Updated Concerns on the Material Interactions

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Material Interactions

- The compatibility between the structural materials and coolant/breeding materials set key limitations on the allowable temperature.
- The allowable corrosion rate is about 10 mg/m^2-h.
- The corrosion rate is strongly temperature dependent.
- Relax of the corrosion rate will have only a small effect on the allowable temperature.

Corrosion Concerns

- Literature review identified they are limited information on the results of corrosion studies.
- Some of the experimental results do not support the conventional window.
- Much more experimental works will be required to define the corrosion rates.
- Some results for the Li/V, LiPb/SiC and flibe/FS will be discussed here.

Li/V compatibility

- One of the key reasons to use the Li/V blanket is that Li is compatible with V-alloy to high temperature(600 to 700°C).
- BCSS suggested that V is very compatible with Li.
- Some existing data does not agree with this conclusion.

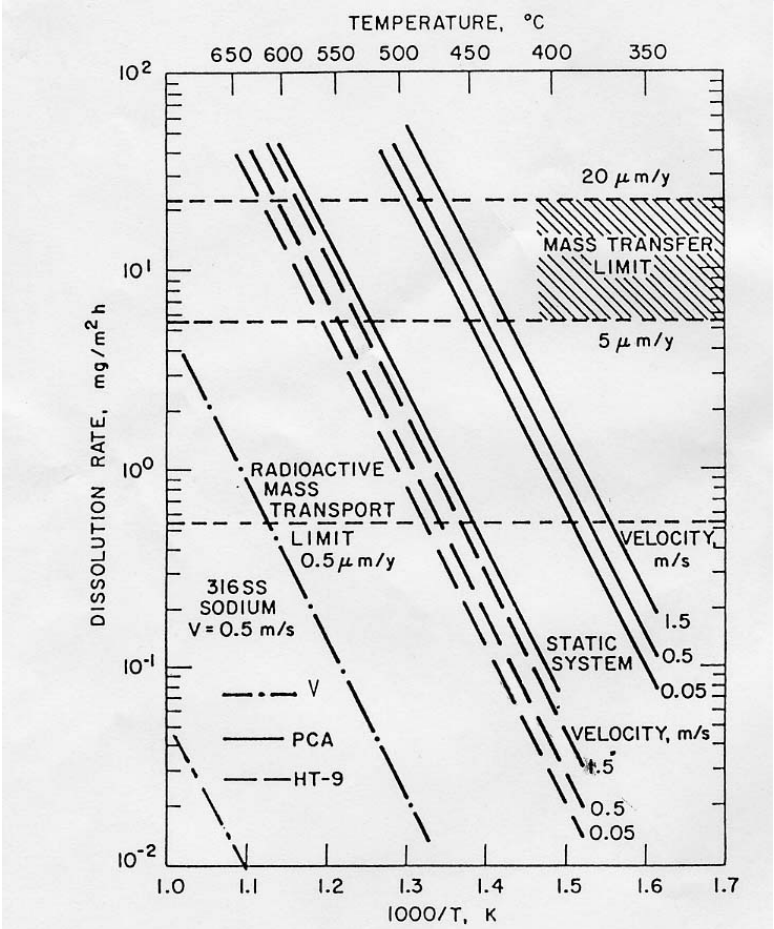

Figure 6.2-4. Effect of temperature on the corrosion rate of PCA and HT-9 alloy in flowing lithium.

Results from ANL work

- Dissolution rates of V in Li were measured for different type of V-alloys.
- This experiment was done in a forced convection loop with Li circulating rate of about 1 liter/m.
- The corrosion behavior was evaluated by measuring weight change.
- The N concentration was between 20 to 100 WPPM.
- Chopra and Smith, “Corrosion behavior of Vanadium Alloys in Flowing Lithium,” Journal of Nuclear Materials, 155-157 (1988).

Corrosion Rate of V-15Cr-5Ti

- Reported corrosion rates:

482°C	427°C
4.97 mg/m^2-hr	0.27 mg/m^2-hr

- The corrosion rate will be 0.1 cm/y at 600C, and 0.5 cm/y at 650C, by extrapolating from the low temperatures.).

