APEX, Task IV Technical Task Proposal for FY2002 ($415k)

Part 1. MHD Experiment, $20k, Anderson (UW)

1. Continue the test of liquid metal void formation in the presence of varying magnetic field strength.
2. Assess the issue of critical heat flux.
3. Assess the issue of liquid metal carry-over for realistic superficial velocities.
4. Study the movement of bubbles or formation of gas channels with gas injection through a porous plate.

Part 2. SiC/SiC neutron fluence limit assessment, $45k

1. Investigate the lifetime of SiC/SiC plasma facing components and assess the possibility of reaching the design goal of 3% burnup (i.e. 1.5 atom% He and ~15 MW.a/m^2).
2. Modeling of the mechanical and thermal conductivity properties of the composite, Youngblood (PNNL), $15k, Shatoff (GA).
3. Modeling of fundamental properties under high neutron flucence, $10k, Ghoniem (UCLA), Sawan (UW).
4. Comparison between modeling and experimental results, L. Snead (ORNL), $20k, Majumdar (ANL).

Part 3. Investigation of the solid first wall and blanket design options, $350k

Task IV Part 3. Investigation of the solid first wall and blanket design options, $350k

Scope

Investigate key issues and develop a practical high performance design with FS-class including NCF as the structural material and Flibe/Flinabe as the breeder material.

Introduction

Since the early 1980s via the BCSS program and others, we have systematically evaluated what could be the best combination of structural, breeder and coolant materials. We have worked on different structural materials from FS, V-alloy, SiC/SiC to W-alloy, and with different combinations of solid and liquid breeder materials. It confirms again and again that an acceptable fusion power reactor can only be achieved with acceptable material combinations, in addition to the handling of unavoidable interactions with the plasma. We also recognize that in recent years the physics community has learned a lot in the areas of plasma interaction with the first wall and divertor materials and on the possibility of disruption detection and mitigation. However, in order to assure that we are going to have a robust design, we still need to have designs that can handle a few disruptions, which could be caused by events other than plasma instability. For the selection of structural and breeding materials for next two years we are driven by two recent observations: The first one is the community's desire to re-consider the FS-class of structural material including the recent introduction of Nanocomposite ferritic (NCF) alloy, and the second one is the use of Flibe or Flinabe as the breeding material. With this selection of materials, it would also enhance our opportunity of providing support to the nearer term DT machine while projecting what we will need for power reactors. These observations and materials selection then guided us to the selection of sub-tasks for next two years as stated in the following.

Milestones

1. Scope conceptual FW/blanket designs with the selected structural, coolant, and breeding material options. 6/02
2. Complete the reference design assessment. 6/03
3. Document design and critical issues. 9/03

APEX Task IV Solid Wall and Blanket Design
Sub-tasks and Budget

0. Coordination:
$50k Wong, (GA); $10k, Malang, (Consultant)

1. Structural Materials:
$10k, Mattas, (ANL); $30k + Materials program support, Material Engineer "TBD by Zinkle et al."(ORNL/UCSB)

- **Provide update and projection on material properties on FS and NCF alloys.**
- **Provide data and evaluation on compatibility between different materials.**
- **Evaluate fabrication methods and testing.**

2. Breeder/multiplier materials:
$0k, Task III and JUPITER-2 (UCSD/INEEL/ORNL/Task III)

- **Provide update and projection on material properties on Flibe and Flinabe.**
- **Provide data and evaluation on compatibility between different materials.**

This task will be performed in coordination with the APEX task III team.

3. FW/blanket design:

$20k Sviatoslavsky; $40k Corradini et al.,(UW); $35k Nelson, ORNL; $25k Wong, GA; $20k Majumdar, ANL (Total $140k)

- **Assess innovative designs to maximize the coolant outlet temperature while using the combination of FS, NCF and other materials. Provide CAD and engineering design support.**

4. Divertor:

$0k ALPS program, Mattas, (ANL), Nygren, (SNL), Wong, (GA)

- **Assess performance limits of advanced FS alloys**

5. Neutronics:

$40k Sawan, Khater, (UW); $20k Youssef, (UCLA)

- **Provide neutronics support to nuclear and thermal performance, material radiation damage, safety and waste disposal assessment, with possible additional assessment on the first wall plasma facing material design as described in task 8.**

6. Safety and safety design:

$30k Merrill, (INEEL)

