Liquid Breeder Option Outlook

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This session...

- Tritium extraction/control design and analysis for DCLL
  S. Willms
- Use of Nb or Ta alloys for permeator and HX applications in the DCLL TBM A Path to High Temperature Realization
  R. Kurtz
- Compatibility Issues and Report on Compatibility meeting, Comments on He-cooled FS/Li system
  D-K. Sze
- Remarks on Liquid Breeder Options
  S. Malang
- Discussion on US liquid breeder strategy

Is a change of direction warranted?
Recent History on Liquid Breeder TBM

- Evaluated various liquid breeder options since 2002 – Self-Cooled and Dual Coolant LM and Molten Salt
  - Self-cooled LM (Li, LiPb) required coatings or flow channel inserts and high velocity flow for FW cooling.
  - Li/V required accelerated vanadium development, prospect of coatings seemed questionable, lithium use with any water a significant hazard.
  - Separately cooled system seemed not attractive.

- Decision was to select DCLL as the primary option and DC Molten Salt as secondary option
  - DCLL represented a direct improvement of HCLL requiring only existing FS structural material and not large extrapolation of SiC composite technology.
  - Leverage of large EU program in HCLL including tritium issues, FS compatibility.
  - More interest from other international ITER parties: China, EU.
  - Molten salt issues were not well known, “Better the devil you know…”

Malang will discuss this more.
What has changed? Why rethink this now?

- Interest in the lowest development cost liquid breeder option that makes sense
  - Situation with materials program and ITER basic machine budget crunch
- Re-introduction of the idea of helium-cooled ferritic steel with lithium breeder
  - Korea interested, some Japanese professors interested, US materials people interested, Russia?
- Research on DCLL getting into more detail regarding associated issues
  - High temperature TE and HX
Helium Cooled Lithium (HCLi) Concept

- Similar to HCLL but with Lithium breeder
  - Entire blanket is Helium cooled
  - Heat generated in Li breeder conducts into He cooled stiffening plates
  - Li circulated as needed to remove tritium
- Tritium permeation is not expected to be a problem
- Helium exit temperature limited by FS strength and Li/FS corrosion and structure and helium boundary layer dT to about ~500°C, needs to be evaluated
- Tritium removal from Li must be developed
- Amount of structure needed for heat transfer into He has not been evaluated, may be similar to HCLL
- Breeding potential and the need for multiplier has not been evaluated
<table>
<thead>
<tr>
<th>Pathway to advanced concept using SiC as structural material</th>
<th>Pathway to high temperature requires V + insulator, or AFS+corrosion barrier</th>
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<tbody>
<tr>
<td>No heat transfer area needed between breeder and helium – reduced structure</td>
<td>Large heat transfer area needed to maximize He outlet temp – more structure</td>
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<td>PbLi requires no multiplier</td>
<td>Additional structure requires multiplier?</td>
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<td>Tritium extraction and HX systems for PbLi at high temperature requires R&amp;D</td>
<td>Tritium extraction from Li requires R&amp;D</td>
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<td>Chemistry control (Po, Hg, etc.) and FS corrosion require R&amp;D – EU</td>
<td>Chemistry control of Li? FS corrosion limit ~550C</td>
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<td>MHD of PbLi coolant requires R&amp;D – US &amp; EU</td>
<td>Smaller MHD effects, depends on recirculation rate and heat transfer needs</td>
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<td>T permeation requires R&amp;D – EU &amp; US</td>
<td>No tritium permeation from Li is expected</td>
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<td>FCI must be developed – US + Partners</td>
<td>No FCI development required</td>
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My Opinion on Liquid Breeder Options

- The reasons for the selection of DCLL have not really changed.
- DCLL may still be the lowest cost liquid breeder option due to strong EU role in its development – various strategies exist with different development costs.
- DCLL has the most attractive potential for reactor deployment.
- Li breeder testing and development in ITER and DEMO may be very limited by water cooled divertor, shield or VV. The risk and cost is difficult to quantify.