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Invitation à la soutenance de thèse

AIR-OIL NUMERICAL SIMULATIONS OF A BEARING CHAMBER

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Auditorium de l'ONERA Toulouse, 2 avenue Edouard Belin

Devant le jury composé de :

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Résumé

The current trend towards more powerful and fuel-efficient aircraft engines produces the need for improved bearings, capable of transferring higher mechanical loads between rotating and stationary machine components, at extreme temperatures and higher engine speeds. The bearings demand lubrication oil at all times in order to reduce friction, dissipate heat, drive tiny debris away and therefore ensure the mechanical integrity of the engine. The resulting oil mass flow rates within the engine are significant and thus the lubricant must be continuously recycled via an oil recirculation system. The bearing chambers are essentially sealed chambers adjacent to, or sometimes enclosing the bearings, whereby the ejected oil is channeled into after lubrication. They are typically sealed with pressurized air on the opposite side, which is passed through a labyrinth seal in order to provide flow obstruction. Typically, a vent port opening is included on the top for the air to escape, and a scavenge port opening is located near the bottom to lead the oil to the oil scavenge pumps and back to the reservoir. While still flowing within the bearing chamber, the oil and the air form a complex two-phase flow due to the presence of centrifugal effects, aerodynamic shear and gravity forces.

The objective of this thesis is to assess different computational modeling approaches for the simulation of a simplified bearing chamber test rig, hereby named ELUBSYS, for which some experimental measurements are available. Namely, an interfacial multi-fluid diffuse-interface approach, an Eulerian Integral Thin Film (EITF) approach, a two-way coupled Discrete Parcel Method approach, and, lastly, an EITF-DPM coupled approach are tested in terms of accuracy, efficiency and robustness.

First, the numerical predictions of the gaseous flow dynamics within the chamber are validated. These are characterized by the interaction between the azimuthal flow driven by the shaft and the axial flow

resulting from the injection of sealing air to prevent oil leakage. This results in different large-scale dynamics, namely the presence of either a single or two counter-rotating vortical structures. The associated flow regimes are denoted sealing air dominated regimes, transitional regimes and rotational speed dominated regimes in the literature. It is shown that the gaseous solver is capable of capturing these large-scale dynamics and reproduce the main flow fields, be it with Large Eddy (LES) or Reynolds Averaged Navier Stokes (RANS) Simulation approaches.

Then, the multifluid approach is used to gain some insight into the large-scale two-phase flow dynamics within the bearing chamber. It appears that the axial momentum of the sealing air bends the injected oil ring towards the bearing chamber walls. This results in a significant deposition of oil onto the chamber walls directly after injection. Thus, the time required to fill the bearing chamber with oil is dictated by a viscous scale of the liquid film, i.e. several seconds, making the compressible multifluid approach computationally inefficient. For this reason, only one multifluid approach is performed and used to derive boundary conditions for simplified approaches, namely the mass split between the oil flowing on the sidewalls and the liquid dispersed within the volume of the chamber.

For high-speed rotational regimes, characterized by higher levels of shear with respect to gravity, the Eulerian Integral Thin Film Approach is found to yield satisfactory predictions of the oil film distribution within the bearing chamber. Oil film dynamics are dominated by gravity effects at lower rotational speeds, resulting in the formation of an oil pool at the bottom of the chamber. More importantly, it seems that dispersed phase dynamics play a more important role regarding the oil film dynamics, especially towards the vent port. As a conclusion, The EITF and DPM methods can be used to assist in the design of bearing chambers of low geometric complexity, such as the ELUBSYS configuration.. Moreover, preliminary tests indicate a relative robustness of these simplified approaches with respect to the initial conditions, namely the injection thickness and velocity of the liquid film as well as the size distribution of the droplets.

Mots clés

Fluid mechanics, Bearing chambers, Two-phase flows, Atomization, Liquid Film, Dispersed Phase