APEX Status:

Introductory Remarks

APEX Meeting

UCLA

November 2-4, 1998

Mohamed Abdou
SUMMARY ITEMS

• Considerable Progress has been achieved so far, but we still have a long, difficult road ahead of us.

• The APEX ambitious goals and team spirit are providing an environment conducive to innovation. New ideas are already emerging (liquid rotation in fast moving first wall jet, FRC, surface turbulence, heat transfer enhancement, low vapor pressure SnLi coolant, high temperature refractory alloy applications, etc.

* Mohamed Sawan will lead the Evaluation Criteria Group.

* Simple and Effective Evaluation Criteria have been prepared and will be presented Tuesday.

• Dai-Kai Sze will lead the “Tritium and Liquid Coolants / Breeders Data Base” group. [The scope of the flibe group is expanded to address Li, Flibe, SnLi, and other options].

• An Interim Report Outline has been developed for discussion during this meeting.
SUMMARY ITEMS
(continued)


- Note that ISFNT-5 in Rome, September '99, is an excellent opportunity to present the APEX work. Please submit good papers. Abstracts are due January 19, 1999. Please let M. Abdou know of the title and authors for papers you plan on submitting. (We need to ensure coordination among us and good visibility at the Conference).

* Next APEX Meeting will probably include the US-Japan High Power Density Workshop. (Date: February, 1998, either 9-12 or 16-19).
APEX
Leader: M. Abdou

Conceptualization & Analysis of Design Ideas

Innovative (Revolutionary) Concepts

Liquid Concepts (no solid FW)
  - Ying

Li₂O Particulate (no structural FW)
  - Sze

Other Concepts

Extending Limits of Evolutionary Concepts

Interface with Programs Outside APEX
  - Plasma Interface
    - Meade
  - Materials
    - Zinkle
  - Safety
    - McCarthy
  - Systems Studies Interface
    - Tillack
  - ALPS/PFC Interface
    - Mattas/Ulrickson

Common Analysis Groups
  - Mechanical Design
    - Nelson
  - Fluid Mechanics and MHD
    - Morley
  - Tritium and Liquids Data
    - Sze
  - Power Conversion
    - Sze

EM Lithium Blanket
  - Woolley

Liquid GMD Blankets
  - Ying

FRC-Specific Issues
  - Moir/Ying

Liquid Wall
  - Morley

Evaluation Criteria
  - Sawan

High-T Refractory FW with He Cooling
  - Wong/Ulrickson

Evaporative Cooling FW
  - Malang/Mattas

Higher-Power-Density behind FW
  -
APEX Schedule and Milestones for Phase I

Year 1
10/97

Scoping & Approach

Understand and Quantify Key Limits

Design Idea Formulation and Screening

Year 2
10/98

Interim Report 7/99

Workshop

Scientific Evaluation 9/99

Year 3
10/99

Identify R&D, POP

Plan for Phase II

Phase I Report

10/00

Preliminary Design (In-Vessel System for ST, FRC, ICC)

FAPA Evaluation

Promising Concepts

Modeling and Analysis

Small Scale Experiments
Interim Report Schedule

1. Detailed Outline (February 15, 1999)
   January 31, 1999 Key Author for each section:
   -Send detailed outline for your Chapter
   with names of key authors for each section
   Mid-February: Finalize Report Outline

2. Draft Assembly (June 1)
   -Section Authors send first draft to Chapter Key
   Author with copies to other authors
   -Comments to be sent back to authors by June
   15
   -Second Draft to Key author by June 30

3. Draft Report (July 1)
   -Key Authors send Chapters to M. Abdou and to
   all members of the team
   -Comments from Team to Authors by July 15

4. Final Interim Report (July 30) [Firm Deadline]
   -All Chapters mailed to M. Abdou

5. Mail Report (August 15)
   -UCLA will mail Report to Community
APEX Interim Report
Draft Outline

Executive Summary (Abdou)

