BISON: An Implicit Solution Framework for Fuel Performance Simulation

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The simulation of light water reactor fuel performance involves complex thermomechanical processes between fuel pellets, made of fissile material, and the protective cladding that surrounds the pellets. Advancing fuel design and analysis capability requires progress in both modeling fuel material behavior and the development of a multidimensional computational framework that couples these models in a consistent, accurate, and efficient manner to describe how the fuel geometry and behavior changes during burnup.

This presentation examines various mathematical and computational issues that impact the modeling of the thermomechanical response of reactor fuel, and are thus important to the development of INL's fuel performance code, *BISON*. The code employs advanced methods for solving coupled partial differential equation systems that describe multidimensional fuel thermomechanics, heat generation, and transport within the fuel. *BISON* is intended to serve as a multiscale host platform that models the engineering geometry of the fuel and that integrates multiscale material models with the macroscale geometry. This finite element framework supports the coarse mesh that describes the fuel geometry, models the mechanical and thermal interaction between the pellet and cladding, and describes the coupling between the plenum gas and the mechanical behavior of the fuel at the macroscale. The Jacobian-free Newton Krylov architecture of *BISON* supports the easy and flexible integration of meso- and microscale material models that describe the behavior of the pellet and cladding materials. Further, *BISON* is designed for efficient performance on parallel computers, exhibiting excellent scalability on a representative multiscale calculation using over 1000 processors.