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Tritium Export Preparation for ITER Operation & Fusion Applications

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1. Introduction

Tritium used in ITER (International Thermonuclear Experimental Reactor) will be supplied by external sources.

In the present study, we are proposing to try to export the tritium from WTRF (Wolsong Tritium Removal Facility) for ITER operation, fusion and other applications. In Korea, tritium is being treated as a kind of waste to manage for disposal by TRF. But, Canada is doing business with tritium by removing from CANDU reactors and exporting to foreign countries. So, if we have TRF near future, we can develop the related technology to cover this field.

2. Methods and Results

2.1 WTRF

Liquid phase catalytic exchange (LPCE) has been known as an effective process for removal of tritium from tritiated heavy water in heavy water reactors. The platinum catalyst supported on a hydrophobic styrene divinylbenzene copolymer (SDBC) and the LPCE column has been developed to be applicable to the Wolsong tritium removal facility (WTRF) in Korea. The catalytic performance test has been carried out with a recycle reactor of short catalyst packed columns. The catalytic rate constants were measured at 60°C and 80 °C and various gas velocities and were used in the WTRF LPCE column design.

The overall WTRF design has been based on the various contractor's (AECL, KEPRI, Kinectrics, etc) experiences with heavy water detritiation and tritium handling technologies developed and proven over the past decades. The facility was designed to treat 100kg of tritiated heavy water per hour, and removal of 97% of the tritium per pass from moderator and heat transport heavy water meeting the specification below 10Ci/kg. The recovered tritium will be immobilized as a metal hydride to secure its long term storage at equal to or greater than 99% tritium. The tritium removal process using the Korean hydrophobic platinum catalyst and cryogenic distillation process was made up of the main four steps of separation, purification, concentration, storage for the heavy water and deuterium. The tritium removed from the detritiation process is reacted with titanium metal at room temperature, to from a stable metal tritide.

2.2 Tritium for applications

Right now, only Canada can supply large amount of civilian tritium, and around or over 20 kg is available from Canada. For the fusion energy production of 1000 MW including alpha heat for a year, we need 55.8 kg of tritium. This is a huge amount of tritium considering the available tritium in our hands now. Furthermore, fusion has never bred tritium up to now. ITER startup tritium inventory is estimated to be around 3 kg, and the DEMO startup tritium inventory is likely to be between 4-10 kg. Fig. 1 shows the worldwide tritium inventories without fusion, with ITER-FEAT and with 1000 MW fusion by 10% availability and no tritium breeding. Availability of external tritium supply for continued fusion development beyond ITER first phase is an issue. Large power D-T facilities must breed their own tritium. This is why ITER's extended phase was planned to include the installation of a tritium breeding blanket. Blanket development and ITER-TBM are necessary in the near term to allow continued development of D-T fusion.

Wolsong Tritium Removal Facility (WTRF) is now under construction to remove the tritium from heavy water at CANDU reactors in Korea. That means that more than 10 kg of tritium from Korea is available additionally. WTRF will start its operation at the end of this year. Additional Korean tritium supply can be a marginal source to the startup inventories and the consumption in ITER and DEMO. Korea is to deliver the tritium storage and delivery system to ITER and this can be very good opportunity to take advantage of Korean tritium supply.

The achievable tritium breeding ratio should be somewhat larger than the required tritium breeding ratio. The achievable tritium breeding ratio is a function of technology, material and physics. Most of our works on Korean fusion energy development path should be focused on increasing the achievable tritium breeding ratio by the developments of technology, material and physics. The required tritium breeding ratio is 1+G, where G is the margin required to account for tritium losses, radioactive decay, tritium inventory in plant components, and supply inventory for start-up of other plants.

Physics and technology R&D needs to assess the potential for achieving "Tritium Self-Sufficiency". So, we are going to establish the conditions governing the scientific feasibility of the D-T cycle, i.e., determine the "phase-space" of plasma, nuclear, material, and technological conditions in which tritium self-sufficiency can be attained. And, we need to develop and test FW/Blankets/PFC that can operate in the integrated fusion environment under reactor-relevant conditions. The ITER Test Blanket Module (TBM) is essential for experimental verification of several principles necessary for assessing tritium self-sufficiency. R&D on FW/Blanket/PFC and Tritium Processing Systems should be done by minimizing Tritium inventory in components, much faster tritium processing system, particularly processing of the plasma exhaust, and improving reliability of tritium-producing (blanket) and tritium processing systems. TBR means tritium breeding ratio. The R&D on physics concepts should be added to improve the tritium fractional burn-up in the plasma.

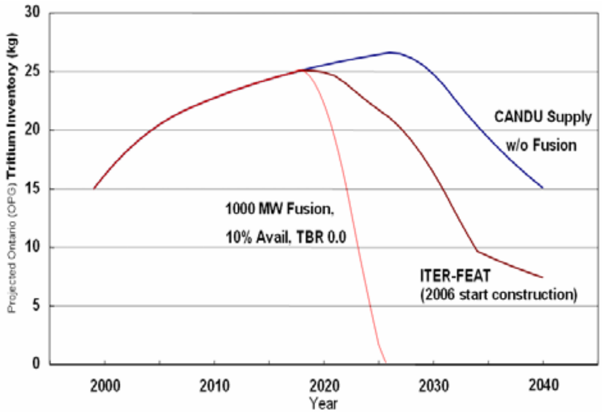

Figure 1. World Tritium Supply Would be Exhausted by 2025, if ITER were to Run at 1000 MW at 10% Availability

Although KHNP has not yet decided to use the pure tritium for any other purpose, we expect to take advantage in the permanent energy development like fusion reactor or other commercials in the future. The self-luminous glass tube (SLGT) mass production was attempted using a laser technology. Manufacturing process of the SLGT utilizing tritium gas and design of tritium handling facilities have been developed to minimize the technical staff's exposure by tritium uptake and the emission of tritium to the environment.

Actually, tritium is a kind of waste to be handled with care and technology, so we should develop related technology for tritium handling. Basically, we are selling the technology not the material "tritium" itself. But, before that we should define and prepare for all the required legal, strategic and political approaches to come up with tritium itself and its technology.

3. Conclusion

Wolsong Tritium Removal Facility (WTRF) is now under construction to remove the tritium from heavy water at CANDU reactors in Korea. Three major technical issues for WTRF were discussed as liquid phase catalytic exchange (LPCE), cryogenic distillation, and metal hydride storage. WTRF is to start its operation from the end of 2006. It may remove(produce) about 3.5 kg/yr of tritium for the first two years, and the tritium levels in the moderators will be steadily reduced and saturated. At saturated state, 0.6-0.7 kg of tritium per year can be produced from WTRF. It depends on the TRF operation itself. Additionally, the tritium consumption by nuclear fusion was discussed from ITER operation.

For ITER construction, Korea would deliver the tritium storage and delivery system based on ZrCo storage material. Required R&D activities have been initiated and we hope that the large amount of tritium from WTRF can be utilized for fusion research and other areas.

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