Master Thesis - “Development of a Low-Order Compressor Inlet Distortion Model Through Coupled 0D and 2D Flow Analysis” (30 credits/20 weeks – 2 student[s])

About us

GKN Aerospace is the world’s leading multi-technology tier 1 aerospace supplier. With 33 manufacturing locations in 12 countries, we serve over 90% of the world’s aircraft and engine manufacturers. We design and manufacture innovative smart aerospace systems and components. Our technologies are used in aircraft ranging from the most used civil aircraft to the world’s advanced 5th generation fighter aircraft and the Ariane orbital rockets used by ESA.

Project Background

The increasing interest in native jet engine development has created a need for fast and efficient methods capable of predicting off-design engine performance and installation effects during the early design phases. While high-fidelity Computational Fluid Dynamics (CFD) can provide detailed insight, it is often too computationally expensive for iterative design studies. Consequently, low-order approaches such as 0D performance models and 1D/2D meanline and streamline methods remain essential design tools.

A major challenge in modern engine design is predicting the impact of inlet distortion on compressor performance and stability. Installation effects arising from intake geometry, boundary layer ingestion, aircraft manoeuvres, crosswinds, and embedded engine configurations can generate significant circumferential and radial flow non-uniformities at the compressor face. These distortions can reduce pressure ratio and efficiency, alter engine matching, and decrease compressor stability margins, potentially leading to rotating stall or surge.

Among the available low-order methods, the Parallel Compressor approach has become widely used for modelling inlet distortion. By representing the compressor as multiple parallel flow passages subjected to different inlet conditions, it captures key effects of circumferential distortion, including stability loss and circumferential variations in blade loading. However, conventional Parallel Compressor models rely heavily on empirical corrections and calibration against CFD or experimental data. They also neglect important physical phenomena such as radial flow redistribution, swirl transport, and non-uniform inlet flow angles.

With future propulsion concepts being embedded within the airframe, these limitations become more significant with higher levels of distortion. There is therefore a need for modelling techniques that retain the computational efficiency of low-order methods while incorporating additional physics.

This project aims to develop a standalone low-order method for predicting the performance and stability effects of compressor inlet distortion without requiring calibration from CFD or rig testing. The proposed approach will build upon the Parallel Compressor method by coupling it with a two-dimensional streamline solver to account for radial equilibrium effects, spanwise flow redistribution, swirl transport, and variable inlet flow angles. The final objective is to develop a model suitable for integration into a 0D engine performance code, providing sufficiently accurate predictions of stability margin and performance degradation to support early-stage engine design studies.

Assignment Description

The thesis worker(s) will:

- Conduct a literature review of compressor inlet distortion and existing low-order modelling methods
- Develop and implement a 2D meanline/streamline methodology for multistage compressors subjected to inlet distortion
- Integrate the methodology with GKN's existing 0D engine performance tools
- Verify the methodology against published research data and available high-fidelity simulations

Project milestones

- Literature Study
  - Review compressor inlet distortion mechanisms and existing low-order modelling approaches
  - Identify limitations and opportunities for improved prediction methods
- Method Development: Develop a 2D meanline/streamline model capable of predicting:
  - Performance and stability effects of non-uniform inlet total pressure and swirl
  - Radial and circumferential flow redistribution caused by inlet distortion
- Verification and Validation
  - Assess model predictions against published research data and available GKN CFD analyses

Deliverables

- A coupled 0D/2D compressor distortion modelling method
- A documented implementation suitable for integration with GKN performance tools
- Assessment of prediction capability, limitations, and recommended future development
- A master's thesis report and presentation

Qualifications

- M.Sc. student in a relevant engineering discipline (e.g. Aerospace Engineering, Mechanical Engineering or Applied Mechanics)
- Proficient in Python and/or C++ programming
- Fundamental understanding of gas turbine engines and compressor aerodynamics
- Fundamental understanding of fluid mechanics and CFD
- Interest in simulation, numerical analysis, and propulsion systems
- Interest in aircraft performance and conceptual design methods

Apply by

Please submit: CV/Resume, cover letter, and academic transcript to Atle Nyberg (Atle.Nyberg@gknaerospace.com).