APEX, Task IV Technical Task Proposal for FY2002

Part 1. MHD Experiment

This part is a continuation of the MHD boiling experiment at UW. With the operation of the magnetic field coil they will be able to investigate void formation and development in the liquid metal under the presence of the magnetic field. **Mark Anderson of UW will provide details of the proposed tasks for FY02.**

Part 2. Investigation of the solid first wall option

Introduction

We have been asked by Prof. Mohamed Abdou to recommend a technical plan for FY02, which is attached in the following. We have incorporated impressions expressed as early as last year by the team, recent comments and observations by S. Malang and M. Abdou.

After many expert-years of study, in the area of first wall and blanket design, we have been leading the world in the projection of what could be the performance of fusion power reactors. Since early 1980s via the BCSS program and others, we systematically evaluated what could be the best combination of structural, breeder and coolant materials. Off and on we evaluated the combination of FW/Blanket and divertor designs. It is through the systems study that the FW/Blanket, divertor and plasma interaction designs were evaluated. **We have worked on different structural materials from FS, V-alloy, SiC/SiC to W-alloy, and different combination 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 understanding of plasma physics.** Our task is to focus on the solid first wall option while the rest of the APEX tasks are to work on liquid wall option. **We should also recognize that in recent years we have learned a lot more on the area of plasma interaction with the first wall and divertor materials and on the possibility of disruption detection and mitigation. Correspondingly, we will have to come up with disruption tolerant design options.** We have the opportunity to balance the needs to make progress from what we have learned and **provide support to our nearer term DT machine while projecting what we need for power reactors**. **Two recent observations** are being pointed out in recent notes. **The first one is to review and use nearer term materials like FS**, which also has the advanced option of oxide **dispersion doped FS (ODFS), and NCF**. **The second is** the recognition on the potential advantages of **breeder material like Flibe**. There is also the desire on the evaluation of materials like metal matrix composite and bag configuration material options for advanced designs.

Based on the above observations, we would like to propose the following technical tasks for APEX-Task IV for FY2002.

The proposed approach is: Within the resources that we can gather we will advance the understanding on the design of high performance tokamak Solid-FW/Blanket/Divertor system, and identify critical issues related to the selected concept. (This goes without saying that we have assumed understanding on the performance needs in areas of performance, safety and economics.)

Technical task areas are listed in the following
(Possible responsible institutions are also noted)

1. **Structural Materials**: (ORNL/UCSB)

   Description: Provide necessary design data for the optimum utilization of **FS, ODFS and NCF** materials with the selected tritium breeding material.
   Comments: Task IV team members supported this selection.

2. **Breeder/multiplier materials**: (UCSD/INEEL/ORNL/task III)

   Description: Use **Flibe/Be** as the tritium breeder and neutron multiplier material.
   Comments: **This task will be evaluated in coordination with the APEX task III team.** Our approach is to evaluate the optimum application for this FS/Flibe material combination but not to treat this assessment as a comparative study with other more conventional tritium breeding materials. Relatively, Flinabe will need more Be for tritium breeding adequacy and will have afterheat and activation concerns with Na, even though it may have the benefit in lower vapor pressure, we will keep this material under the watch status.

3. **FW/blanket design**: (UW/Malang/GA/ANL/ORNL)

   Description: Perform configuration/maintenance/structural/thermal designs, aiming for high performance and simplicity.

   Comments: **Assess innovation designs to maximize the coolant outlet temperature while possibly using the combination of FS, ODFS, NCS and other materials.** The design approach could be similar to the ARIES-AT and ARIES-ST FW/blanket designs, but we will have to work on it. We will keep the more advanced/innovative concepts of material matrix composite and bag module concepts in the back burner for the time being.

4. **Divertor:** (SNL/UW/GA/UCSD)

   Description: Perform configuration/maintenance/structural/thermal designs, aiming for high performance and simplicity, in coordination with **credible steady state plasma operation scenarios, no Type-I ELMs.**

Comments: **This should be coordinated with the ALPS program**. At this time we will only work on the steady state burn equilibrium condition with the consideration of the **disruption scenario as noted in task 10.**

5. **Neutronics:** (UW/UCLA)

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

6. **Safety and safety design**: (INEEL/UW/Malang)

   Description: Perform safety design and assessment.
   Comments: **May need to add assessment on tritium in-vessel inventory and safety implications with different proposals on plasma facing surface design as described in task 8.**

7. **Power conversion:** (UCSD/GA)

   Description: **At least focus on the possible utilization of the CCGT** system with the relative low Flibe outlet temperature (~800 C). **Other high performance options should be evaluated when proposed.**
   Comments: Innovation will be needed in coordination with tasks 3 and 4.

8. **Plasma materials interaction:** (GA/ANL/SNL)

   Description: **Identify plasma facing material design/option that can last the lifetime of the FW/blanket/divertor module, can withstand a few disruptions, while keeping acceptable impurity ingress to the plasma.**
   Comments: With further assessment, **we could evaluate the multiple W/C or W/SiC-coatings concept**, which is being proposed to be tested at DIII-D.

9. **FS impacts on tokamak reactor:** (GA/PPPL/UT/ORNL/Malang)

   Description: **Estimate the impacts of FS steel utilization on plasma operation and plasma stability.**
   Comments: The ferromagnetic issues related to the use all FS design in a tokamak have been known since the identification of FS as the potential structural material. **To address the issues completely, we will need a project by itself. However, we should at least review what has been done analytically and experimentally and see if we can generate some approximated results within the experts and budget that we can find. The issues of FS impacts on plasma confinement and stability should be reviewed and potential pros and cons should be identified. We should also identify optimum maintenance schemes while satisfying the feedback current path requirements.**

10. **Design with disruption detection and mitigation**: (GA/ANL/UCSD)

    Description: **Review the status on disruption detection and mitigation. Evaluate design impacts from various schemes.**
    Comments: **Recent experimental success from DIII-D with fast/massive Ne injection to reduce the thermal and runaway electrons impacts from disruption encourages more experiments to be performed next year.** These experiments would then be able to provide some initial results on disruption detection and active feedback. Different scenarios can be included into our design evaluation and help us to evaluate the possibility of this combination with the multiple materials chamber wall coatings could then form an approach to improve the availability of the tokamak power reactor design.

11. **Systems:** (UCSD or GA)

    Description: **This task is to provide a consistent set of parameters for the reference reactor design.** It should also provide estimated power and heat flux distributions and the trade offs between wall erosion and plasma impurity balance and reactivity.
    Comments: **This should be a relative simple but necessary task.**

Additional observations

This is not a FW/blanket comparison study. We propose to focus on the optimization of the FS/Flibe option for the next period and this selection does not inhabit the Task IV team to investigate other solid wall /breeder/coolant options in the future.

We envision that this FS assessment to be a multi-years design and evaluation effort. Critical issues will be identified. Technical and program review will be performed annually based on direction from the APEX program. Attention will be paid to the evolution of present experimental devices to all FS FW/blanket designs.

This is an integrated assessment approach covering many tasks, we will also leverage other tasks and personnel to cover the technical work, but new tasks and personnel will also be introduced gradually…mostly on FS interaction with a tokamak device.