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Conceptual Design of Tritium Extraction System

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ABSTRACT:

The first generation of fusion reactors will use deuterium and tritium as fuel. Since tritium is not available in nature, it must be produced in the fusion reactor blanket which surrounds the plasma zone. Tritium extraction facility has been designed and fabricated. Calibration procedure has been performed to determine tritium losses, if any during the extraction. Lithium compounds were irradiated using Am-Be neutron source. Out of pile extraction from neutron irradiated lithium compounds was carried out by flushing the samples with helium plus 0.1 % hydrogen as a carrier gas in the temperature range 450°C to 900°C. Tritium losses will have been estimated. Extracted tritium activity will be measured by commercially available liquid scintillation counter.

Key words: Tritium, Out of pile extraction, Liquid scintillation counter

1. Introduction:

Various lithium containing ceramics are investigated as tritium breeding materials for fusion reactors. The main material requirements for a breeder blanket are:

a high tritium production rate which can be achieved by material with a high lithium density

a high tritium release rate to limit the inventory and high mechanical, chemical and irradiation stability, also up to high burn up.

These requirements are the guidelines for the experiments. The tritium extraction facility was developed for the purpose of measuring absolute tritium activities in neutron irradiated metallic lithium samples. This research paper includes calibration procedure and the conceptual designing for tritium extraction system.

2. Tritium extraction from the ceramic breeder material:

Breeder materials can be distinguished in two classes, Solids and liquids. Liquid breeders are essentially the alloy Pb-17Li (Pb with 17 at%Li,melting point 235°C) and pure Li(melting point 177°C).As solid breeder materials, different types of lithiated ceramics are utilized. Examples are $LiAlO_2$,Li_2SiO_3,Li_2O,Li_2ZrO_3,$Li_6Zr_2O_7$,Li_8ZrO_6 with different micro-structures and product shapes.

The T extraction from solid breeder and liquid metals lead to a process stream of purge gas from where the T must be recovered. Therefore, the blanket specific tritium extraction system (TES) is an essential part of the fuel cycle of a fusion power plant.

2.1 Tritium Extraction from Li:

Blankets using Li are usually of the self cooled type and use V-alloys as structural material. The tritium solubility in Li is very high. Therefore, the tritium pressure over Li is very low, with a reasonable T concentration in the Li.The typical design goal for the T recovery system is to limit the T concentration in the Li to approximate 1 appm.

The best developed T recovery process is the molten salt extraction method.The LiT will dissolve in a mixed molten salt.The tritium dissolved in the molten salt can be recovered by electrolysis.The molten salt used for T recovery will be dissolved in the Li and carried back to the blanket.The effect of the molten salt in the Li to the corrosion of the structural material is a concern.

2.2 Tritium Extraction From Ceramics:

Blanket concepts using lithiated ceramics as a breeder material are now being developed mainly in Europe and Japan. The specific issues for T extraction are purge gas compassion (effect of hydrogen, water or oxygen addition), T permeation into the coolant,ceramic breeder specification and the purge gas pressure drop evolution in the pebble bed due to possible disintegration of pebbles irradiated to high dpa and Li burn up.

T extraction from ceramic breeder blenkets is necessary for the self sufficiency fuel of the reactor ITER.(International Thermonuclear Experimental Reactor).So tritium extraction facility has to be developed.

In this paper conceptual designing for tritium extraction system is shown to extract tne tritium from the ceramic compound.

3.Conceptual design of Tritium Extraction System:

Tritium is extracted from irradiated lithium samples by isotopic dilution method using normal hydrogen as a carrier gas. The extraction apparatus is illustrated in figure.

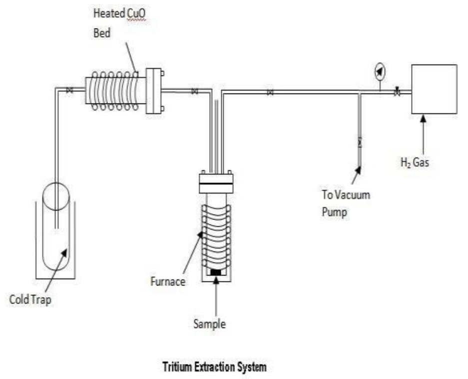

Fig.3.1 Extraction system design

After placing the sample (irradiated Lithium compound) in the furnace, the system is evacuated and valved off. About 1 atm of ultra pure hydrogen is added to the furnace. The furnace is heated causing the lithium can to melt,LiH to form,to melt, and then to dissociate as the furnace temperature rises above 850^{o}C.Using a valve to control flow rates, the hydrogen – tritium mixture is allowed to slowly pass over a hot (around 750^{o}C) bed of freshly activated CuO.Steam (HTO+H_2O) from CuO bed is collected as ice in a flask maintained at liquid nitrogen temperature. So we can get vapor form of tritiated water in the flask and when it is cooled by liquid nitrogen it is converted into liquid form (tritiated water).Hydrogen still remaining in the reservoir serves as a carrier to sweep out the last traces of tritium from the system. When all the hydrogen has been converted to ice the run is terminated.

4.Acknoledgement:

I would like to thank the members of Instititute for Plasma Research,who had helped me a lot in the fabrication of the assembly.

5. Conclusion

By the extraction system we can extract out the tritium which is produced by irradiation in the sample.

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