APEX Teleconference Summary - Task 3
RE Nygren 17aug2000

Summaries of the Work and Plans for APEX Task 3 were given in the following presentations (all available on the APEX website):

- Plasma-Liquid Surface Interactions and Plasma Edge Modeling (Rognlien)
- Overall Progress on the Lithium CLIFF Design (Sze)
- Progress and Plans for Task III CLIFF Configuration Studies (Nelson)
- Integration of Liquid Divertor (Nygren)

Tom Rognlien reviewed work on plasma-liquid surface interactions and plasma edge modeling. He noted that there was a strong dependence upon position of the evaporation rate of the first wall since the temperature increased along the poloidal length from top to bottom. However, the change from a uniform to a ramped wall source did not produce a large change in the core impurity level, and the effect diminished at higher wall gas flux rates. A new case (100°C rise) was added to the upper limit for wall impurities that triggered MARFE-like behavior in the model. He discussed the conditions used for ITER calculations of radiation to the FW, the pro's and con's of a high radiated fraction and the three elements - core Bremsstrahlung, core-edge line radiation and X-point radiation. The subject of radiation was a major point of discussion later. Tom also outlined plans for future work.

Dai Kai Sze presented an overview of the ARIES-RS/CLIFF/Li design and on the calculated poloidal heat flux to the FW, concerns with FW temperature and power conversion and erosion and activation issues. The temperature dependence of the depth of penetration of Bremsstrahlung radiation and its poloidal distribution has raised the concern of making a self consistent set of assumptions on which to base the FW heat loads and work in this area was reviewed. Three suggestions were presented to increase the operating temperature window for Li in order to obtain better power conversion efficiency: 1) better model of how Bremsstrahlung radiation is deposited; increased Li flow velocity of 20m/s; and 3) include non-uniform poloidal heat flux. The potential problem of increased corrosion with higher velocity was noted. The near term plan is to assess whether there is a sufficient temperature window for the Li design.

Brad Nelson reviewed the extensive CAD development for the AREIS-RS/CLIFF/Flibe design and plans for the Li design. The CAD design for the Flibe system includes the vacuum vessel, shield module, fast flow cassette (Flibe injection nozzles at top of device), inboard and outboard SiC bags for containing the blanket flow, supply headers and the divertor cassette. The FW consists of a fast flowing layer on the surface of the SiC blanket bags. The design includes considerations for penetrations and maintenance. A plastic stereolithography mockup of the fast flow nozzle was made. In the presentation, some concerns about the Li design versus Flibe were noted, e.g., higher thermal conductivity of Li helps but strong MHD effects are a concern.

Richard Nygren summarized work on the integration of a divertor into the ARIES-RS/CLIFF/Flibe design. The simplest case (FW extended into a divertor) was studied to see if this was workable. The scheme provides little spreading of the heat load due to limitations in the incline of the divertor (~70°) with respect to the flux surface and the small amount of flux expansion (2X). Helium pumping was provided using relatively large horizontal pumping ports as well as the large drain ports. Adequate pumping was calculated for the case of a high recycling divertor. The ports take 40% of the toroidal coverage of the outboard divertor but this fraction could probably be reduced somewhat. The heat loads to the divertor were studied in a parametric evaluation using the heat load profile obtained by Rensink/Rognlien for a high recycling Flibe case. Flibe surface temperature profiles calculated by Smolentsev indicated a temperature rise of over 300°C for a peak heat flux of ~50 $MW/m^2$. Specific limits for heat loads and temperatures in the divertor were not developed. However, the temperatures are probably higher than acceptable temperatures especially in considering the very optimistic assumption of only 10% of the particle power conducted into the divertor. The greater power to the outboard divertor target (40/60 assumed) and space for pumping ducts makes the peak heat load on the outboard divertor ~2.5 times higher than that on the inboard divertor. One approach to decrease the heat load to the outboard divertor is to use a nozzle (and introduce a separate divertor stream) so that the target can have a smaller angle (15-20°) to the flux surface. This approach will probably be used in the Li design. The MHD effects associated with this flow will be a major concern in obtaining a reliable estimate of the heat transfer and surface temperatures in the divertor.

In the ensuing discussion, the issue of how to model the deposition of the Bremsstrahlung radiation and the radiated power fraction received extensive discussion. Abdou suggested a parametric approach with three values for the deposited power (see action item). Sze again noted the need for a larger operating window for temperature to make the Li design feasible. Ulrickson noted that 500°C might be a limit in the divertor due to a sheath breakdown as calculated by Brooks. Regarding the Li design, the importance of MHD effects on flow was again stressed by Sze. Nygren and Morley and the need for guiding assumptions on MHD effects as engineering evaluations proceed.

Action: Mohamed Sawan will organize a conference call to resolve the parametric approach to deposited power loads on the FW (and divertor).