Consider a coupled set of physics equations described by PDEs given below. The problem deals with conjugate heat transfer in a single porous channel where the material diffuses the heat produced in the solid to the cooler fluid flowing by the wall surface.

1) Heat conduction equation in 3-D Cartesian system:

$$\left(\rho C_p\right)\frac{\partial T_s(\underline{r},t)}{\partial t} - \nabla.\left(k(T_s)\nabla T_s(\underline{r},t)\right) = S(r,T_s) - h(T_s - T_f) \qquad (1)$$

Where $\underline{r}$ and t represent the independent variables position and time, $T_s(\underline{r},t)$ is the temperature distribution as a function of space and time, $\rho(\underline{r})$ is the density of the material, $C_p(\underline{r})$ is the heat capacity of the material, $k(\underline{r},T_s)$ is the heat conduction coefficient as a dependent function of position and Temperature, $S(\underline{r},T_s)$ is the driving source term and finally h is the heat transfer coefficient between the solid and the fluid at the surface.

2) Fluid flow equations: 1-D Euler flow with heat addition

$$\frac{\partial U}{\partial t} - \nabla.F = Q \qquad (2)$$

Where

$$U = \begin{bmatrix} \rho \\ \rho u \\ \rho E \end{bmatrix}$$ represents the unknowns density, momentum and total energy,

$$F = \begin{bmatrix} \rho \underline{u} \\ \rho u^2 + P \\ u\left(\rho E + P\right) \end{bmatrix}$$ represents the flux,

$$Q = \begin{bmatrix} 0 \\ 0 \\ h(T_s - T_f) \end{bmatrix}$$ represents the flux,

Naturally, for this problem 2 different mesh representations are necessary. One 3D mesh for discretizing the heat conduction equation and a 1-D axial mesh for fluid flow. A simplification can be made as to make the axial mesh coincide for both the physics and use prisms to discretized the 3-D diffusion-reaction PDE. This simplifies the projection of solution onto other physics and any loss of accuracy thereof.

Of course the mesh structure needs to be flexible enough to add another physics in the future, namely the neutron diffusion (or transport) equation whose length scales are much shorter than say fluid flow.