The Dirichlet-Neumann iteration for unsteady thermal fluid structure interaction

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ABSTRACT

The efficient simulation of thermal interaction between fluids and structures is crucial in the design of many industrial products, e.g. thermal anti-icing systems of airplanes, gas quenching, which is an industrial heat treatment of metal workpieces or the cooling of rocket thrust chambers.

Unsteady thermal fluid structure interaction is modelled using two partial differential equations describing a fluid and a structure which are coupled at an interface. The models chosen for the fluid and the structure are the compressible Navier-Stokes equations and the nonlinear heat equation respectively.

The standard algorithm to find solutions of the coupled problem is the Dirichlet-Neumann iteration, where the PDEs are solved separately using Dirichlet-, respectively Neumann boundary with data given from the solution of the other problem. Previous numerical experiments [1] show that this iteration is fast, and although the iteration has been analyzed and a convergence condition is given in [3], the convergence rates have not been computed. Therefore, we present a convergence analysis for the discretized equations of the thermal transmission problem [2]. This analysis predicts very accurately the behavior of the Dirichlet-Neumann iteration. Moreover, we could also estimate the asymptotic behavior of the convergence rates when both the spatial mesh size and the stepsize tend to 0.

We present here the experimental convergence rates computed for several time dependent cooling systems and we compare them with the theoretical convergence analysis performed earlier for the thermal transmission problem.

REFERENCES

