Effect of crystallographic texture on the thermoelastic properties of Zr alloys for cooling channels

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ABSTRACT

This work is concerned with homogenization techniques for correlating the macroscopic thermoelastic properties of polycrystalline solids with the thermoelastic properties of the constituent crystals and the crystallographic texture distribution. More specifically, techniques are applied to study the response of zirconium alloys employed in the coolant channels of certain nuclear reactors under normal operating conditions. This study is required to validate the structural design of the channels in accordance with the ASME III BPVC design standards. The constitutive models often employed in this process are macro-phenomenological and one-dimensional leading to a high degree of conservativism. By contrast, the multi-scale models developed in this work incorporate explicit information about the microstructure of the solid and consequently allow us to assess the influence of crystallographic texture on the anisotropic thermoelastic response. This information could be used to select suitable fabrication routes for the channels.

The models rely on the use of the so-called self-consistent homogenization scheme of Willis [1] whereby the polycrystalline microstructure is assumed to exhibit separation of length scales and ergodicity. They require the numerical solution of a single tensorial equation which can be addressed very efficiently by the fixed-point method. The resulting predictions are exact to second order in the heterogeneity contrast and satisfy all pertinent bounds.

REFERENCES

[1] J.R. Willis. “Variational and related methods for the overall properties of composites”. Adv. Appl. Mech. 21, 1--78 (1981).