主 論 文 要 旨

Title Fracture Mechanics and Material Studies on Long-term Structural Integrity Assessment of Fast Reactor Components

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Abstract

This paper describes development of structural integrity assessment methods for Sodium cooled Fast Reactor (SFR) components and development of innovative structural material suitable for SFR components.

Firstly, simplified creep-fatigue crack growth assessment method is proposed taking plastic and creep deformations into account, because SFR components are used at elevated temperature. Fatigue crack growth under elasto-plastic stress-strain conditions is estimated using the elastic follow up parameter which is employed in structure designing of SFR components. A plastic correction factor based on the reference stress is also adopted to calculate inelastic fracture mechanics parameter. Creep crack growth is estimated taking stress relaxation during holding period into account. In the evaluation of stress relaxation behavior, elastic follow up concept is employed as well. The crack growth assessment methods are validated using some structure test data. As a result, validity of the methods is successfully demonstrated.

Secondly, in order to achieve a compact SFR plant designing, high chromium (Cr) ferritic steel suitable for SFR component material is developed. Since the SFR is operated at elevated temperature and its design life is up to 60 years, “long-term microstructure stability at elevated temperature” is supposed to be the most essential characteristic for SFR component material. As a result, it is clarified that tungsten (W) results in embrittlement of the material by precipitating as Laves phase at microstructure boundaries. Since the demonstration of Leak Before Break (LBB) aspect is strongly required in SFR pipes, fracture toughness is very important for SFR material. Therefore, it is proposed that W should be substituted by molybdenum (Mo) to maintain the fracture toughness after long-term aging at elevated temperature. In addition, a material strength standard and a creep-fatigue damage assessment method are also proposed. Creep-fatigue damage assessment method is validated by using some experimental data.