Other Results

- Corrosion of V3Ti1Si by Li was measured by Adelhelm.
- A pumped Li loop was used, with velocity of 7 cm/s.
- The Li temperature was 806 to 823K.
- The N concentration was 8 to 64 wppm.
- The measured V corrosion rate was between 2 to 20 mg/m^2-hr.
- There was a minimum corrosion rate at X_N = 30 ppm.

Gh. Adelhelm, "Corrosion of V3Ti-1Si in flowing Lithium," Fusion Technology,8, July 1985, P. 541.

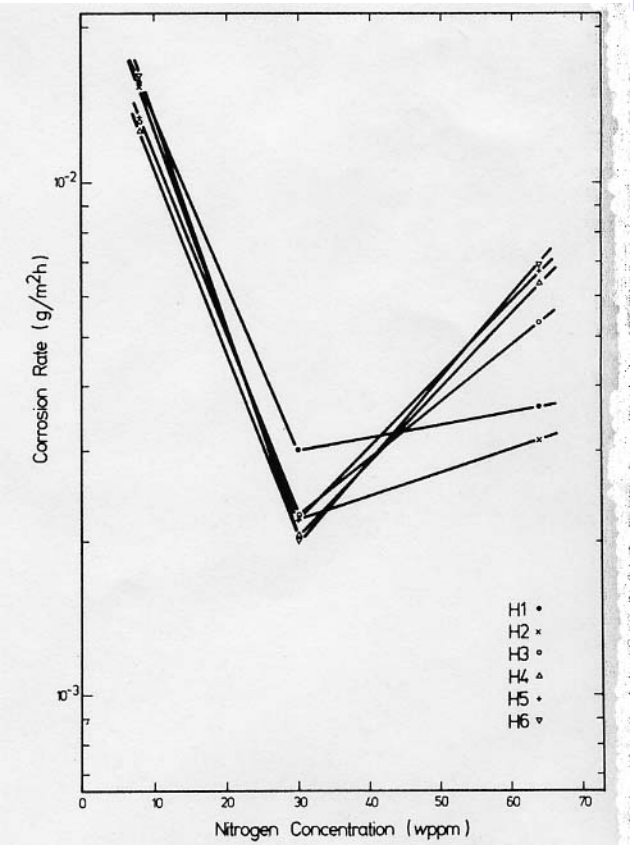

Fig. 5: Corrosion rate constant of the hot leg coupons (H1-H6) as a function of the nitrogen content in the lithium (806-822 K) assuming linear corrosion rates

Other Information

- Some work from RF reported weight gain in V/Li corrosion experiments.
- Those were from capsule tests with very high N concentration.
- No data is available to suggest that the corrosion rate on V by Li is low at high temperature.
- Chopra concluded "the dissolution rates of all vanadium alloys were greater than of ferritic steels (in his experiments)."

