

---

## **Master thesis and internship[BR]- Master's thesis : Modelling of Gas Foil Bearing with a high order Discontinuous Galerkin Method[BR]- Integration Internship**

**Auteur** : Alshikh Saleh, Ammar

**Promoteur(s)** : Hillewaert, Koen

**Faculté** : Faculté des Sciences appliquées

**Diplôme** : Master en ingénieur civil en aérospatiale, à finalité spécialisée en "aerospace engineering"

**Année académique** : 2021-2022

**URI/URL** : <http://hdl.handle.net/2268.2/15884>

---

### *Avertissement à l'attention des usagers :*

*Tous les documents placés en accès ouvert sur le site le site MatheO sont protégés par le droit d'auteur. Conformément aux principes énoncés par la "Budapest Open Access Initiative"(BOAI, 2002), l'utilisateur du site peut lire, télécharger, copier, transmettre, imprimer, chercher ou faire un lien vers le texte intégral de ces documents, les disséquer pour les indexer, s'en servir de données pour un logiciel, ou s'en servir à toute autre fin légale (ou prévue par la réglementation relative au droit d'auteur). Toute utilisation du document à des fins commerciales est strictement interdite.*

*Par ailleurs, l'utilisateur s'engage à respecter les droits moraux de l'auteur, principalement le droit à l'intégrité de l'oeuvre et le droit de paternité et ce dans toute utilisation que l'utilisateur entreprend. Ainsi, à titre d'exemple, lorsqu'il reproduira un document par extrait ou dans son intégralité, l'utilisateur citera de manière complète les sources telles que mentionnées ci-dessus. Toute utilisation non explicitement autorisée ci-avant (telle que par exemple, la modification du document ou son résumé) nécessite l'autorisation préalable et expresse des auteurs ou de leurs ayants droit.*

---

# Modelling of Gas Foil Bearing with a high order Discontinuous Galerkin Method

Ammar Alshikh Saleh

Academic supervisors: KOEN HILLEWEART

Industrial supervisor: MARTIN HEYLEN

Master in Aerospace Engineering

Faculty of Applied Sciences, University of Liège

Academic year 2021-2022

## Abstract

In recent years, foil bearings, a special class of gas bearings, began to receive widespread converge in many scientific publications because of their advantages of environmental durability, higher reliability in operation (oil-free), and higher load capacity at high speed. Air Foil Bearing (AFB) supporting direct drive compressors or/and turbines have been gaining popularity in recent years. Mitis SA is developing a new generation of clean energy converters for decentralized Combined Heat and Power (CHP) based on flameless combustion chamber microturbines. Mitis SA is using AFB in their systems to guarantee an oil-free system and increase reliability.

The overall objective of this work is to contribute to a better understanding of the AFB technology. The work focuses particularly on the behaviour of the lubrication gas film. Numerical simulations of the isothermal, steady state Reynolds equation using the Discontinuous Galerkin Finite Element Method (DG-FEM) are performed. Compared to classical FD and FV methods, such a method provides high accuracy in terms of interpolation and spectral properties on unstructured meshes without opting for large stencils. The work comprises the development and implementation of a numerical prediction code with the use of DG-FEM. The numerical aspect of the hyperbolic-elliptic problem has been addressed with the implementation of specific approaches. First, upwind flux has been proposed for the convective formulation, and then an incomplete internal penalty method (IIPM) has been considered to evaluate the diffusive interface flux. Newton-Raphson method has been used to solve the nonlinear equation. The residual and the inverse of the Jacobian have been computed using direct solver, which is based upon the LU factorization technique. All these strategies were implemented in ForDGe, an immersed boundary, and in turn, Adaptive Mech Refinement (AMR) on multiple order Cartesian grids, still under development at the University of Liège.

The modelling of the foil structure is built based upon existing models. The coupling between structural and fluid parts has been done at the level of the film thickness using the Simple Elastic Foundation Model (SEFM). The validity of the analysis and numerical code has been assessed by comparing predictions to experimental and/or numerical published data.

This work would be recognized as the reference, providing numerical results for GFBS used by Mitis SA and/or any kind of GFBS with variable geometries and different working gases and operating conditions.

**Keywords:** Discontinuous Galerkin, Gas foil bearing, Reynolds equation, Bearing number, Load capacity