia Tech is an example.

Nevertheless, several phenomena have been neglected, and reducing the distance between the distortion source and the compressor strengthens their interaction. The first effect overlooked so far is the lack of feedback from the compressor on the flow inside the S-Duct. The distortion grid becomes non-representative if it is not designed with the compressor present. Moreover, unsteady effects are absent even though they can promote compressor stall or surge. This issue raises the need for a methodology that can best represent the unsteadiness of the distortion when the simulation relies on a URANS (modeled-turbulence) approach.

Today, the main studies are experimental. For example, the work carried out at Cranfield with a fan rotor is not very representative of a real compressor, and the research performed by the German Federal Armed Forces University, which placed an S-Duct in front of the Larzac 04 engine to study the interaction with that engine’s BP compressor. The latter study focused on the compressor’s feedback on the flow in the “AIP” plane and on distortion indices. Because of the high cost, very few numerical studies have addressed the whole system. To the best of our knowledge, the simulations are still decoupled. To investigate the flow in a serpentine air inlet, the Zonal Detached Eddy Simulation developed at ONERA must be used. In compressors, the main approaches are URANS and BodyForce.

The objectives of this thesis are to numerically study the interaction between a serpentine air inlet and the CME2 compressor, and to revisit the numerical strategy that relies on using a distortion pattern which does not take this interaction or unsteadiness into account.

Collaborations envisagées

Collaborative work with LMFL (ENSAM Lille)

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