Contribution ID: **117** Type: **Poster**

Single Pass RF Driver (SPRFD) Chamber Considerations

Thursday, 16 August 2012 14:35 (2h 40m)

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The primary functions of a chamber are fivefold: maintain vacuum integrity, contain the heat exchange working fluid, provide entry ports for beams, coolant and fuel pellet, provide structural containment and additional neutron shielding, and finally it must contain and facilitate extraction of the tritium produced during the reaction of neutrons with the working fluid. Each functions comes with constraints and the sum of these constraints that makes up the specifications for the chamber.

We have placed neutron moderation and beam access as the first and second conditions for without them there is no fusion reaction and the rest of the chamber function is meaningless. The SPRFD system uses four beams that approach the target through a set of ports that are 180 degrees apart. The HILIFE II Reference Point Design (RPD) chamber confirmed that the minimum solid angle for four beams is about 5 degrees, a limit set by the steering and focusing magnet geometry outside the containment structure. The SPRFD calls for beam access is through two sets of four ports on opposite sides of the center of the chamber. The RFP design uses liquid jets of FLiBe to control the neutron flux from the igniting pellet. Our initial neutron control will be the natural lithium sabot that carries the fuel pellet into the chamber. This sabot has a 30 cm radius and has two holes that allow access for the four beams from each side. . The entire sabot and a substantial fraction of the lithium rain, and falling liquid sheets surrounding the sabot, will be vaporized as a result of ignition. We estimate that a minimum of 3.5 tons of lithium will be heated to more than 900 degrees during each ignition.

Cool <250oC lithium will be sprayed on the walls to create a liquid vortex coated wall to protect the central part of the chamber. Between this continuously coated wall and the hot plasma core will be many jets and sprays of liquid lithium, probably augmented by some cascading sheets of liquid. These liquid sheets, jets, and droplet spray will be the primary blast dampers as well as being the major heat exchange media. The vapor pressure of liquid 250oC lithium will bring the vacuum to 10-5 Torr in less than half a second leaving time to introduce the next pellet and sabot in time for the next shot. Each sabot assembly will be launched from a spinning holder about 12 meters above the chamber center and will be falling about 15 meters a second at the time of ignition.

Although direct extraction of energy from the plasma resulting from ignition would be desirable, this is not a process that is currently in practice. Thus our energy extraction will be via heat exchangers to a secondary working fluid thence to thermochemical processes and then steam to drive conventional turbines. The extraction of helium and all three isotopes of Hydrogen, will be a major effort at all times. The secondary working fluid will also have to be treated to prevent Tritium from being transferred to the steam generation system.

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Session Classification: Poster session