# Estimation of Fuel Performance under a Large Break Loss-of-Coolant-Accident Condition of the Accident Tolerant Fuel

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## 1. Introduction

Research and Development on the accident tolerant fuel (ATF) to improve the performance of nuclear fuel under accident conditions is underway in various countries. In Korea, researches on accident tolerant fuel are being conducted by research groups and industries. In particular, the coated cladding and the metal microcell pellet developed by KAERI meet performance requirements for ATF at a high level [1, 2]. According to the DOE-Program of ATF [3], ATF should have similar or better performance under normal operation conditions and design basis accidents as well as in beyond design basis accidents compared to conventional nuclear fuels. In this study, the effect of ATF developed by KAERI were estimated using system analysis code and fuel performance code for a large break loss-of-coolant-accident (LBLOCA), which is a typical design basis accident.

## 2. Methods and Results

The nuclear fuel behavior in the accident condition is greatly influenced by the thermal hydraulic conditions outside the cladding. Therefore, an integrated analysis of fuel performance and thermal hydraulics is necessary for accurate analysis. However, in this study, the system analysis was used to calculate the thermal hydraulic condition, and the fuel performance was analyzed with boundary condition from this result. The normal operation performance required for accident analysis were performed using FRAPCON code [4].

### *2.1 System Analysis*

The system analysis was conducted with RELAP5 for the OPR-1000. In the analysis of the LBLOCA scenario based on the OPR1000 used in the previous study, the peak cladding temperature (PCT) showed a low behavior of less than 800 K [5]. In this study, the conservative assumptions are introduced to make higher cladding temperature under hypothetical condition. The result of PCT shows in Fig. 1. Compared to the previous analysis, the cladding temperature increased to about 40 K at the blowdown peak and 180 K at the reflood peak, but it is still maintain a low temperature of less than 1000 K.

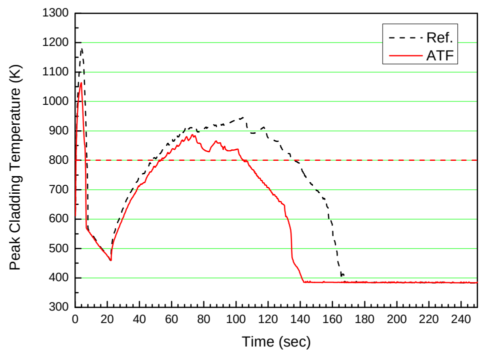


Fig. 1. The peak cladding temperature of LBLOCA condition from RELAP5.

The separate effect of the reduced oxidation rate and the increased pellet thermal conductivity is showed in Fig. 2. The oxidation rate of the cladding was reduced to 1/1000 and the thermal conductivity of the pellet was increased by 150%. The increased thermal conductivity of the pellet clearly shows that it contributes to the reduction of PCT in the blowdown and the reflood regime. Since the metal water reaction in the RELAP5 is calculated at the high temperature above 1273 K, the effect of reduced oxidation rate is not present at all in this scenario.

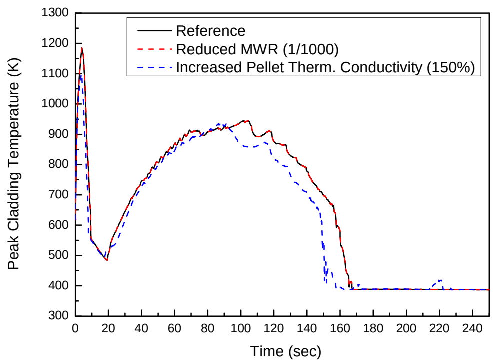


Fig. 2. The separate effect of the reduced cladding oxidation and increased pellet thermal conductivity on PCT

### *2.2 Fuel Performance analysis*

For the ATF, several properties are modified in the fuel performance code, FRAPCON/FRAPTRAN based on out-of-pile test results. In the fuel performance analysis, the rod internal pressure, the fuel centerline temperature, and the gap conductance were mainly evaluated. There was no significant difference in rod internal pressure between the reference and the ATF. However, the fuel centerline temperature is significantly lowered due to increased pellet thermal conductivity as shown in Fig. 3. In the case of the reference fuel, the contact between the pellet and the cladding occurred due to the deformation of the cladding at the beginning of the accident, but the ATF maintains a constant gap due to the lowered fuel temperature as shown in Fig. 4. This leads to a large difference in the gap conductance.

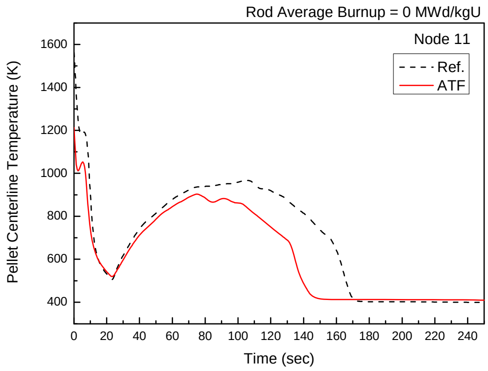


Fig. 3. The centerline temperature of the fuel pellet.

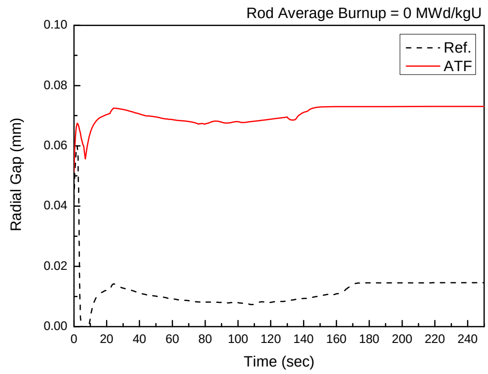


Fig. 4. The radial gap between the pellet and the cladding.

## 3. Conclusions

In this study, the system analysis with RELAP5 and the fuel performance analysis with FRAPTRAN were performed to estimate characteristics of the ATF under a LBLOCA scenario. KAERI is developing coated cladding for decreasing the oxidation and metal microcell UO2 pellet for increasing the thermal conductivity. For the analysis, the properties are modified based on out-of-pile test. The fuel performance analysis was performed with the system analysis results as boundary conditions.

In the applied LBLOCA scenario, the peak cladding temperature did not exceed 1000 K except for a short time during blowdown phase. Therefore, the improved oxidation resistance of the coated cladding was not reflected. However, it was confirmed that the increased thermal conductivity of the metal microcell pellet is effective in reducing the fuel centerline temperature and reducing the deformation of the fuel.

We will continue to evaluate the effects of ATF for the various scenarios of the design basis accident and the beyond design accident.

## ACKNOWLEDGEMENTS

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