1. Introduction (Abdou)

2. Overview (Abdou, Morley, Ying, Sze, Mattas, Zinkle, Nelson)


4. Thick Liquid Blanket Concept (Ying, Gulec, Moir, Nelson, Youssef, Sze, Hassanein, Smolentsev, et al)
   4.1 Introduction
   4.2 Idea Description
      4.2.1 Applications to Tokamaks
      4.2.2 Applications to ST
      4.2.3 Applications to FRC
   4.3 Heat Transfer Analysis
   4.4 Fluid Mechanics Analysis
   4.5 Initial Mechanical Design Description
   4.6 Neutronics Analysis
4.7 Evaluation of Liquid Options (Li, flibe, SnLi)
4.8 Performance Summary and Tables (Tables per Evaluation Criteria Requirements)
4.9 Key Issues and R&D

5. Electromagnetically Restrained Lithium Blanket (R. Woolley, et al)

6. Liquid Wall Concept, CLIFF (Morley, Ying, Gulec, Nelson, Smolentsev)

7. Data Base for Liquid Breeders and Coolants, Li, flibe, LiPb, and LiSn (Sze, et al)

8. Li2O Particulate Flow Concept, APPLE (Sze, Igor, Sawan, Tillack, et al)


12. Materials Considerations and Data Base (Zinkle, Ghoniem, Billone, Majumdar, Mattas)

13. Safety Consideration and Analysis (McCarthy, et al)


15. Tritium (Sze, Willms)

16. Power Conversion (Sze, et al)

17. Evaluation Criteria (Sawan, et al)
18. Key Issues and R & D, near term and intermediate term (Abdou, all lead authors for Chapters)
APEX Community Workshop

• We plan to hold an APEX Workshop for the community

**Purposes**
- Communicate Progress, New Idea, and Results of Analysis to the community
- Receive Feedback from community
- Stimulate others to think of new ideas

• Date for the Workshop
- After Interim Report is Issued
- Interim Report will be issued August 15 but there are scheduling conflicts
- Snowmass: July 11-24
- IEA Workshop on Beryllium: September 15-17
- ISFNT-5 (Rome) is September 19-24
- ICFRM (Colorado, Springs) is October 11-15

Date for Workshop?
September 8-10?
October 19-21?
Scientific Evaluation Criteria

(1) Does the concept meet the minimum functional requirements?
   - Tritium breeding
   - Tritium extraction
   - Vacuum
   - Plasma exhaust
   - Power extraction

(2) Does the concept have potential for improved attractiveness?
   - High power density and heat flux handling
   - High power conversion efficiency
   - High availability (low failure rate and short maintenance time)
   - High safety & environmental attributes
   - Low cost

(3) What are the design margins and uncertainties?
    (e.g., in temperatures, stresses, and TBR)

(4) Were major critical issues addressed and R&D needs identified?
Scientific Evaluation Approach

- The evaluation group will develop the criteria for the Scientific Evaluation

- The evaluation group will add more details to the evaluation criteria with some quantitative requirements (e.g., for TBR)

- The evaluation criteria will be utilized to compare different options in the same concept (e.g., compare performance of different breeders in liquid wall concepts)

- Immediately after the community workshop, the evaluation group will collectively evaluate the concepts based on information in the interim report and feedback from the community workshop

- Experts from outside the team might be added to the evaluation group during the concept evaluation
Monday, November 2
8:30 a.m.  Coffee/Muffins

Session I: Study Status and Direction (Chair: Sam Berk)
9:00 a.m.  OFES Remarks
9:15 a.m.  Status
9:50 a.m.  Secretary's Announcements

Session II: APPLE and EVOLVE Concepts (Chair: Richard Mattas)
10:00 a.m.  APPLE Concept:
            • Progress
            • Particulate Flow Dynamics
            • Configuration and Engineering

11:00 a.m.  EVOLVE Concept:
            • Status of EVOLVE
            • Neutronics of EVOLVE

12:00 noon  Group Discussion
12:30 p.m.  Lunch

Session III: Liquid Wall Concepts (Chairs: Neil Morley and Brad Nelson)
1:30 p.m.   Recent Analysis and Design Implementation for the
            Convective Liquid Flow First Wall (CLiFF) Concept
            Morley

1:50 p.m.   Progress on the GMD Thick Liquid Wall Design for
            Advanced Tokamak Configuration
            Ying

2:20 p.m.   Heat Transfer Issues for Liquid FW Concepts:
            • Turbulent Heat Transfer Enhancement
            • Impact of Temperature Distribution on Flow Stability
            Gao/Ying

