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STABILITY OF COUPLING METHODS FOR CONJUGATE HEAT TRANSFER

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Abstract. We suggest a novel approach for coupled computations of conjugate heat transfer, considering the exchange of the boundary conditions between fluid and solid solver. Many engineering design processes require to predict temperature distributions, e.g. the life of a turbine blade reduces by half with an increased metal temperature of 30 Kelvin [1]. In case of a complex flow field, the temperature prediction is improved if the fluid and solid temperature computations are coupled. Besides the need for two different solvers, the challenge arises through the different time scales in the solid and the fluid that can vary by orders of magnitude and increase the computational cost. Within the multi-physics environment COOLFluiD 3, developed at the von Krmn Institute for Fluid Dynamics, we included four different coupling strategies. In all methods, boundary conditions are exchanged until equal temperatures and heat fluxes at the interface from the solid to the fluid domain. The first method sets a temperature distribution to the fluid solver that predicts a heat flux distribution imposed to the solid solver [2]. The second method sets a heat flux distribution to the fluid solver computing a temperature field for the solid [3]. A third method imposes a temperature field to the fluid returning a Robin boundary condition to the solid using the wall heat transfer equation [4]. Based on a stability analysis for the existing coupling procedures [5], we postulated a new method, imposing a heat flux distribution to the fluid solver that returns a Robin boundary condition to the solid solver [6]. The stability of all methods only depend on the dimensionless Biot number, the ratio of conductive to convective thermal resistance. For flat plate computations, the result of each method is in good agreement with an analytical solution.

We compare the novel coupling strategy with the established methods. Considering the stability, the new approach is advantageous, especially for high Biot numbers. Further, it converges faster concluding that it can improve efficiency and accuracy of conjugate heat transfer computations.

1 INTRODUCTION

All the participants whose Abstract has been accepted for presentation at the Conference are kindly requested to submit the Full Paper electronically via the web page of the Conference, http://congress.cimne.com/coupled2013 *before February 28*, 2013. *The submission of the full paper is not mandatory but highly recommended as the Conference Proceedings (full papers) will be submitted for indexation in the Conference Proceedings Citation Index - ISI Web of Knowledge (Thomson Reuters) and SCOPUS database.* The Full Paper should be written following the format of macros for submission. The file must be converted to Portable Document Format (PDF) before submission via the Conference site. The organizers do not commit themselves to include in the Proceedings any Full Paper received later than the above-mentioned deadline. The corresponding author should be the speaker, and is expected to register and pay his registration fee during the advance period (before 28 February 2013) for the Full Paper to be included in the technical program of the Conference.

2 NUMERICAL METHOD AND COUPLING PROCEDURES

2.1 EQUATIONS

A displayed equation is numbered, using Arabic numbers in parentheses. It should be centered, leaving a 6pt space above and below to separate it from the surrounding text.

The following example is a single line equation:

$$Ax = b \tag{1}$$

The next example is a multi-line equation:

$$\begin{aligned} Ax &= b \\ Ax &= b \end{aligned} \tag{2}$$

3 STABILITY

4 RESULTS AND DISCUSSION

5 CONCLUSIONS

- Full Papers in format for publication should be submitted electronically via the web page of the Conference http://congress.cimne.com/coupled2013, before February

Table 1: Example of the construction of one table

C11	C12	C13
C21	C22	C23
C31	C32	C33
C41	C42	C43
C51	C52	C53

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- The speaker (corresponding author) is expected to pay his registration fee during the advance period (before February 28th 2013) for the presentation to be included in the final program of the Conference. Only one presentation per registration is allowed.

6 ACKNOWLEDGEMENTS

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