R&D of Tritium Technology as SHI

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Sumitomo Heavy Industries (SHI) participated in an R&D programme on tritium processing for the first time in 1967 by joining the advanced thermal reactor project. (The thermal reactor is cooled by light water and moderated by heavy water.) From that time SHI has developed various kind of tritium handling technologies. On the basis of cooperation with Sulzer (Sulzer Chemtech Ltd. Switzerland), SHI developed a system for removing waste water for fuel reprocessing plants by water distillation technology. In the field of fusion technology, SHI has developed a hydrogen isotope separation system by cryogenic distillation and thermal diffusion methods, and a tritium storage bed. Fundamental data required for the system design were obtained through the production and operation of the above prototype systems. Recently, SHI has also been taking part in the design and planning of ITER. In the future, along with ITER design, SHI will aim at developing tritium measuring technology.

1.Introduction

In 1967 SHI joined in the advanced thermal reactor project . (The thermal reactor named as "FUGEN" is cooled by light water and moderated by heavy water.) In this project SHI experienced various kinds of tritium handling technologies. The large scale R&D for this technology was carried out through cooperation with Sulzer Chemtech Ltd. of Switzerland on the tritium removal technology for fuel reprocessing plants. In this R&D the Water Distillation technology which was developed by Sulzer was applied and modified.

SHI has developed a hydrogen isotope separation technology by cryogenic distillation which might be used for the fuel recovering process in fusion reactors and tritium extraction system in heavy water reactors. In this development we obtained various kinds of design data by using cryogenic distillation system experimental apparatus.

SHI originally developed a tritium storage material (LaNi3Mn2), which was installed in the tritium storage getter.

In the field of fusion technology SHI has contributed to the development of a tritium handling technology based on the above-mentioned technologies. For example, SHI participated in the construction of the Tritium Process Laboratory (TPL) by the Japan Atomic Energy Research Institute (JAERI) and delivered some experimental apparatus.

Now, SHI is undertaking a feasibility study on a tritium recovery system by water distillation for ITER.

This paper summarizes the tritium handling technologies possessed by SHI.

2.Hydrogen Isotope Separation

SHI has had the following experiences with hydrogen isotope separation.

2.1 Water Distillation

This technology was basically received from Sulzer and developed by SHI to be applied to waste water from the fuel reprocessing plant. The main distinctions of this technology are shown below.

- The system constitution is very simple because the treated material is just water (steam)

- The system operation can easily be made continuous and fully automatic because it is a distillation process system which uses established technology.
- Strict management is required for the environment and working area because tritium, which is the separation object, is a radioactive material. However, the operation pressure of this system is usually about 50-200 torr, so this system can easily prevent tritium from leaking into the environment and the safety of this system is very high.

The separation method must use a tower with many separation stages because the separation coefficient is small. But the tower can be made relatively small by using the packing for hydrogen isotope separation developed by Sulzer, which is fine (small HETP). The scale of the total system can thus be made comparatively small. The Sulzer packing configuration is shown in Figure 1.

We have produced large-size test apparatus for a separation system for D_2O/H_2O and obtained preliminary data for separation ability, system operation, etc.

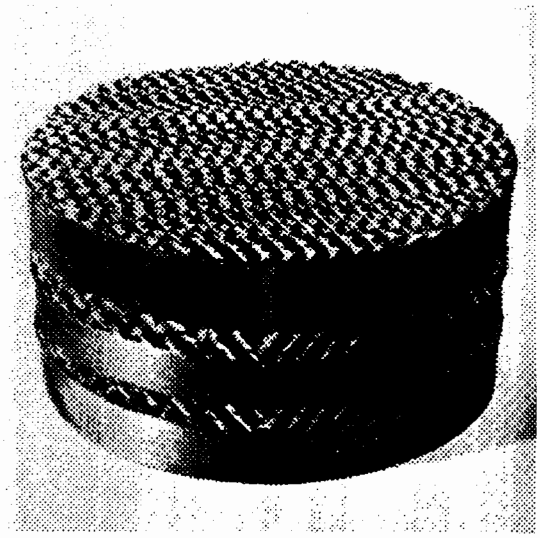

Figure 1 Configuration of Sulzer Packing

2.2 Cryogenic distillation

In the scope of application of fusion reactors to fuel recovering systems and heavy reactor tritium extraction systems, we are attempting to apply a cryogenic distillation technique to hydrogen isotope separation.

The basic design data for the device design was acquired through the experimental apparatus which was made by SHI. The specification for this apparatus and the operational conditions of this experiment are shown below [1].

