Coupling schemes for conjugate heat transfer for transient flight cycles

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ABSTRACT

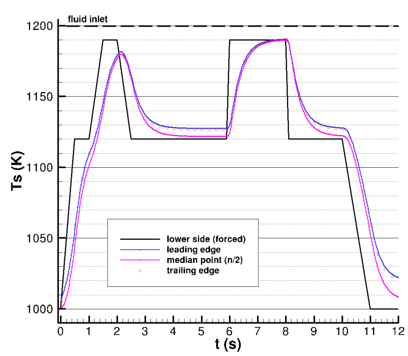
Transient flight cycles need accurate and stable solutions to the fluid flow/heat transfer problem. This problem is classically solved by coupling solvers for the fluid and thermal sub-problems, but this coupling is a new problem for which stable solutions are not easy to obtain in all cases [1].

Dirichlet-Robin and Neumann-Robin boundary conditions, with computed optimal parameter, have been successfully used here for coupling fluid and thermal systems, respectively solved by the Fluent (ANSYS) and ZéBuLoN (Onera/Northwest Numerics/Centre des Matériaux) codes.

The chosen test-case is here the simple but stiff problem of a metallic plate, with on one side a prescribed temperature profile and along the other an airflow with prescribed initial temperature. The leading-edge of the plate is a singularity, where the flux coefficient is theoretically infinite.

Fast convergence is achieved for any Biot number, provided that the correct Dirichlet-Robin or Neumann-Robin boundary condition and the (computed) optimal parameter are used [2]. Smooth convergence on temperature is achieved up to 1.e-10 K (for numerical validation purposes) in less then 30 coupling iterations, while the simple "heat transfer coefficient" (h) method gives here erratic pseudo-convergence around 0.1 K, even for 100 coupling iterations.

The fluid mesh is refined both normally to the plate for adequate boundary-layer representation, and longitudinally at the leading edge, to represent the maximum in heat transfer coefficient (smoothed singularity).



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