Implementation of tritium permeation models in the CFD code FLUENT

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A number of additions have been made to the commercial CFD code Fluent in order to model tritium permeation. In addition to fluid dynamics, Fluent is capable of solving heat transfer in coupled solid and fluid regions, as well as advection-diffusion equations for arbitrary user-defined scalar variables. While the latter are suitable for calculating tritium concentrations in both fluids and solids, additional code has been implemented to properly treat solubility at fluid-metal interfaces, according to a flux balance and Sievert's Law. The model incorporates temperature dependent solubility and diffusion coefficients based on the solved temperature distribution.

The method has been employed to model the THX experiment at INL, which investigates hydrogen permeation in helium and candidate structural materials for high temperature gas reactor heat exchangers. Results compare favourably with experiment data. Subsequent analyses will investigate the effect of oxide layers on permeability.

While the present results are for hydrogen in helium and metals, the implementation is sufficiently general that it is easily extended to any fluid and solid materials, in arbitrary 2D or 3D geometries.