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PARTITION OF UNITY FINITE ELEMENT FOR SOLVING TIME DEPENDENT HEAT TRANSFER PROBLEMS

M Shadi Mohamed
School of Engineering and Computing Sciences, Durham University, Durham DH1 3LE, United Kingdom, m.s.mohamed@durham.ac.uk

Mohammed Seaid
School of Engineering and Computing Sciences, Durham University, Durham DH1 3LE, United Kingdom, m.seaid@durham.ac.uk

Jon Trevelyan
School of Engineering and Computing Sciences, Durham University, Durham DH1 3LE, United Kingdom, jon.trevelyan@durham.ac.uk

Omar Laghrouche
School of the Built Environment, Heriot-Watt University, Edinburgh, EH14 4AS, o.laghrouche@hw.ac.uk

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ABSTRACT

Recovering the temperature field in an object subjected to sudden cooling, when removed out of a furnace for example, is usually a challenge for numerical methods such as the finite element method. The sudden drop of the ambient temperature while the object is still hot results in a sharp heat gradient on the outer surface, that can be hard to recover unless highly refined meshes are used. The cooling phase until this sharp gradient decreases may last for a considerable time span depending on the thermal conductivity. This can be a real burden when small time steps are needed to solve the problem. The accuracy in recovering this phase using numerical simulation can be crucial for accurately predicting different physical properties of the object. For different industries such a simulation can be highly efficient in reducing the costs.

In this work we propose to enrich the finite element solution space with exponential and hyperbolic functions to accurately recover sharp heat gradients on coarse meshes. Since two numerically different equations (energy and radiative transfer equations) are coupled to describe the problem, two different enrichments are proposed on the same mesh. This approach can reduce the computational effort whereas a similar approach with the finite element method can only be possible when two different meshes are used. However, using two different meshes may increase the computational effort due to the mapping required between the two meshes.