APEX

Introductory Remarks and Highlights of FY02 Plan

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Outline

- Key Points from FY01
- FY02 PLAN
  - Process - Thoughts behind strategy
  - Common Interest among Tasks
- Documentation (Papers & Reports)

Key Points from Effort Last Year (FY01)

- **The MFE Chamber Peer Review was conducted in April 2001**
  - We passed with very good grades
  - Thanks to everyone
- **On Liquid Walls**
  - Constructed two new facilities:

    M-TOR (toroidal magnetic facility) for LM MHD

    FLIHY for Free Surface Transport Phenomena
  - Both facilities are now operational and initial tests were performed.
  - Related Development: JUPITER-II was initiated. Facility to explore innovative techniques for enhancing heat transfer in low-conductivity fluids is completed.
  - Discovery of low-melting point, low-conductivity fluid (flinabe).

    This makes Low-Conductivity fluids strong competitors to liquid metals (this is reflected in our work plan for FY02).

Key Points from Effort Last Year (FY01)

- **On Liquid Walls (cont'd)**
  - Progress on Design Exploration
  - Better understanding of liquid wall flow issues and clearer assessment of the needs for model development and experiments.
  - SBIR Phase II Grant was awarded to HyPerComp to develop, in collaboration with UCLA, a 3-D MHD Free Surface Flow Code.
  - The First International Workshop on Free Surface Flow was held in Japan in May 2001. Strong participation from APEX.
  - A workshop was held October 11, 2001 in collaboration with HyPerComp to consult with renowned experts in fluid dynamics code development.
  - We worked hard to interact with world-renowned experts on fluid dynamics, free surface and MHD. There is considerable interest in the problems we are addressing for liquid walls.

Key Points from Effort Last Year (FY01) (continued)

- **Material Retreat at UC Santa Barbara, August 2001**

  - The Material and Chamber Communities will work together more closely.

  - In particular, the material community would identify a structural material that has the best potential to be available for construction of a fusion device in about 30 years.

  - The Material Community identified NCF (nano-composited ferritic steel)

    This material will be explored as a "reference structural material" in APEX for both solid walls (Task IV) and liquid walls (Task III). The material community will provide material properties. (Bob Odette as the key person)

  - The Material Community (Zinkle/Odette) will identify a "Material Engineer" who will serve as a liaison between Materials and Chamber and provide APEX with material properties and analysis.

Key Points from Effort Last Year (FY01) (continued)

- **Solid Walls**
  - Completed EVOLVE (report to document work is being finalized)
  - Evaluated SiC/LiPb concept (report expected)
  - "General Outcome":
    *EVOLVE is an attractive option, but Tungsten is a CHALLENGE that the Material Community is not enthusiastic about addressing.

    *Negative findings on SiC/LiPb; Difficulty in assessing SiC (state-of-the-art not advanced).
  - No further work in APEX on EVOLVE is warranted until, and unless, the Material Community initiates significant effort on tungsten (or any high-temperature refractory alloy). Documentation of SiC/LiPb will be completed with no new work planned.
  - A small experiment was started at UW to test void formation in Li in the presence of magnetic fields.

    This experiment for EVOLVE will be completed in early FY02 and no further effort is planned in this area.

FY02 PLAN

PROCESS

- Broad Guidelines and Technical Priorities were discussed with the Task Leaders.

  The Task Leaders were asked to develop detailed technical plans for their Tasks

- These plans were reviewed and discussed in an APEX Steering Committee conference call on October 10, 2001. Feedback was provided and the Task Leaders were asked to submit REVISED Technical Plans with recommendations for performers and level of effort.

  [We asked for names of scientists and their level of effort to be specified. It is not acceptable to specify only institutions without specific names of scientists/performers.]

- The Revised Plans and Resource Allocations were discussed among the individual groups for each task and then opened for comments from the Steering Committee.

- M. Abdou and M. Sawan extensively reviewed the plans for consistency with technical guidelines, resource allocation, missing information, etc.

  Important comments were conveyed and discussed with the Task Leaders. Most issues were resolved, with only a small number of issues remaining to be resolved this week:

  e.g. - specific technical work scope for one scientist

  - providing specific names for scientists and their level of effort in one organization

  - would LIMITS (at SNL) effort be charged to APEX or ALPS?

- We have a GOOD PLAN. We trust every APEX team member will give his/her best effort to make major contributions to the technical effort and make FY02 a big success.

