COOLANT STRUCTURAL MATERIALS

COMPATIBILITY

APEX Task III 6 a,b

S. Sharafat and N. M. Ghoniem

The University of California at Los Angeles (UCLA)
Los Angeles, CA. 90095-1597, USA

Joint APEX Electronic Meeting

USA

March 24, 2000

Compatibility Issues

Three compatibility issues and **three** design specific issues:

COMPATIBILITY	DESIGN ISSUES
Liquid Metal Corrosion Chemical leaching	Structural Material Choice and Operating Window
Liquid Metal Erosion Mechanical mass transfer	Insulating Coating Self-Healing or Not
Liquid Metal Embrittlement Degradation of strength	Bi-Metallic Loop Economics

Approach

1. **Extensive Review of Experimental Data Base:**
   - **Over the past decade research in liquid blankets resulted in a number of experimental programs to investigate feasibility issues (ITER, LHD)**
   - **Over 72 published reports have been identified for review.**

2. **Use of Thermodynamic Analysis:**
   - **Activation, Gibbs's free energy, and solubility are used to estimate interactions between liquid metals and structural materials**
   - **Interactions between liquid metals and ceramic insulating materials have been reported for:**
     Oxides,
     Nitrides, and
     Carbides

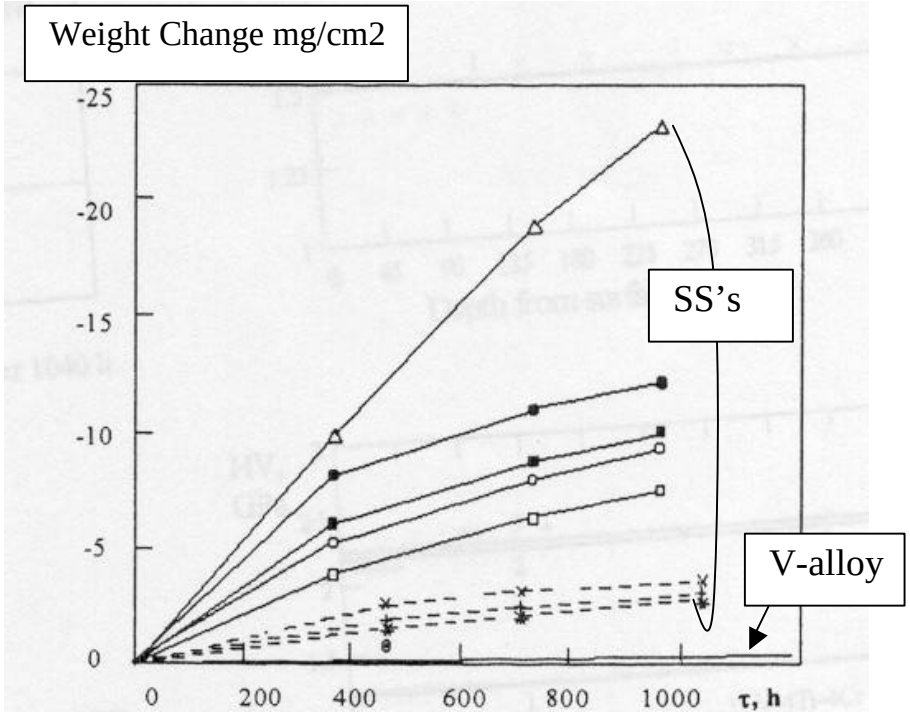
Experimental and Analytical Material Matrix

		Lack Data
Liquid Metal	Li, Li17-Pb83	FliBe, Sn-Li
Structural Materials (Experimental)	V, Alloys : V-Ti-Cr, V-Cr-Ti-Zr SS: Fe-C-Cr-Ni-Mo,	W, W-Re, ODS-W, Ferritic Steels
Insulating Ceramics (Thermodynamic analysis, some experimental)	Oxides: Y_2O_3, CaO, Al_2O_3, MgO, SiO_2, Cr_2O_3 Carbides: β-SiC, TiC, ZrC, TaC Nitrides: BN, AlN, TiN, ZrN, VN, CrN	SiC unstable in Li, but stable in Li-Pb[1] (no info on SiC and FliBe or SiC and LiSn)
Impurities (effects on compatibility)	O, N, C, H	

[1] Hubberstey, 1997

Compatibility between Li and V-Alloys/Insulating Coating

Vanadium and SS Stability in Li (450°C, 400 wpm N)[1]:



Vanadium alloys are superior to Cr and Cr-Ni Steel alloys

Insulating Coating Stability based on Gibbs's Free Energy [2]:

Li (773 K)	
Species	**$D_fG_{ceramic}$ (kJ/mole)**
Y_2O_3	**-1678.8**
Al_2O_3	**-1432.6**
Cr_2O_3	**-927.7**
CaO	**-554.1**
AlN	**-219.2**
BN	**206.1**
VN	**-150.2**
CrN	**-61.6**

Among the ceramics the Yittria is the most stable

[1] Evtikhin, V.A., 1998

[2] Hubberstey, P., 1997

Nozzle Design Issues

Two Issues:

1) Wear of Nozzle ➔ Lifetime
2) Effects of Nozzle Geometry ➔ Performance

A review of **NOZZLE WEAR** based on high temperature liquids is being conducted (no data with liquid metals).

EFFECTS OF NOZZLE GEOMETRY (diameter and aspect ratio) on the local heat transfer coefficients has been studied and will be reported.