Numerical Simulation of the thermo-mechanical coupling behaviors in the plate-type dispersion nuclear fuel elements considering the heterogeneous irradiation conditions

Yunmei Zhao, *Shurong Ding, Xin Gong, Yongzhong Huo

Department of Mechanics and Engineering Science, Fudan University, Shanghai 200433

*Corresponding author: dsr1971@163.com

The plate-type dispersion nuclear fuel element contains alloy cladding and fuel meat, which can be structurally considered as a sandwich plate. The nuclear fuel meat is a composite fuel with the nuclear fuel particles embedded in the metal matrix. Under the extremely harsh irradiation environment in the reactor, the complex irradiation-thermo-mechanical-coupling behaviors occur and evolve with burnup in the fuel elements. Considering heat generation and irradiation swelling in the homogenized fuel meat and the irradiation-induced hardening and growth effects in the cladding under the heterogeneous neutron irradiation conditions, the three dimensional large deformation constitutive relations and stress update algorithms in the co-rotational coordinate system are respectively built, and numerical simulation of the thermo-mechanical coupling behaviors evolution is realized with the validated user material subroutines UMAT and UMATHT in ABAQUS. The influence of plate boundary constraint conditions and the texture factor of cladding on the thermo-mechanical behaviors are investigated.

Keywords: Irradiation growth, Irradiation creep, Stress update algorithm, Thermo-mechanical coupling