INVITED

Feasibility and Deployment Strategy of Water Cooled Thorium Breeder Reactor

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It is well known that thermal breeder is possible to design if thorium is used as its fuel. While it is theoretically correct, thermal spectrum is not necessarily the most suitable to achieve breeding and high burn-up simultaneous slyeven for thorium fuel. Obtaining breeding ratio slightly greater than unity is inevitable for sustaining thorium fission system and also high burn-up is essential requirement for the economy of nuclear power generation.

The author have studied water cooled thorium breeder reactor based on matured pressurized water reactor (PWR) plant technology for several years. Through these studies it is concluded that reduced moderated core by arranging fuel pins in a triangular tight lattice array with heavy water coolant in the primary loop by replacing original light water is appropriate for achieving sufficient breeding performance as sustainable fission system and high enough burn-up as an economical power plant.

One optimum core for instance that produces 3500MW thermal output using Th-^{233}U oxide fuel shows a breeding ratio of 1.07 and averaged burn-up of about 80 GWd/t with a long cycle length of about 1300 days. The key design parameter to make these performances possible is the moderator to fuel volume ratio (MFR). Figure 1 showsthe relation between neutronic performances and design parameters such as MFR and U-233 enrichment. The optimum MFR is found to be around 0.6-0.4 that corresponds to 2.3-1.5mm of pin gap. The required enrichment of ^{233}U for the fresh fuel is about 7wt% and total heavy metal inventory is about 200tons.

The design of all fuel assemblies are identical and all fuel pellets have single enrichment. No blanket assemblies are required. These fuel features of this breeder simplify its fuel fabrication process and recycling technology. The Doppler coefficient and coolant reactivity coefficient are negative during all cycles and in all location in the core despite it being a large scale breeder reactor.

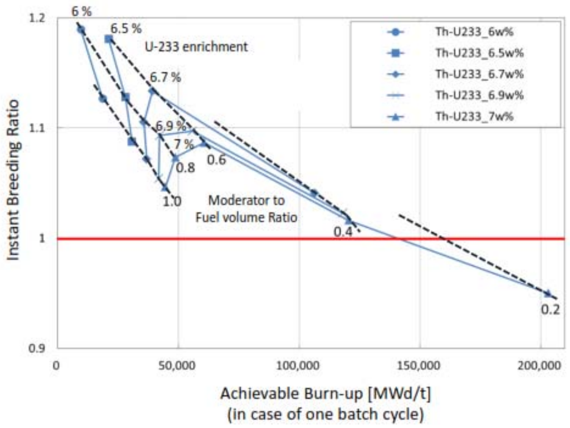

Figure 1 Fuel design and breeding/burn-up performances of heavy water cooled thorium breeder

As a strategy to deploy this sustainable thorium reactor, three-step deployment scenario is proposed as drawn in Fig. 2

The heavy water cooled thorium reactor is feasible to be introduced by using Pu recovered from spent fuel of LWR, keeping continuity with current LWR infrastructure. This thorium reactor can be operated as sustainable energy supplier and also MA transmuter to realize future society with less long-lived nuclear waste.

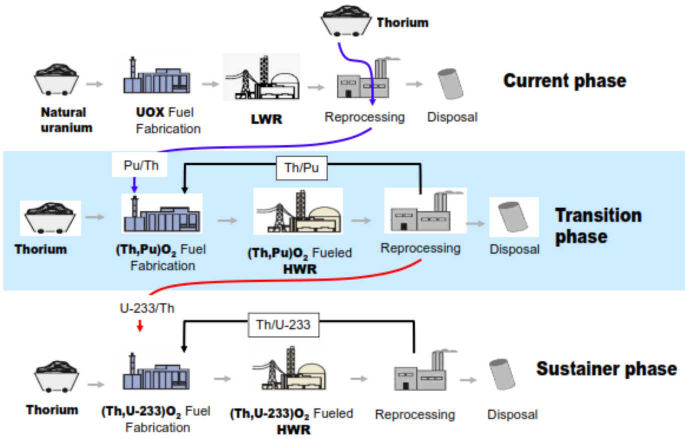

Fig. 2 Strategy to introduce sustainable thorium reactor keeping continuity with today's LWR cycle

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Dr. Naoyuki Takaki has been now working as a professor of the Nuclear Safety Engineering Department at Tokyo City University since 2012.

After joining to TEPCO in 1992, he had mainly served in Nuclear Research and Development Center and head office to develop commercial fast breeder reactor for 16 years, including 4 years of experience as a visiting associate professor at Tokyo Institute of Technology. In 2008 he resigned TEPCO and was transferred to Tokai University.

His major interest includes advanced reactor design, thorium fuel cycle, nuclear transmutation, decommissioning of damaged core etc.