Experimental & Numerical Study of Ceramic Breeder Pebble Bed Thermal Deformation Behavior

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The objective of this paper is to develop predictive capability for pebble bed deformation. The phenomena and parameters involved in ceramic breeder pebble bed thermal deformation are complex. First, unlike solid material, stress distribution in a pebble bed system is highly concentrated at the local zone of contact area. Second, deformation behavior is time-dependent.

According to previous studies[1,2], the initial strain rate can be significant, but as the contact area grows, it can become much relaxed and simultaneously stress magnitude is reduced. Therefore, deformation mechanisms at contact points in the pebble bed system are different and evolve with time. Deformation in the pebble bed may be detrimental and, therefore, understanding its behavior is important to ensure adequate blanket performance.

The experimental facility is built and operated under reactor-like temperature operating conditions (500-800^{o}C). The test pebble bed structure represents a simplified model of a typical solid breeder blanket system, which provides data of fundamental thermal deformation behavior. The recorded data includes the deformation magnitudes of interaction between the structural wall and pebble bed at different times and temperatures. Numerical simulation based on finite element method (FEM) is employed to study details of the deformation. Constitutive equations of the creep model derived experimentally by Bühler[3] have been incorporated into the numerical model. The preliminary results show that the simulation is able to capture thermal deformation characteristics. However, the absolute values still need to be resolved using correct material properties.

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[1] J. Reimann and G. Wörner, "Thermal Creep of Ceramic Breeder Pebble Beds", *"Proceedings CBBI-9"*, Toki (2000)
[2] J. An, A.Y. Ying and M. Abdou, Progress on Experimental & Numerical Study on Ceramic Breeder Pebble Bed Thermal Creep Behavior, CBBI-11, Japan, 2003
[3] L. Bühler, Continuum models for pebble beds in fusion blankets, FZKA 6561 (2002)