2:40 p.m.   Mechanical Design for Piping and Penetrations in Liquid Concepts
            Nelson

3:10 p.m.   Coffee Break

3:25 p.m.   Axisymmetric Simulation of EM Restrained Lithium
            Blankets
            Woolley

3:55 p.m.   Shield Performance and Magnet Protection in Thick
            Liquid Wall Concepts
            Youssef

4:10 p.m.   Summary of the Flibe Assessment Group and Report on
            the ORNL Flibe Meeting
            Sze

5:00 p.m.   Sn-Li, A Coolant/Breeder Material Developed for
            APEX/ALPS Applications
            • Breeding Potential Relative to Other Liquid Breeder
            • Safety Issues Of Li-Sn and Flibe
            Sze, Sawan, McCarthy

5:50 p.m.   Group Discussion
6:15 p.m.   Adjourn
Tuesday, November 3
8:00 a.m. Coffee/Muffins

**Session IV: He-Cooled Refractory Metal FW/Blanket/Divertor Concept (Chair: Mahmoud Youssef)**

8:30 a.m. The Helium-Refractory First Wall Blanket CAD Nelson
8:50 a.m. Design Model for Dual Channel He Cooled Heat Sink Nygren
9:05 a.m. Profiles of Heating Rates and Damage in the He-Cooled Refractory Metals Concept Youssef

**Session V: Materials and Database Evaluation (Chair: Steve Zinkle)**

9:15 a.m. Updated Data on Corrosion of Structural Materials (including volatile oxidation of Mo, W, oxygen partial pressure vs. temperature limits) Ghoniem
9:40 a.m. Thermomechanical Properties of W-Re Alloys Zinkle
10:05 a.m. Coffee Break

**Session VI: FRC Configuration (Chair: Robert Woolley)**

10:20 a.m. FRC Design Status Gulec/Moir/ Santarus
10:30 a.m. Liquid Blanket Configurations for FRC Gulec
11:20 a.m. Group Discussion

**Session VII: Plasma Interface Issues (Chair: Richard Mattas)**

11:30 a.m. Bremsstrahlung Radiation Spectrum Uchimoto
11:50 a.m. Impurity Ion Penetration into the Edge Plasma Region Rognlien
12:20 p.m. Lunch
1:30 p.m. Summary of Work of ALPS/APEX Plasma Modeling Group Rognlien/Brooks
2:00 p.m. Disruption/Surface Stability Hassanein
2:20 p.m. Summary of Japanese Activities on Liquid Metal Studies Nygren
2:50 p.m. Group Discussion
3:15 p.m. Coffee Break

**Session VIII: Evaluation Criteria and Discussion on Concepts (Chairs: M. Abdou and M. Sawan)**

3:30 p.m. Evaluation Criteria Sawan
3:45 p.m. Discussion on Evaluation Criteria
4:15 p.m. Discussion by Participants on all Concepts and Options for Concepts (Key Issues, suggestions, etc. from APEX team point of view)

6:00 p.m. Adjoin

**Evening:** Group may wish to meet for dinner. Wendy can help with reservations.
Wednesday, November 4
8:00 a.m. Coffee/Muffins
Session IX: Key Issues and Plans (Chairs: Mahmoud Youssef and Mohamed Sawan)
8:30 a.m. Each speaker is to summarize key technical issues, planned
tasks (what will be done and who will do it) for the next 6
months, and schedule other open technical and
management issues.
CLIFF (15 min)
GMD and FRC (15 min)
APPLE (15 min)
EVOLVE (15 min)
He-cooled Refractory (15 min)
Mechanical Design (15 min)
Materials (10 min)
Safety (10 min)
Plasma Disruption (10 min)
10:30 a.m. Coffee Break
10:45 a.m. Virtual Laboratory for Technology
Session X: Study Direction (Session Chair: Mohamed Abdou)
11:00 a.m.
• Comments and Suggestions on Future Directions
• Interim Report Outline and Schedule
• Solicitation of New Ideas
• Competitive Proposals Process
• Next Meeting Plans
• Plans for US-Japan Workshops
12:30 p.m. Adjourn