Zone-by-zone non-conformal remeshing strategy applied to 2D and 3D thermal additive manufacturing FE simulations

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Studying the evolution of the thermal and mechanical fields during an Additive Manufacturing (AM) process requires the use of non-linear thermo-mechanical simulations. Moreover, the physical nature of AM processes imposes a very fine discretization and requires altering the geometry of the model throughout the simulations to model the addition of small layers of matter (only a few µm in some AM processes). This creates big computational challenges specific to this type of simulation. Using the Finite Element Method to model such a process thus requires a very fine mesh in the vicinity of the deposition zone, however, as this deposition zone gets more distant from a previously deposited layer, the mesh does not change, creating extremely fine meshes throughout the deposited piece. This particularity makes AM simulations especially suitable for remeshing strategies, allowing the mesh to be coarsened as the deposition zone gets further away.

Previous work includes the implementation of an additive manufacturing module in the fully implicit in-house Finite Element code “Metafor”, which is developed at the University of Liège, as well as a preliminary 2D implementation of a remeshing strategy for AM simulations (C. Laruelle, R. Boman, L. Papeleux and J.-P. Ponthot, “Element activation method and non-conformal dynamic remeshing strategy to model additive manufacturing”, in *ESAFORM 2021[Online]*).

This work focuses on improving the efficiency of AM simulations in Metafor by implementing a 2D/3D zone-by-zone non-conformal remeshing strategy to drastically reduce the computational cost of AM simulations without hindering the accuracy of the results. The remeshing is done zone-by-zone using non-conformal meshes where hanging nodes are handled via the use of Lagrange multipliers. The mesh data transfer used in the remeshing process is based on projection methods involving finite volumes. The choice of using Lagrange multipliers to handle the hanging nodes in this type of simulation allows for more freedom regarding the type of meshes that can be generated during the remeshing process.

Results from the literature are used to verify the model against 2D and 3D numerical results as well as to validate the model in 3D against experimental results. The impact of the remeshing strategy on the computational cost and on the accuracy of the results is also discussed. The advantages of the choice of using Lagrange multipliers to handle the hanging nodes is also shown in this work.