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Improving the performance of CFD solvers for quenching simulations using Hessian based a-posteriori error estimator

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Due to their complexity, the simulation of industrial processes allows to predict how they actually behave in a given set of operating conditions. In our work, We're especially interested in quenching process defined as the cooling process in which heated material is cooled down at a faster rate in order to get the desired properties of the metal. Quenching is a highly non-linear process because of strong coupling between fluid mechanics, heat transfer at different interfaces and for many others reasons which makes it very complicated to be simulated. Stabilized finite element method is used because it allows to consider flows with a high Reynolds number. We also use the anisotropic mesh adaptation leading to a finer description of interfaces while taking into account fluid properties. What is important to notice is that mesh adaptation plays an important role in reducing the CPU time required.

The proposed research deals with the use of information from anisotropic mesh adaptation procedure to control the convergence of linear solvers via an adaptive stopping criterion following the strategy developed by G. Manzinalli for convection-diffusion problems in [1]. The idea is to use the a-posteriori error estimator allowing to build a metric tensor defined based on the Hessian of the approximated solution and used to adapt the mesh . The a-posteriori error estimator is also used as a stopping criterion. In other words, we run the linear solver iterations as long as the algebraic residual is not controlled by a fraction of the Hessian based a-posteriori error estimator weighted by a constant. A rigorous study based on mathematical results allowed to estimate this constant thanks to the Krylov solver. As our error estimator is Hessian based and in P_1 finite elements the Hessian is defined per element we were brought to use Non-smooth interpolation operators [2] to reduild the Hessian on nodes in order to work on the same topology as the metric. The resulting framework has been implemented and tested on analytical and high Reynolds number test cases.

REFERENCES

[1] G. Manzinali, E. Hachem, Y. Mesri, Adaptive stopping criterion for iterative linear solvers combined with anisotropic mesh adaptation, application to convection-dominated problems, Computer Methods in Applied Mechanics and Engineering.

[2] O. C. Zienkiewicz & J. Z. Zhu, The superconvergent patch recovery and a posteriori error estimates. Part 1: The recovery technique. International Journal for Numerical Methods in Engineering.