Recent P&T Related Activities in CRIEPI: Development of Pyrochemical Processing and Metallic Fuel Technologies

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Abstract

The development of innovative nuclear fuel cycle technology that has the advantages of economic and safe power generation as well as proliferation resistance is strongly expected to be an effective measure for achieving environmental sustainability and satisfying the increasing energy demand. Metallic fuel cycle technology, consisting of a metallic fuel fast reactor, pyrometallurgical reprocessing and fuel fabrication by injection casting, has been attracting increasing attention as one of the most promising nuclear fuel cycle technologies for achieving the above requirements.

From the viewpoint of partitioning and transmutation as well, the metallic fuel cycle technology has excellent advantages. The metallic fuel which has a standard composition of U-Pu-Zr incorporates very high content of the minor actinides (MA) homogeneously into itself and gives superior MA burning efficiency. In the pyrometallurgical reprocessing, no additional steps for MA recovery are needed contrary to the aqueous processes since it always accompanies the U-Pu product inevitably due to their similar thermodynamic properties.

CRIEPI started research and development on the pyrochemical processing and metallic fuel technologies at 1986 with domestic and international collaborations. Since 1994, CRIEPI and JAEA have jointly started studying the basics of actinide behaviours in molten salt and liquid metal systems, and expanded the joint study to carry out the integrated pyro-processing test and the metal fuel fabrication test for irradiation in JOYO reactor. The basic feasibility of pyrometallurgical reprocessing, such as the recovery of uranium and transuranium elements by electrorefining, has already been confirmed. Since 2009, an engineering-scale fuel cycle test as a project entrusted by Japanese government is in progress to obtain the data required for design of pyro-processing equipment for practical use. In the joint study between CRIEPI and JRC-ITU, the irradiation integrity of MA containing metal fuels up to 10 at.%BU and the recovery of MAs from both irradiated metal fuels and spent MOX fuels have been demonstrated.

Regarding the pyrochemical technology, additional advantage lies in its flexibility to accept the other type of fuels, such as oxides and nitrides. Conventional UO_2 and MOX fuels can be supplied to the pyrometallurgical treatment after reduction to metals by adoption of the electrochemical reduction technique. In the joint study with JRC-ITU, it has been demonstrated that the irradiated MOX fuels can be successfully reduced to metals by this method. After this technological achievement and the adaptability to diverse materials of various physical/chemical properties, the pyro-processing is currently under preliminary evaluation for its applicability to the treatment of the corium, mainly consisting of $(U,Zr)O_2$, formed during the accident of the Fukushima Dai-ichi nuclear power plant.