Contribution ID: **34** Type: **not specified**

Post-test examination of a Li-Ta heat pipe exposed to H plasma in Magnum PSI

Monday, 17 September 2018 11:00 (2 hours)

The authors exposed a radiatively cooled, ~195-mm-long, lithium-filled tantalum heat pipe (HP) to a hydrogen plasma in DIFFER's linear plasma source Magnum PSI continuously for ~2 hours. We kept the overall heat load on the inclined HP constant, varied the tilt and peak heat flux to ~2.5 MWm2. The HP operated at ~1000-1100 C. Diagnostics included near infra-red thermography from two orthogonal ports. [1]

We stopped after an initial breach occurred near the beam axis intercept. ~0.06 g of lithium formed a 6-mm-diameter nodule and coating covered half of the area wetted by the beam. Several seconds later, a transverse crack opened; lithium flowed out quickly and wetted an area ~30 mm2. Fractography and post-test metallography showed differing breach mechanisms. The first site had prior material damage. The second breach occurred as the HP cooled. With creep and relaxation during the exposure, the site would have tensile loading during cooling. A tantalum disk annealed in a hydrogen furnace was available for comparative evidence of hydrogen embrittlement.

Sandia had purchased an existing tantalum HP from Aavid-Thermacore, Inc. The test showed prolonged operation, gave useful data and we judged it a success. However, tantalum would not be the right choice for a future PFC. The paper also discusses HP configurations and materials for future PFCs.

[1] G.F. Matthews, R. Nygren, T. Morgan, S.A. Silburn, "Demonstration of the potential for exchangeable PFCs based on radiatively cooled lithium heat pipes in Magnum PSI," this conference.

Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525. This work was also part-funded by the RCUK Energy Programme under grant EP/I501045.

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Session Classification: P1

Track Classification: Plasma Facing Components