- **Perform safety design and assessment with possible additional assessment on in-vessel tritium inventory and safety implications with plasma facing surface design as described in task 8.**

7. Power conversion:

$0k Task III, (UCSD/GA)

- **Focus on the possible utilization of the CCGT system with the relatively low Flibe outlet temperature (~700° C).**
- **Other high performance power conversion options should be evaluated when proposed.**

8. Plasma materials interaction:

$5k + supplement from DiMES, Wong, (GA)

- **Identify plasma facing material design/option that can last the lifetime of the FW/blanket/divertor module, while maintaining acceptable impurity ingress to the plasma. As examples, we could evaluate the options of W coated FW and/or multiple W/C or W/SiC-coated FW, which has been proposed to be tested at DIII-D.**

9. FS impacts on tokamak reactor:
$10k Wong, (GA)

- **Review the impacts of FS steel utilization on the plasma operation and plasma stability, while operating at the FW/blanket operating conditions. Report on available analytical and experimental results and status of modeling capability.**

10. Design with disruption detection and mitigation:
$5k Wong, (GA)

- **Review and report on the status of disruption detection and mitigation.**
- **Report on available analysis and design approaches.**
- **Assess disruption impacts on the first wall design.**

11. Systems:
$0k, Wong, (GA)

- **Provide a consistent set of parameters for the reference reactor design.**

Estimate of the effect of temperature on the ferromagnetic effect of FS

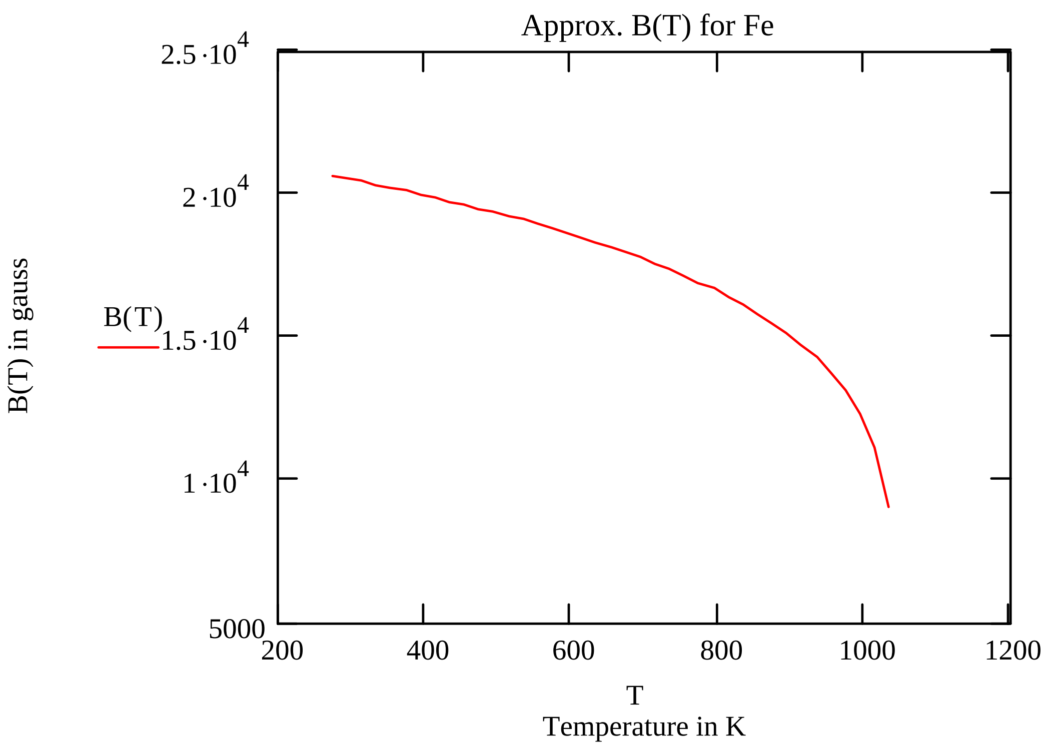
$$Tc := 1043$$

Critical temperature of Fe in K

$$T := 273, 293..\ 1273$$

$$B(T) := 1740 \cdot 4 \cdot \pi \cdot \left(1 - \frac{T}{Tc}\right)^{0.19}$$

Saturation magnetic induction B(T) in gauss T in K



$$B(0) = 2.187 \times 10^{4}$$

$$B(293) = 2.054 \times 10^{4}$$