DEVELOPMENT AND VALIDATION OF A THERMO-MECHANICAL CONSTITUTIVE MODEL FOR LITHIUM ORTHOSILICATE PEBBLE BEDS

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Packed pebble beds are granular systems composed of small particles generally arranged in irregular lattices and surrounded by a gas filling their interstitial spaces. They show non-linear and coupled thermal and mechanical behaviours, which are under theoretical and experimental investigation to set-up a realistic constitutive model to be adopted for design-oriented purposes.

At the Department of Nuclear Engineering (DIN) of the University of Palermo a realistic constitutive model of fusion-relevant pebble beds thermo-mechanical behaviour was developed adopting a "continuous" approach, based on the assumption that a pebble bed could be considered as a continuous, homogeneous and isotropic medium, characterized by effective thermal and mechanical properties strictly depending on its temperature, pressure and/or mechanical volumetric strain.

Within this framework, an experimental research campaign was launched at DIN to assess the functional dependences of lithium orthosilicate polydisperse pebble bed effective thermal diffusive properties on both temperature and equivalent pressure, by means of the purposely-outlined Improved Current Pulse method. Moreover, the test campaign aimed to the further qualification of the aforementioned DIN constitutive model, by checking its aptitude to numerically reproduce experimental results whether implemented in purposely outlined numerical analysis based on the Finite Element Method (FEM).

The ATTAR-1 test section was set-up and a test campaign was carried out on a 24 mm high reference polydisperse lithium orthosilicate pebble bed, at temperatures ranging from 20 °C up to 450 °C and equivalent pressures up to 50 bar. The functional dependences of the pebble bed thermal diffusive properties on both temperature and pressure were derived and they agree quite well with those shown in literature.

A three dimensional FEM model of the ATTAR-1 test section was set-up and three selected tests of the experimental campaign were numerically simulated adopting the DIN constitutive model, by means of a quoted FEM code. The numerical results obtained as to the behaviour in time of temperature and pressure in selected points of the test section agree quite well with the experimental, thus encouraging the adoption of the model.