Distillation Column:
~ 17mmI.D × 500 mmH
Packing: "Dicson ring"
Cold Box:
600/800 mm ϕ × 2100 mmH
Fluid: H_2, HD, D_2 gas
Operation Pressure:
900~1300 Torr
Operation Temperature:
21~25°K
Hydrogen isotope analysis:
Gas chromatography method
(Cryogenic cooled column + TCD)
carrier gas: neon

2.3 Thermal difusion (by using the column with water cooled wall)

Because of the small scale of operation and low energy efficiency, it has been considered unsuitable for the large-scale separation of hydrogen isotopes. However, the required inventory is small and the column construction is simple, and this method may be suitable for a tritium separation process on a relatively small scale.

From above point of view, a tritium separation technique was developed at SHI by the thermal diffusion method. Also a test system has been installed in TPL and we have obtained good results which demonstrates a successful application of the method to small-scale tritium separation[2]. The configuration of this equipment is shown in Figure 2. This equipment was installed in a globe box with a scale of 1500L × 1200W × 3000H (mm), and operated by remote control from the control panel which was outside of the globe box.

2.4 Thermal diffusion (by using the column with cryogenic wall)

It was pointed out that the separation coefficient was made larger when using the column with the cryogenic wall as compared to using the column with water cooled wall

[3]. SHI has actually manufactured the column with cryogenic wall and confirmed the above-mentioned increase of separation factor through experiments using this column . SHI also has the basic design data for the hydrogen isotope separation system using the thermal diffusion column with cryogenic wall.

An experimental apparatus was installed in TPL and research using tritium is currently underway[4]. The schematic view of this apparatus is shown in Figure 3.

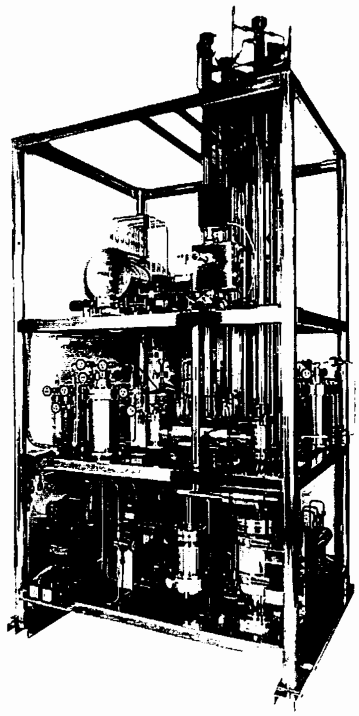

Figure 2 Experimental apparatus of the thermal diffusion process

3.The development of tritium storage material

Uranium is said to be used for tritium storage because of the following merits [5].

