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Multiscale modelling of cracking in CeO2 and UO2 pellets

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High temperature and temperature gradient in nuclear fuel causes internal stresses in the structure that result fuel deformation, such as swelling, creep and cracking. These phenomena have consequences to e.g. fuel's thermal conductivity and fission gas release, which are critical safety parameters. Currently the modelling of these phenomena mainly rely on empirical correlations. This means that the models are not extendable to problems beyond the experimental data used in the derivation nor in new fuel designs. More physics oriented and universal solutions can be obtained with decreasing the time and length scales to take into account microscale phenomena and couple them to macroscopic modelling.

We present a comparative study of the cracking in CeO₂ and UO₂ pellets with different centre line temperatures and temperature gradients. In the comparison we apply a multiscale software called properTune [1] developed at VTT and compare the results and modelling to the INL's mesoscale fuel performance code MARMOT [2]. Both codes rely on the MOOSE framework developed at INL. Later on, we plan to compare the results with the corresponding experiments.

[1] T. Suhonen, A. Laukkanen, T. Andersson, T. Pinomaa, and K. Holmberg (2016). VTT ProperTune: Computational multiscale materials modeling concept. Web publication/site, Retrieved from http://www.match-a4m.eu/index.php/latest/news/148-propertune
[2] M.R. Tonks, D. Gaston, P.C. Millett, D. Andrs, and P. Talbot. An object-oriented finite element framework for multiphysics phase field simulations. Comp. Mat. Sci., 51(1):20–29, 2012.

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