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Nuclear thermal hydraulics modelling using automatic code generation

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Thermal hydraulics analysis forms a crucial part of nuclear safety and reactor design. With more stringent safety demands and newer reactors being developed, there is the need for more accurate modelling codes. Automatic code generation could contribute to this by making code that is faster to implement, more readable and more maintainable. Devito [1] is a domain specific language (DSL) specialized for finite difference stencil computation. Starting with symbolic expressions defined in Sympy, the Devito compiler generates optimized C++ code that targets the architecture it is being used on such as CPUs, GPUs or clusters. The main applications of this software have been in geophysics and image processing. However, there is the potential to extend this to computational fluid dynamics, as seen in other code generation frameworks [2, 3]. The high-level abstraction facilitates writing code that is less likely to be error prone, which is an important attribute for any code, especially large codes.

Here we present a fluid solver being developed in Devito for thermal hydraulics analysis of nuclear reactors. Complex solid geometries are represented as volume-averaged porous media which significantly reduces the simulation demands. This is similar to other porous media codes being developed for nuclear thermal hydraulics analysis [4]. The aim here is to demonstrate the additional benefits of a fluid solver written using a DSL that supports automatic code generation. Test cases for pressurized water reactor assembly problems will be presented for validating the computational results.

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