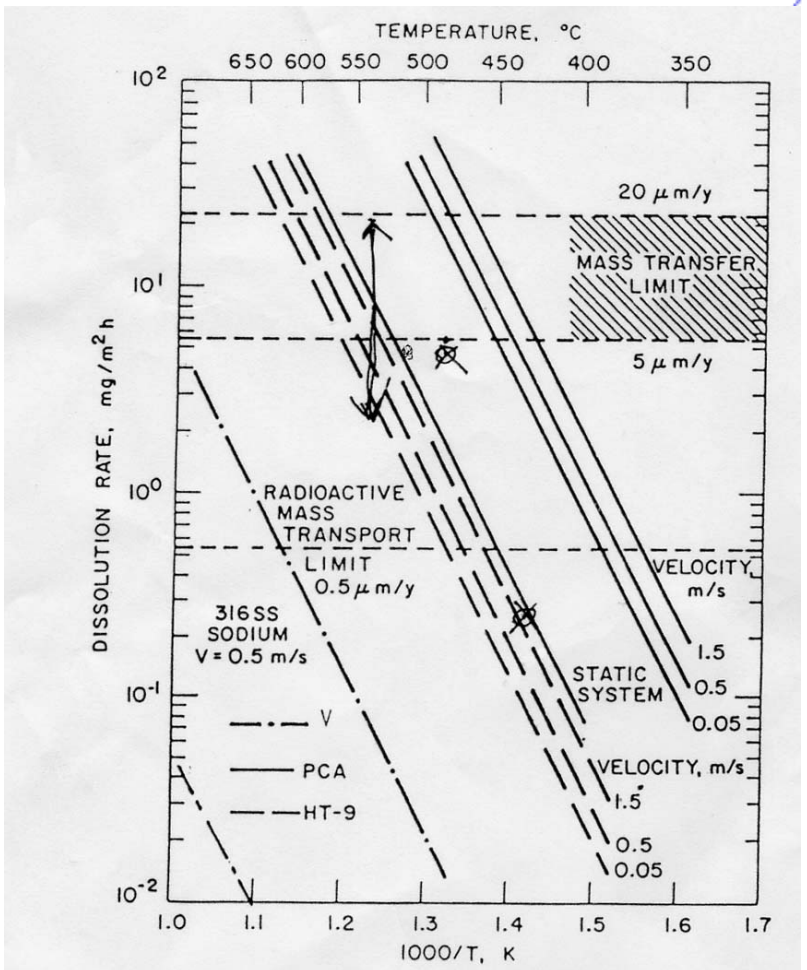

Figure 6.2-4. Effect of temperature on the corrosion rate of PCA and HT-9 alloy in flowing lithium.

Question

- What is the base to suggest that Li/V blanket can operate at 600 to 700°C?

LiPb/SiC Compatibility

- It has been suggested that LiPb and SiC is compatible up to 800°C, and maybe higher.
- Available experimental results do not support this suggestion.
- Based on experimental results, it can not be concluded that if SiC is compatible, or not compatible, with LiPb at 800°C.

LiPb/SiC Experiment

- The work was done in a rotating disk set up, with a rotational speed of 800 revolutions/m (1.67 m/s).
- The temperature of the experiment was 800°C, and up to 3100h.
- Both the coupons and the LiPb sample were investigated at the end of the experiements.

SiC Coupons

- It was difficult to clean up LiPb from the SiC coupons.
- Therefore, it was not possible to measure the weight variation of the SiC speciman after the test.
- No information was obtained on either weight gain, or weight lost, during its contact with liquid LiPb.

LiPb Samples

- The Si concentration in LiPb is about 12 wppm, both before and after the test.
- The author suggested that no dissolution occurred during the test perhaps due to the low Si solubility in LiPb.
- However, this also suggested that the Si is saturated in LiPb at a concentration of 12 wppm.
- 12 wppm is a very high solubility. If we assume that the Si concentration in LiPb is always at a saturation level, (Which may not be), the removal rate of Si from SiC will be very high.
- There is potential that the entire blanket structure can be removed in one day.
- 12 wppm solubility is a cause for concern.

LiPb/SiC Compatibility

- There is no data available to suggest if SiC is compatible to LiPb at 800°C, or not compatible.
- ORNL recently did some SiC/LiPb compatibility test, at 1000°C and 800°C.
- Air in leak ruined the 1000°C experiment.
- ORNL is still investigating methods to remove LiPb from the SiC coupons.

REDOX Reaction

- For MSBR, the following Redox reaction was used to control TF and F_2 potential.

  $UF_3 + F \text{ -----} \rightarrow UF_4$

- A possible Redox reaction for fusion application is

  $Be + 2F \text{ ----} \rightarrow BeF_2$

- This redox reaction is being studied at INEL as a part of JUPITER-II collaboration.

Conclusion

- There are only limited experimental results to assess the compatibility between many structural materials and coolant/breeding materials.
- Careful review of those results raised questions on the temperature limits set for the systems.
- More detailed assessments on the condition of the experiments, the results of the experiments, and the conclusions draw from those results is required.