- larger storage capacity than other materials
- low equivalent pressure at room

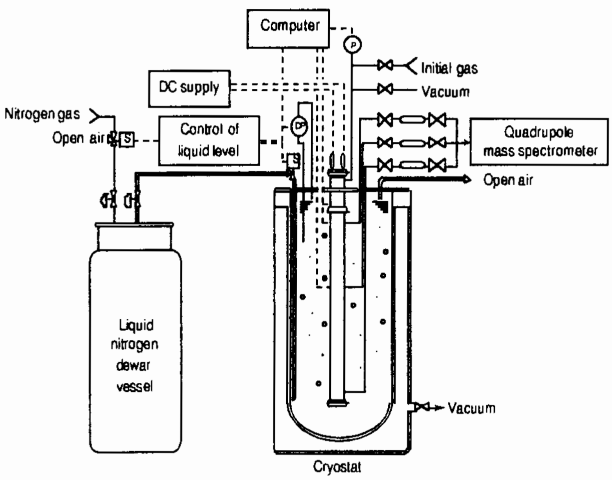

Figure 3 Schematic diagram of thermal diffusion column using cryogenic-wall

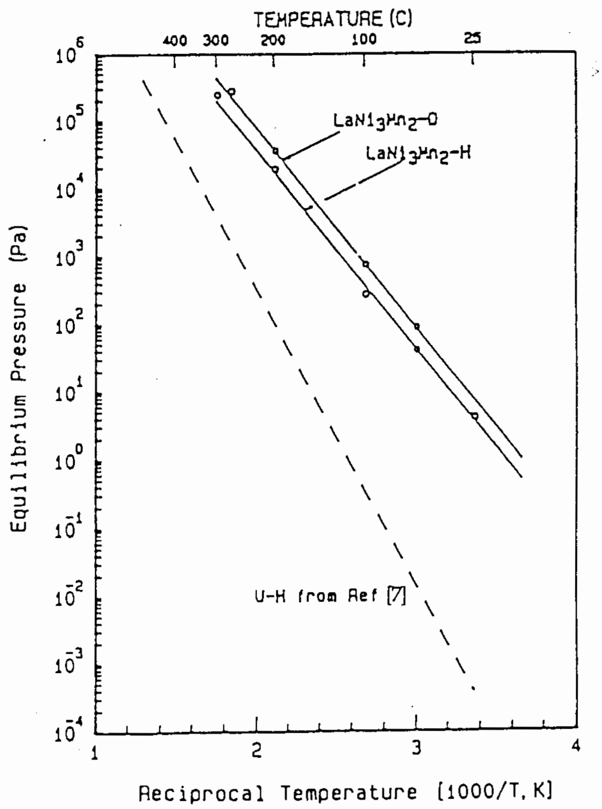

Figure 4 The temperature dependence of the equilibrium hydrogen pressure for the $LaNi_3Mn_2$ and uranium hydrides

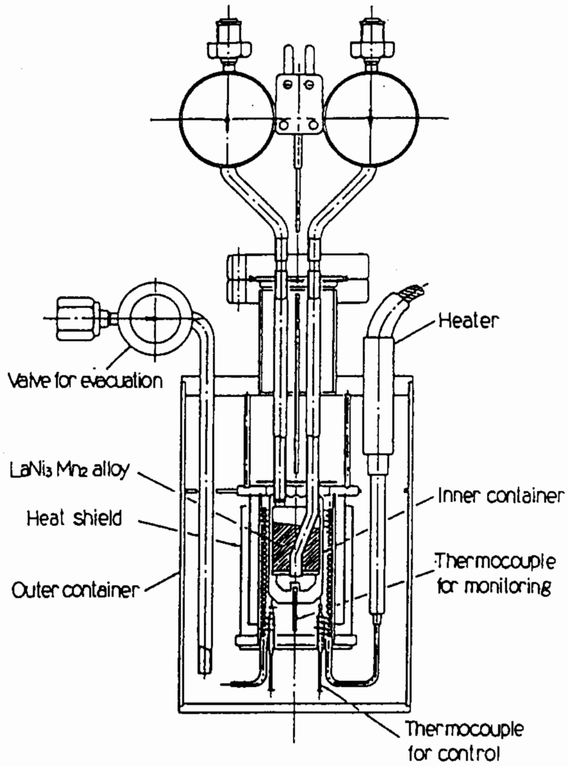

Figure 5 Cross-section of tritium storage getter

temperature

- high equivalent pressure at 300~400°C

On the other hand, much care should be taken during the treatment and management of uranium because of its radioactivity.

The development of a tritium storage material which is more suitable than uranium has been anticipated due to the treatment of a large quantity of tritium in the fuel processing of fusion reactor. SHI studied LaNi alloy as a candidate for a tritium storage material and developed a getter which used $LaNi_3Mn_2$ for tritium storage material[6]. Figure 4 shows the temperature dependence of the plateau pressure (van't Hof plot) for $LaNi_3Mn_2$ and an example of a tritium getter using this material is shown in Figure 5.

Although the equilibrium pressure at room temperature is slightly high for this getter material, the temperature at which it provides tritium is relatively low and the chance of tritium permeation is also low. Furthermore, as it is not radioactive like uranium, this material can be considered for use with experimental apparatus which handles small amounts of tritium.

4.The other tritium treatment technology

SHI has delivered various kinds experimental apparatus other than the above mentioned.

Some of these apparatus are stated below.

- Tritium storage system
  SHI assembled the apparatus using some uranium getters (manufactured by NUKEM of Germany) which was provided by JAERI, and delivered to TPL of JAERI. This system is capable of storing a large quantity (~ 30,000 Ci) of tritium at one time and provides it to other experimental apparatus as necessary.

- Tritium measuring system
  This system is an experimental apparatus for tritium measurement of fusion fuel processing, and it was delivered to TPL of JAERI. This system is designed to the measure of high-level tritium in the fueling systems of fusion reactors.
- Tritium target fabrication system
  This is an experimental apparatus for producing tritium targets for neutron beam sources which does not use tritium for the target material.
- Tritium gas handling system for muon catalyzed fusion experiments
  This apparatus is a gas handling system for the purification and mixing of the target gases (duterium and tritium gas) which is the target for muon beam in this experiment.
  This apparatus removes impurities by a Pd filter, separates isotopes by gas chromatography, and effectively performs batch handling of a relatively small quantity of gas within a limited inventory.

