The DUPIC Alternative for Backend Fuel Cycle

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1. Background

The proliferation risk in backend fuel cycle has long been a topic of polemics as was culminated by the International Nuclear Fuel Cycle Evaluation (INFCE) under the auspice of IAEA. The INFCE was addressed to systematic identification of diversion problems and to recommendation of possible measures to mitigate them.

Today, decades after the INFCE, the nuclear energy industry is confronted with stark reality represented by sluggish market and public opposition (especially to radwaste sites) in addition to the continuing concern to proliferation risks. Among these factors, the issue of proliferation risk is a priority consideration all along the backend fuel cycle. Looking back to the INFCE era, there has not been significant enhancement for proliferation resistance in backend fuel cycle technologies. The concept of denaturing fissile material to render it radioactive, as suggested at the time of INFCE, has never been materialized up to now.

2. The DUPIC Technology

From the early nineties, a research programme, called DUPIC (Direct Use of Spent PWR Fuel in CANDU) has been being undertaken in an international exercise involving Korea, Canada, the U.S. and later the IAEA. The basic idea of this fuel cycle alternative is that the spent fuel from LWR contains enough fissile remnant to be burnt again in CANDUs thanks to its excellent neutron economy. A systematic R&D plan has now gained a full momentum to verify experimentally the DUPIC fuel cycle concept.

- Compatibility with Existing CANDU System

  A basic premise that should be considered for a realistic fuel cycle today is the compatibility with existing power reactors, rather than to invent new one. Thanks to the symmetric refuelling structure of CANDU core, no significant modification of the existing system is required. Reactor physics with DUPIC fuel in the CANDU is in analysis to look at safety and controllability of reactor systems.

- Feasibility of DUPIC Fuel Fabrication

To transform spent PWR fuel into CANDU-type fuel bundle, a dry process based on a process called OREOX, among others, is being tested as a reference (A similar process called AIROX had been studied, in the past U.S. efforts, with an aim to burn spent LWR fuel again in LWR, but by adding enriched uranium).

The overall process for DUPIC fuel fabrication is not much different from that of fresh CANDU fuel, but it must be performed in a hot cell facility requiring remote operation and maintenance as a new dimension in technological efforts and costs. This is just the penalty to the enhanced safeguardability of the radioactive process. This new direction, however, is convergent to the recent technical trend toward increasing automation in the manufacturing industry to reduce labor costs and risks.

- Safeguards

The DUPIC fuel fabrication is resistant to proliferation not only because it involves no separation of fissile material but also because the heavy shielding enclosing the radioactive process act as a barrier to diversion possibility. This is just the concept of "spent fuel standard" as authored by the National Academy of Science of the U.S. in the context of weapon plutonium disposition.

In the DUPIC program, systems for containment and surveillance are being developed to augment the safeguardability of DUPIC fuel fabrication. A recent outcome of this developmental efforts is an instrument that can measure fissile content in the spent fuel material with enhanced accuracy.

3. The DUPIC Alternative

The DUPIC alternative as a proliferation resistant fuel cycle concept offers a multiple benefits that are expectable from PWR-CANDU synergism in comparison with once-through option. Such benefits are maximized at a reactor a ratio between 3 PWRs and 1 CANDU (depending on burnup). At this optimal ratio, up to 30% saving in natural uranium possible. Another advantage, more significant in today's perspective, is the muliple reduction in spent fuel arising by removal of spent PWR fuel and by the doubling burnup in CANDU. Corollary to this quantity reduction, it was also revealed that there would be a "quality effect" of radiotoxicity reduction by DUPIC in the final disposal of spent fuel.

Regarding the DUPIC economics, a study in the DUPIC program has indicated that the DUPIC alternative can be competitive with once-through, as well as other recycle options taking the synergetic effects into account.

4. International DUPIC Link

The DUPIC fuel cycle concept is characterized by burning spent PWR fuel again in CANDU, without separating any fissile material, taking advantage of high neutron economy of heavy water reactors. It requires therefore a reactor mix PWR-CANDU, which Korea adopted coincidently. The possibility of DUPIC fuel linkage from LWR to HWR is not, however, limited to mixed reactor counties like Korea : it can be extended to countries of LWR or HWR by international cooperation if such linkage is agreed between the interested countries.

5. Conclusion

The DUPIC fuel cycle is an emerging alternative in fuel cycle backend for synergism between PWR and CANDU (and between LWR and HWR, in general). A conspicuous feature of the DUPIC fuel cycle concept is the proliferation resistance which is unique in its kind. The developmental efforts are now in full swing, under international cooperation frame, in anticipation of multiple benefits on national and international level.

Reference

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