Thoughts behind the FY02 Plan Strategy

Liquid Walls

The following points had a large impact on the development of the technical plan for FY02

1) 3-D MHD Modeling

- We made great progress on developing 2-D MHD codes. We utilized effectively the codes developed.
- However, **further progress on design and analysis of liquid walls requires a 3-D MHD Free-Surface Code**. This is equally true for the design of experiments in present plasma devices (Task I) and for design of liquid walls in future fusion facilities (Task III)

2) Discovery of Flinabe

- A low melting point (240 - 310 C) flinabe makes low-conductivity fluids a potentially competitive attractive option again. (We put the flibe work on hold a year ago.)
- Since MHD effects are not controlling, design of low-conductivity liquid walls can proceed without waiting for MHD effects.
- Many critical issues can be addressed for low-conductivity fluids (that are also relevant to liquid metals). These include: fluid flow in complex geometry, restraining forces, flow around penetrations, heat transfer at the free surface, pumping, nozzles, divertor integration options, etc.

Thoughts behind the FY02 Plan Strategy (cont'd)

Underlying Strategy for Liquid Wall Effort in FY02

Effective Parallel Effort

A - Develop 3-D MHD codes in Task II (in addition to continuing model development for low-conductivity free-surface flows) and conduct MHD experiments (and other low-? experiments).

B - Explore Designs and Engineering Issues for Flinabe in Task III. Tremendous progress can be made using tools developed last year (modified Flow 3-D, a number of free-surface fluid flow and heat transfer codes and data).

C - Devote most of Task I to MHD experiments (supporting Task II) while continuing to explore options and issues for testing in plasma experiments.

Note: UCLA initiated effort on "basic proof-of-principle" experiment for fluid flow (curved wall/water; look at restraining forces, flow around penetrations, etc.) Work by Mo Dagher with guidance from Task III.

Thoughts behind the FY02 Plan Strategy (cont'd)

Solid Walls

Key Points that influenced the strategy for FY02

1) **The agreement with the Material Community to use NFC as reference structural material with maximum operating temperature of 800C.**

   - This makes it possible to open the design window for flibe in solid wall designs.

2) **Flinabe with low melting point.**

   - This makes NFC/flinabe a potentially attractive solid wall design option

Underlying Strategy for Solid Wall Effort in FY02

Using NFC as a reference structural material, explore the most innovative solid wall designs. For FY02, limit breeder/coolant to only flibe and flinabe and compare both.

Common Interests between Tasks III and IV and also with JUPITER-II

- Advanced Ferritic (NFC) structural material is common to Task III (liquid walls) and Task IV (solid walls). Also, Flinabe is a common breeder/coolant.

  - *We should try to learn the benefits and flaws of adding liquid walls (1-2 cm Cliff-type) to a solid wall design. Tasks III and IV need to work together to give us insights into what such direct comparison reveals.*

- With Flibe and Flinabe in a solid wall design with advanced ferritic in Task IV there is a Direct Common Interest between APEX and JUPITER-II. Also, the work of Task-III is of interest to the Japanese (they want to explore Flinabe and they want to learn about liquid walls).

  - *This common interest will be mutually beneficial to APEX and JUPITER-II.*

Other Comments on Liquid Wall Tasks (I, II, III)

- A certain amount of knowledge and basic tools are required, whether we want to do experiments in plasma devices or explore a reactor design.
  - *This is particularly evident in the case of 3-D MHD Free Surface*
- It is INCORRECT to say that the lack of 3-D MHD will hinder progress on reactor design (Task III) but that progress can be made on design of a test module in a plasma device (Task I). Both need fundamental knowledge and basic tools that we have yet to develop.
  - *Task II modeling and experiments effort is CRITICAL for both Tasks I and III*
  - *Task III will not suffer from the lack of 3-D MHD in FY02 because Task III will focus on Flinabe.*
  - *Making progress on Task I in FY02 requires more thoughts and careful planning.*
    - * Shift to supporting MHD modeling and experiments effort of Task II?
    - * Consider a low-conductivity fluid for test module in plasma experiment?

This Meeting

- Report and discuss Technical Progress by Team Members.
- Task Leaders will present detailed technical plans.
  Comments and Discussion are Encouraged
- Town Meeting Wednesday evening jointly with ALPS.
- General Discussion Session planned for Friday Morning.
- Steering Committee Meeting Thursday Evening (and wrap-up meeting after the General Discussion Session).

Journal Papers and Reports

* As usual, we pay considerable attention in APEX to documenting our work. We encourage submission of papers to scholarly journals, and writing reports.

* M. Sawan will summarize the status of Reports and Papers.