5.The study for ITER design

On the basis of above mentioned technology for hydrogen isotope separation, SHI has carried out the study of tritium recovery from the cooling water from first wall and divertor and the waste water. In this paper ,the summary of the system study at 1994 is shown as follows[8].

The tritium recovery process applied in this study is " Water distillation & VPCE (Vapor Phase Catalytic Exchange)" and the study was carried out on the following condition.

- Feed condition
  - (Cooling water)
    - Flow rate : 100kg/h
    - Tritium concentration : 10Ci/kg
  - (Waste water)
    - Flow rate : 20kg/h
    - Tritium concentration : 0.1Ci/kg
- Product condition
  - (Cooling water)
    - Flow rate : 100kg/h
    - Tritium concentration : 0.46Ci/kg
  - (Waste water)
    - Flow rate : 20kg/h
    - Tritium concentration : 1.0E-10 (mole fraction)

The result of the study on the above design condition and the schematic flow is shown in Figure 6 and the specification of the distillation column which is the main equipment of this system is shown as follows.

- Column Number : 3
- Type of Column : Regular Packing Column
- Packing : Sumitomo-Sulzer Packing CY-Type
- Inside Dia. of Column
  - Column 1-1 : 1.2m
  - Column 1-2 : 1.2m
  - Column 2 : 0.65m
- Height of Column
  - Column 1-1 : 29m
  - Column 1-2 : 29m
  - Column 2 : 48m

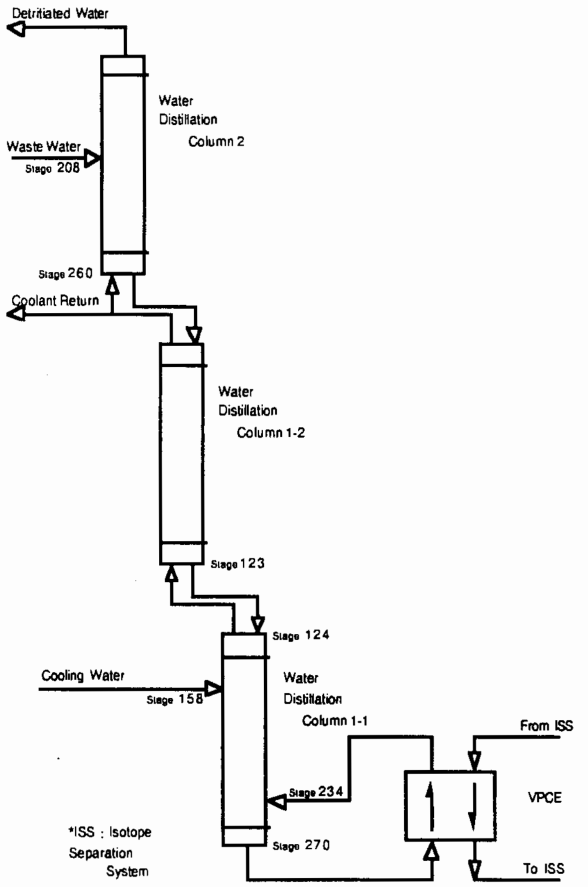

Figure 6 Schematic flow of tritium recovery process

The tritium inventory of this system was estimated as about 2.15E+5 Ci. The breakdown is shown as follows.

- Water Distillation system
  - Column 1-1&1-2 1.5E+5 Ci
  - Column 2 6.4E+1 Ci
  - Reboiler 1.2E+3 Ci
  - Other Equipments and Piping 3.6E+4 Ci
- VPCE
  - Evaporator 2.6E+4 Ci
  - Super Heater 1.8E+2 Ci
  - Other Equipment and Piping 1.5E+3 Ci

6.The development on fusion technology in future

In the field of fusion technology, the development of tritium handling technology will be continued on the basis of the technology held by SHI. Particularly, SHI will make an effort to develop the following.

· On the ITER design, SHI continues to study tritium recovery from cooling water and waste water on the basis of the above-mentioned isotope separation technology.

· SHI aims to develop new technology for tritium measurement-management.

7.Summary

SHI possesses various kinds of tritium handling technology. The main technologies of these developments are Hydrogen Isotope Separation and the development of tritium storage material. Hydrogen Isotope Separation technologies are the water distillation, cryogenic distillation and thermal diffusion methods. On the other hand, SHI developed LaNi alloy as a tritium storage material.

On the basis of these technologies, SHI is undertaking research and development of a tritium recovery system for ITER design.

In the field of fusion technology, the development of tritium handling technology will be continue in future. Particularly, SHI will make an effort to study ITER design and to develop new technology for tritium measurement.

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