

Aero-thermo-mechanical simulation of a labyrinth seal

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ABSTRACT

A partitioned coupling method is set up to simulate the aero-thermo-mechanical phenomena occurring in an aircraft engine labyrinth seal (see e.g. [1, 2]). The 3D simulation couples the finite volume fluid solver CEDRE (<http://cedre.onera.fr/>) and the finite element thermo-mechanical solver Z-set (<http://www.zset-software.com/>) via the interpolation library Openpalm/Cwipi (http://www.cerfacs.fr/globc/PALM_WEB/).

Although the configuration is a simplified model of a labyrinth seal system, it has several geometrical features that have a significant influence on the stability of the coupling schemes. The system consists of cavities where the fluid flow is relatively slow and is lead by the rotor, of seals where the fluid is forced through the labyrinth, of narrow convergent–divergent parts where the friction heats then expands the fluid. It is also driven by inertial force of the rotor, that deforms the seal up to near-contact. These specificities places this configuration in the class of strongly coupled aero-thermo-mechanical problems.

A partitioned procedure (see [3] and references therein) is adapted to handle those specificities. A Robin boundary condition on the coupled interface [4, 5] stabilizes the coupling scheme and allows a significant reduction of the overall computational costs. The influence of local variations of the fluid flow on this condition will be discussed.

To follow the significant reduction of the section of the labyrinth, an adaptation of moving mesh procedure is proposed. The selected method allows narrowing the seal up to 80%, while keeping a reasonable mesh quality.

With this technical toolbox at hand, the aero-thermal and aero-thermo-mechanical simulations are conducted. In this configuration, it is remarkable that the coupling conditions (as opposed to fixed or adiabatic conditions) drastically improve the convergence of the fluid flow, by allowing heat transfer to transit through the structure. The quantitative results will finally be discussed.

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