PROPOSITION DE SUJET DE THESE

Intitulé : Rotating stall simulations using Zonal Detached Eddy Simulation on an axial compressor, with tip gap size effect

Référence : **SNA-DAAA-2026-05**
(à rappeler dans toute correspondance)

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

Mots clés

Axial compressor, rotating stall, unsteady flow analysis, spectral analysis

Profil et compétences recherchées

Master thesis with CFD / turbomachinery / fluid mechanics lectures

Présentation du projet doctoral, contexte et objectif

The operating range of axial compressors is limited by choke (high mass flow rate) and surge (low mass flow rate) lines. These limits depend on the rotation speed, on the tip gap size, for example. They must be accurately predicted in order to minimize the surge margin defined by the distance between the nominal and the stall operating points, and to maximize the rotor work and the flow compression as this is mandatory to improve the efficiency of the thermodynamic cycle of the engine and to reduce the engine weight.

In many compressors, the surge limit is caused by the tip leakage flow occurring near the casing and generated by the pressure discrepancy between pressure and suction sides. Thus, the tip leakage flow must be investigated to better understand the phenomenon. In some compressors, the rotating stall is observed before surge, or even, without any surge as in the CME2 compressor located at Arts et Metiers Institute of Technology. The rotating stall is characterized by stall cells occurring at the tip and, rotating around the circumference at a speed smaller than the engine rotation speed. An example is plotted in Figure 1.

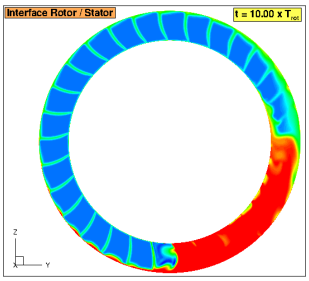

Figure 1 - Rotating stall cell after ten revolutions [13]

The flow behavior near stall (the operating point before stall occurrence) has been widely studied using numerical simulations based on URANS equations, such as in [1] showing the role of the tip leakage vortex on the blockage causing stall inception. Pullan *et al.* [2] investigated the spike occurring in a low-speed compressor, also based on URANS computations. It should be noticed that the spike is a strong perturbation with a small wavelength and can be due to geometrical discrepancy. Dodds and Vahdati [3] showed that URANS method is able to capture some significant aspect of the rotating stall. The stall process was also investigated using high fidelity methods, such as large-scale simulations based on Detached Eddy Simulations [4], but the stall was due to hub corner separation, or Detached Eddy Simulations of the NASA Rotor 67 (isolated rotor) [5]. The stall cell covers six-blade passage and rotates at 48% of the rotor rotational speed. The spike was also studied by [6] and by [7] using Dynamic Mode Decomposition. Proper Orthogonal Decomposition (POD) is also used to investigate the behavior of the tip flow [8][9][10]. He *et al.* [11] used Spectral POD to identify the spatial and temporal behavior of flow structure within the tip leakage flow.

The present PhD aims at investigating the rotating stall occurring in CME2 compressor, for two tip gap sizes as in Rannou *et al* [12]. The PhD will consist in carrying out Zonal Detached Eddy Simulations (ZDES, a hybrid RANS/LES method) of the whole compressor, first on a periodic sector, and then on the full-annulus in order to investigate the influence of the circumferential extent on the stall process, for both tip gap sizes. To do so, several operating points will be considered: the nominal one, a near stall one and a stalled one. The use of ZDES allows a more accurate prediction of the tip flow evolution while entering in the rotation stall regime by comparison to URANS method, although this latter is able to capture the rotation stall onset. As PIV measurements are available at nominal point, and close to the stall onset, simulations will be validated by confronting numerical results to these experimental data. In order to better understand the route to the stall from a stable operating point, a particular attention will be made on the throttling effect. For example, a simulation will be performed from the nominal point up to the stalled one by modifying boundary conditions. A deep unsteady analysis will be performed of all these simulations, using recent tools such as SPOD in order to highlight the role of the tip flow on the stall and confirming or not, the presence of a spike, as suggested by experimental data.

References

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Collaborations envisagées MARIE SKŁODOWSKA-CURIE ACTIONS -- Doctoral Networks (DN) – RE-EXPECTATION project LMFL	
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