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A Second Order Coupling Algorithm for Thermal Fluid-Structure Interaction

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ABSTRACT

The high temperature gradients in a jet engine result in high thermal stresses that can cause failures in some parts of the engine. In that case investigating only the interaction between fluid forces and structural deformations is not sufficient. Therefore developing a model for the heat transport is essential.

The present paper considers a second order coupling algorithm for thermal fluid–structure interaction(TFSI). An implicit partitioned solution approach, which tries to combine the advantages of weakly and strongly coupled schemes is used. Every time step consists of two nested iteration procedures. The first is responsible for the heat transport between the fluid and the solid and the second for the velocity–pressure coupling. In addition, a multigrid technique for accelerating the computations for the fluid part is involved. The quasi-standard coupling interface MpCCI is used for the implementation of the coupling between the finite–volume flow solver FASTEST3D and the finite–elements structural solver FEAP.

Two important things characterize the area of interest – the high temperature gradients and the complexity of the geometry. The former leads to divergency problems of the whole calculation and thats why different underrelaxation procedures are applied for each coupling iteration. Also a simple predictor based system often fails to give a reliable solution although the absence of convergency problems, which makes obligatory the use of a staggered loop between the domains. The non–regular grid, that results from the discretization of the complex geometry, can further enhance the discussed problems. In order to solve the problem we use a coupling algorithm which is designed to preserve a second order accuracy also on strongly distorted grids without any restriction.

Several representative test cases are considered in order to prove the accuracy and to investigate the numerical characteristics of the scheme. By applying different grid configurations we show that the results are of second order of accuracy. Also we discuss the effect of the underrelaxation parameters and the different converence criterions on the number of staggered loop iterations.

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