Fission Gas Release from Accident Tolerant Fuels: A Review

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Abstract

After the Fukushima accident that occurred in March 2011 [1], several countries including Korea, US, and France have developed accident tolerant fuel (ATF) that could mitigate the consequences of nuclear accidents [2]. In the case of accident tolerant pellet, it is supposed to maintain reliability during normal operation and moreover exhibit enhanced retention of fission products even in severe accidents, since such pellets could minimize the release of radioactive materials into the environment.

It is noted that fuel pellet is both the source of radioactive fission products and the first barrier for blocking their release to the environment. KAERI has developed microcell UO_2 pellets to enhance the retention capability of highly radioactive and corrosive fission products [3], especially volatile cesium (Cs) and iodine (I), which are very hazardous in terms of public health. The key concept of the microcell UO_2 pellets is both to increase thermal conductivity for decreasing fuel temperature and also immobilize Cs and I by providing multiple chemical traps inside the pellet [4]. In order to confirm whether the microcell pellets would perform its intended function of increased retaining capabilities, two kinds (metallic and ceramic) of microcell pellets together with the conventional UO_2 pellets were irradiated in the Halden reactor until achieving an average pellet burnup of 16 MWd/kgU [5] at the time of the Halden reactor's permanent shutdown.

Another concept of ATF pellet developed by AREVA and Westinghouse involves modifying the conventional UO_2 pellet with small additives of Cr_2O_3, with increasing grain size up to 7 times great than the undoped UO_2 pellet for suppressing fission gas release (FGR) at extended burnup and power ramps, enhancing the accident tolerance [6]. Different kinds of Cr_2O_3-doped pellets were irradiated in the Halden reactor (IFA-677 and IFA-716) up to an average burnup of around 30 MWd/kgU, during which fuel temperature and rod pressure were measured online [6,7]. And fission gas releases of these pellets were inferred from the measured rod pressure.

We review the concepts of accident tolerant fuel pellets developed so far and their irradiation test results, and to evaluate how much the accident tolerant pellets could reduce FGR, compare their FGRs during irradiation with those of the UO_2 pellet [6-8]. Finally, we discuss how the accident tolerant pellets would impact on accident source term during accidents.

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