Contribution ID: **25** Type: **Contributed Poster**

A Proposed Cryogenic Solution for Direct Internal Recycling

Wednesday, 12 October 2022 14:50 (20 minutes)

Future deuterium-tritium fueled fusion power plants must breed tritium and sustain a burning plasma using a semi-closed loop fuel cycle. The DT fusion fuel cycle is an important aspect of any fusion energy configuration whose purpose is to provide fuel to the plasma, pump and separate plasma exhaust products, and recover fuel from breeding and plasma exhaust products. The current method of separation requires a large building for palladium membranes, cryogenic distillation columns, and other separation equipment. The hydrogen isotope separation method utilized by ITER is time consuming which results in a large tritium inventory in the tritium plant. A 2 GW fusion power plant utilizing the same technology will result in a tritium inventory of ˜4 kg, four times the inventory required for ITER. Scaling a fusion power reactor tritium plant using ITER technology represents an enormous hurdle in tritium inventory required, and solutions to reduce the size and cost of such a system are essential. The concept of directly recirculating the exhaust gas to make fuel pellets was proposed in the 1990s and later termed Direct Internal Recycling (DIR). In this approach the residual fusion fuel in the plasma exhaust stream is separated locally and diverted directly to the fueling systems, bypassing the isotope separation and other processing equipment, and therefore significantly reducing the required size of the tritium plant and resulting plant tritium inventory.

A concept for DIR uses a series of cryogenic pumps to separate the impurities from the machine exhaust gas by utilizing the different triple point temperatures of exhaust constituents. In this concept, the plasma exhaust is initially passed through an impurity trap operating at ˜25-30 K to desublimate impurities such as hydrocarbons, argon, oxygen, and nitrogen. The resulting process stream will consist of deuterium, tritium, helium, and neon (if present). The process stream is then pumped by a continuous cryopump known as a "snail pump". This pump is a steady state continuous cryopump that desubliminates all remaining exhaust gas constituents while allowing helium, a byproduct of the D-T fusion reaction, to pass through. The helium is pumped to the tritium plant for processing while the desublimated material is continuously scraped off, heated up, and diverted to a neon separator (if needed) before transport to the fueling system. This neon separator cryopump will operate in a carefully controlled regime to preferentially pump the neon while the deuterium and tritium pass through. The resulting DT exhaust is then sent to a pump/compressor system and used to supply DT gas directly to the pellet fueling system. The ratio of DT in the resulting fuel stream will be monitored to allow for makeup material to be added to the fuel stream to maintain the desired fuel ratio. This paper will outline the details of this proposed concept and the steps required for the development of this hardware.

Speaker's Affiliation

Oak Ridge National Laboratory

Member State or IGO

United States of America

Primary authors: Dr GEBHART, Trey (Oak Ridge National Laboratory); BAYLOR, Larry (Oak Ridge National Laboratory); MEITNER, Steven (Oak Ridge National Laboratory)

Presenter: Dr GEBHART, Trey (Oak Ridge National Laboratory)

Session Classification: Posters

Track Classification: Interface btw Plasma Physics & Fuel Cycle Technology