IFE Structural Materials: ARIES Assessment

M. C. Billone, A. R. Raffray, D. K. Sze, L. El-Guebaly and the ARIES team

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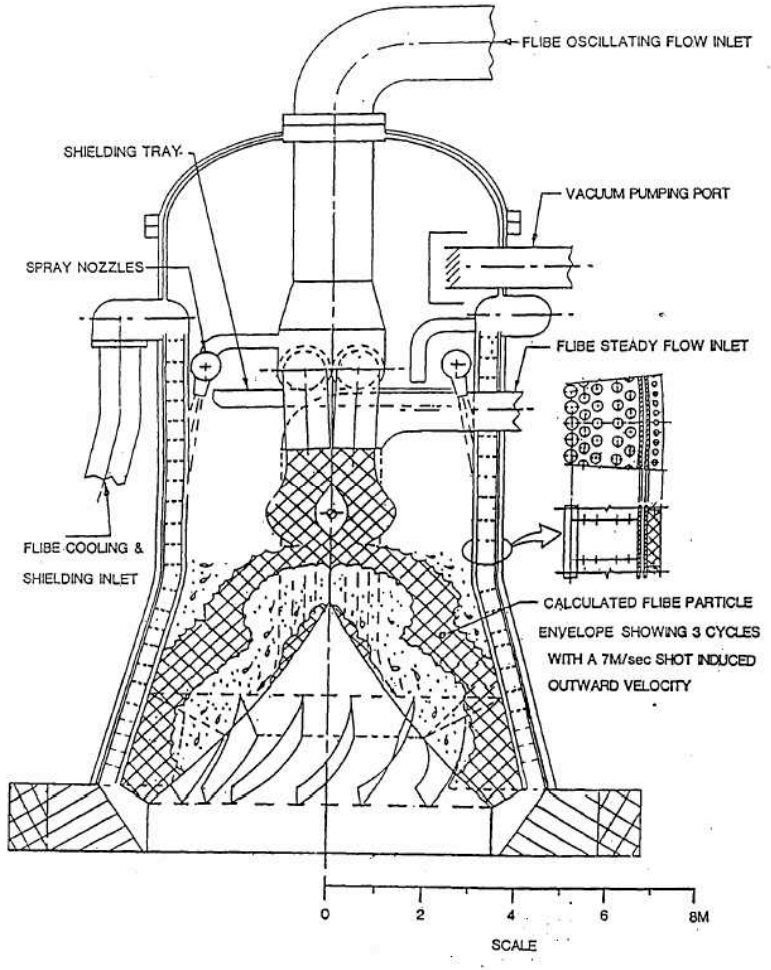
Background

- **The HYLIFE concept utilizes a thick flibe liquid wall.**

- **The initial choice of structural material favored current steels such as 304SS which would alleviate the need for development of advanced structural materials.**

- **As part of the ARIES-IFE study, we have performed an updated assessment of the choice of the power core structural material for the HYLIFE concept.**



- **Complete report can be seen at:** http://aries.ucsd.edu/LIB/REPORT/ENG.shtml

Report Summary (I)

- **304SS has major swelling, activation and He embrittlement issues.**
  - **Swelling (~30% at 100 dpa and 500-600°C) issue could *perhaps* be designed around such as by utilizing the wavy first wall structure assumed in HYLIFE.**
  - **The activation issue could be remedied by drastically reducing Nb and Mo impurities in 304SS although the cost impact of so doing should be assessed.**
  - **However, difficult to see how the He embrittlement issue could be addressed.**
    - **S_m would be reduced from 93 MPa to 53 MPa at 600˚C, and from 88 MPa to 35 MPa at 650°C for unirradiated 304SS.**
    - **He embrittlement would further decrease these design allowable stresses, limitng the maximum temperature to ~550°C and essentially closing the flibe operating temperature window for power plant application.**
- **Thus, alternate structural material candidates must be considered for the power core region.**

Report Summary (II)

- **If a 300 series SS is required as a near-term base line for the design, it is recommended that Ti-modified 316SS (PCA) be considered instead of 304SS for the first wall tubes, connecting bars and rings connecting to the back wall.□**
  - **PCA has better creep and tensile strength up to 600°C - 650°C.**
  - **PCA is less susceptible to He embrittlement.**
  - **However, it needs 2%Mo for strength which creates an activation issue even if all Nb impurity can be removed.**

Report Summary (III)

- **ODS FS and SiC_f/SiC provide the possibility of higher temperature operation and much better power plant performance and are potentially attractive candidates.**
  - **A development effort is needed in particular for SiC_f/SiC.**
  - **Database (e.g. corrosion, erosion) must be expanded for these materials in conjunction with flibe.**
  - **However, even in the present HYLIFE design it is recognized that the nozzle material could be different from 304SS due to the high demands (resistance to erosion, corrosion…) placed on this component.**
  - **Thus, a material development program would be needed for these anyway.**

Report Summary (IV)

- **It is important to consider the conceptual design of a fusion power plant in its proper time frame (50 years +).**
  - **In anticipation of progress by the competition and of what would be attractive to power plant operators, fusion should be looking at configurations and materials of the highest performance and safety.**
  - **In MFE, only near-term experimental reactors such as ITER currently consider austenitic steel in a low fluence, low temperature environment.**
  - **Austenitic steel is not considered for future reactors and is not included in the MFE materials program R&D efforts.**
- **For maximizing synergy between MFE and IFE R&D and to make the most of the information available from the MFE materials program, a strong link is required between the IFE design effort and the MFE material community.**