THERMO-MECHANICAL ANALYSIS OF ITER TEST UNIT CELL UNDER PULSE OPERATION

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Two configurations have served as the reference for designing the ITER test unit cell/submodules: 1) a layered configuration where solid breeder and beryllium pebbles are placed parallel to the first wall (FW), and 2) an edge-on configuration where both beryllium and breeder beds are placed perpendicular to the FW facing the plasma region. The preliminary results show that temperature and stress distribution are different in the two designs. Considered the movability of a pebble bed, the edge-on design shows a better feature of reducing stresses. However, the exact description about the thermo-mechanical behaviors is still limited. Numerical simulation has difficulty in defining the thermal and mechanical properties of a pebble bed, and combining thermal and mechanical analysis under special working condition, such as a pulse operation.

In this paper, 3-D thermo-mechanical analysis about an ITER test unit cell with edge-on configuration will be analyzed by using finite element program. Under influence of temperature, stress and time, material properties of a pebble bed, such as elasticity, creep and thermal conductivity, are not only nonlinear, but also much dependent on stress magnitude. In our FEA, effective material properties, derived from experimental works, will be utilized to simulate the beryllium and breeder pebble beds. Numerical simulation results show that, under pulse radiation heating, the time-dependent stress and temperature distribution are much different from static results.

FEA simulations will provide important information about the unit cell design on two aspects. First, numerical simulations show that the maximum temperature and stress in the breeder pebble bed are not equably distributed. Due to radiation flux distribution, the high temperature and stress are concentrated in the front part close to the First Wall panels. However, by modifying the layout of breeder pebble bed, beryllium pebble bed and coolant channel, the temperature and stress distribution can be changed. Second, simulation provides the time dependent behaviors with thermal creep deformation effects. Involved creep mechanism, the results indicate that the stress can be reduced even though time period only lasts 400 seconds and the equivalent stress is less than 1MPa.