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P3.161 Investigating Ceramic Breeder Pebble Beds Thermomechanics Evolution Using Novel Pressure Mapping Technology

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Ceramic breeder pebble beds undergo complex thermomechanical interactions during blanket operation due to stress build-up and relaxation under the effects of confined thermal expansion, thermal cycling, and creep. Understanding the evolution of such processes can aid in guiding blanket design, breeder materials developments, predicting performance and possible failure modes. This study introduces experimental techniques that enable us to create an environment in which the pebble bed stresses are organically self-generated as a result of relevant temperature gradients and magnitudes that allows us to observe the combined thermomechanical interaction effects on contact pressure rise and fall, as well as temperature fluctuations. A novel non-intrusive in-situ tactile pressure sensing technology is used to generate real-time contact pressure maps that reveal the spatial and temporal stress evolution with emphasis on understanding the roles that each of the thermomechanical forces play in dictating the pebble bed's equilibrium operating conditions. Two types of bed-wall contact pressure drop were recorded: (1) within the subsequent cycles due to pebbles irreversible rearrangements, and (2) within the cycle itself as a result of creep/stress-relaxation. As a result, by the fourth cycle, the contact pressure drops to negligible values. Additionally, the study revealed that the use of bed thermal conductivity at nominal packing configuration needs to be reevaluated since the thermal conductivity can vary with the pebbles' spatial re-distribution. Consequently, two modes self-regulation were captured: (1) stress self-regulation as a result of pressure rise and fall due to thermal expansion and creep/thermal cycling, respectively, and (2) temperature self-regulation due to the locally enhanced thermal conductivity, k, in the core region of the bed accompanied by locally deteriorated k in the surrounding region. These two mechanisms are desirable as they lower the probability of the events of pebbles crushing/bed creep and thermal runaways under high temperatures/stresses and poor heat extraction.

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