20141219-L4 student questions and their answers

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1. **We do not have ITER operating, and we do not have CFETR yet, so what can we do now in the area of thermal hydraulics?**

   Answer: I changed "dynamics" to "hydraulics", assuming that the question deals with the techniques in thermal hydraulics design of the blankets rather the physics of thermal dynamics. I think this is a good question and tough to answer.

   Let me further assume that we should first think about tritium self-sufficiency, it being of critical importance to the success of fusion energy.

   This narrows the answer down to the topic of thermal hydraulic designs that would effectively contain tritium within the blanket system, and minimize loss.

   As suggestion, how about developing, for a HCSB, a thermal hydraulic configuration that minimizes the loss of tritium from the blanket system, while still maximize tritium breeding and power conversion?

   Relevant questions would then include:

   1) How large is the surface area where tritium could permeate through the flow channels to get lost?
   2) How to add layers of helium flush in the blanket so that the escaped tritium could be collected immediately?

   It is anticipated that an implementation of these ideas would lead to substantial alterations to the internal configuration of the HCSB.

2. **We limit the heat flux to the divertor. Is this due to the technology limit or heat transfer limit?**

   Answer: Neither. Divertor is included initially to improve impurity control, with a surprise, a la, the discovery of H-mode that substantially improved plasma confinement, which is now included in the ITER and CFETR design. A divertor concentrates the plasma heat and particle fluxes toward a reduced material surface area, the so-called "divertor footprint", leading to designs that are framed by the limits in heat and particle handling.

3. **How does the ITER divertor come up with the final design?**

   Answer: To justice to this question requires a big and comprehensive answer. I would recommend looking at the paper: Pitts, et al, *J. Nucl. Mat.* **438** (2013) S48, and the references therein.

   In a nutshell, the design walks a fine line between the demands of the plasma confinement and impurity control, and the material limits of heat and particle handling. A key risk factor form this to ITER performance would therefore be in the actual heat and particle fluxes that the design can handle under the fusion nuclear conditions of ITER operation for the first time.

4. **What's your opinion about the method that uses liquid metal to reduce damage to the plasma facing components such as the divertor?**

   Answer: It is apparently useful for some present-day experiments of limited plasma pulse lengths in H and D plasmas. In my opinion, it is handicapped by the strong tendency of lithium to combine with hydrogenic ions into a compound that is stable over a wide temperature range (up to ~1200^{o}K).

5. **What's the divertors' behavior of the JET and TFTR when they are running in D-T mode?**

   Answer: This must be a good question, since there appear to be very few papers on JET divertor conditions during D-T operation. I would recommend: T. Loarer *et al, Nucl. Fusion* **47** (2007) 1112. There were only a limited number of D-T pulses on JET, relative to all the pulses carried out on JET. There are more papers addressing the trace tritium remaining in the plasma facing components (including the divertor plates).

6. **What can we use from ITER when we are designing CFETR? And what cannot?**

   Answer: These questions deserve comprehensive answers. I am handicapped in not knowing the up-to-date design considerations of CFETR in general. So let me punt on this question for now. Hopefully I will learn more about CFETR during the next semester to provide useful answers.