HELIUM-COOLED SOLID BREEDER BLANKET FOR ITER

A. R. Raffray
M. A. Abdou

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HE-COOLED SOLID BREEDER BLANKET CONCEPT FOR ITER

Advantages

- It Can Meet all Absolute Requirements

- Substanial Safety Advantages
  - Inert helium gas and low activation Li_4SiO_4
  - Minimization of tritium leakage
  - Robustness in ability to withstand failure
  - Possibility of passive LOCA accommodation

- Large Design Margin, Flexibility for Power Variation
  - Large SB temperature window
  - Pressure virtually decoupled from temperature

- Reactor-Relevant Materials and Configuration
  - Reduces R&D requirement after ITER
  - Could also reduce the risk for DEMO

- Well-Studied Material and Configuration with Expanding Data Base

- Innovative, Practical Concept for Gap Thermal Conductance

HE-COOLED SOLID BREEDER BLANKET CONCEPT FOR ITER

ISSUES

1. The predictability of the gap conductance between clad and breeder. In the proposed concept, the mix of Be particles design is much more forgiving compared to earlier gas-filled gaps. Such a concept, however, needs to be verified experimentally, first in a simple laboratory experiment and then in a more prototypic environment where irradiation effects would be included.

2. Irradiation effects on solid breeder material properties, in particular those affecting the tritium transport. Note, however, that the estimated tritium inventory in the whole blanket is low (about 1.5g) and uncertainties of up to a factor of 100 can be tolerated.

3. Helium containment. Further effort is required for finding out the extent of the helium leakage problem, and, if required, for developing acceptable solutions.

4. Accurate prediction of the helium purge pressure drop through sphere-pac material is required in particular if the purge gas flow rate is increased for decay heat removal after a LOCA.

UCLA SOLID BREEDER ACTIVITIES

- Tritium Modeling
- SB Experimental Program
- ITER He-Cooled Solid Breeder
  Blanket Design
- He Purge Flow Analysis
- New Areas

SUMMARY

Fusion energy offers major potential advantages:

- Relatively cheap and abundant supply of fusion
- Final products of fusion reaction are not radioactive
- No chain reaction or possibility of melt down
- No need to transport radioactive substances

Issues include:

- Activated structural material - Research and Development required to develop low activation steel
- Considerable technological complexity - High cost
- Time frame is of the order of decades for fusion commercialization

Areas of Contribution to SB Experimental Program

1. Neutronics Calculations

    - Heat generation rate
    - Tritium production rate
    - Burn-up

2. Thermal-Hydraulics Calculations

    - Temperature profile

3. Tritium Calculations

    - Tritium inventory
    - Tritium release

4. Design Relevance

    - Suggestion on materials and configurations based on general design trends (e.g., ITER)

    - Parametric and sensitivity studies

5. Experimental Matrix

    - Suggestion for experimental transients (e.g., temperature, H_2 concentration in purge)

Some Specific Contributions to SB Experimental Program

- Overcheck BEATRIX-II Cycle 11 Neutronics Calculations

- BEATRIX-II Cycle 12 Material Suggestions

- BEATRIX-II Cycle 11 Operational Plan Recommendations

- BEATRIX-II Cycle 12 Calculations:

  Tritium Release, Neutronics, Thermal

- BEATRIX-III Experiment Definition and Scoping Calculations:

  Configuration, Parameters, Materials, Reactor Survey for maximizing fusion prototypical information

MAJOR CANDIDATE BLANKETS FOR FUSION REACTORS

LIQUID METAL BLANKETS (Li, LiPb)

Key Issues

1. MHD Effects
    A. Pressure Drop and Pressure Stresses
    B. Fluid Flow and Heat Transfer
2. Materials Interactions (Corrosion)
    A. Mass Transport
    B. Structural Properties Degradation
3. Tritium Control
    A. Tritium Extraction from the Breeder
    B. Tritium Transport in the Primary Cooling System
4. Irradiation Effects on Material Properties
5. Structural Response in the Fusion Environment
6. Failure Modes
7. DT Fuel Self-Sufficiency

SOLID BREEDER BLANKETS (Lithium Ceramics)

Key Issues

1. Breeder/multiplier tritium inventory and recovery
2. Tritium self-sufficiency
3. Breeder/multiplier/structure mechanical interactions
4. Structural response to environmental conditions
5. Corrosion and mass transfer
6. Tritium permeation and processing from blanket
7. Failure modes and reliability