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A new vision of plasma facing components

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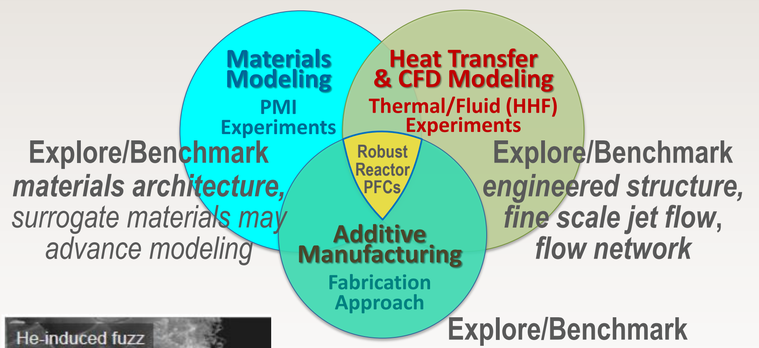
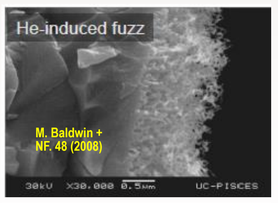
We see in the world:

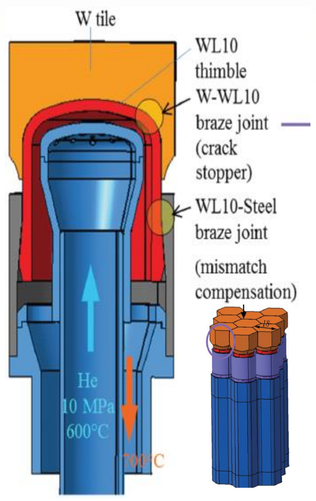
- a growing understanding of tungsten's materials issues
- greater computational capability in materials modeling and CFD, and
- rapidly expanding development of advanced manufacturing methods.

We need to exploit these to develop robust PFCs for a fusion CTF or DEMO.

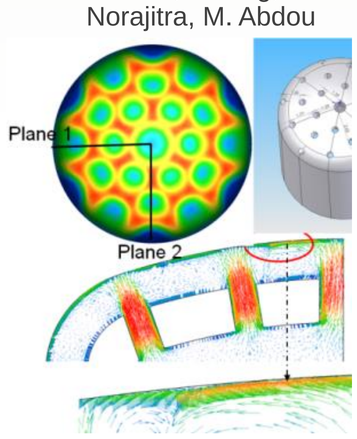




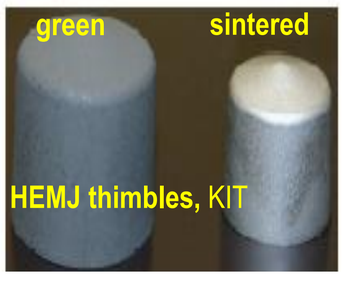
UCSD Jacobs | Mechanical and Aerospace Engineering



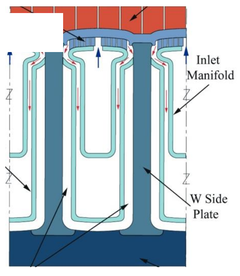
HEMJ CFD analysis
M. Narula, A. Ying, P. Norajitra, M. Abdou



PIM application for mass production of He-cooled divertor parts, at ICFRM-14, S. Antuscha, P. Norajitraa, V. Piottera, H.-J. Ritzhaupt-Kleissla

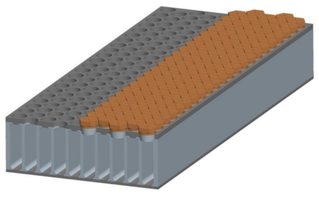


Optimizations of HEMJ .., Wang 2015



M. Tillack, A. Raffray, X. Wang, S. Malang, S. Abdel-Khalik, M. Yoda, D. Youchison,.
... advanced He-cooled W-alloy divertor *FED* 2011

- large area arrays
- common manifolds
- easier assembly
- W/Ferritic for FW



Comments on PFCs with regard to 1. Additive Manufacturing 2. Liquid Surfaces

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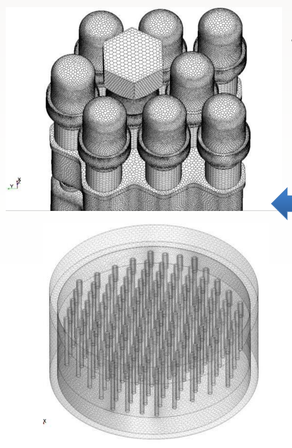
The comments here briefly make points described in more detail elsewhere. Please see the recently published paper (left) regarding additive manufacturing (AM) and PFCs.

The PFMC paper (right) covers aspects of the integration of liquid surface PFCs into nuclear fusion systems. An extensive review of the potential of liquid surface PFCs is in review for publication in *Nuclear Materials and Energy*.

A journal paper on liquid metal embrittlement (LME) with data and explanation of the rapid failure of a ferritic alloy exposed to liquid lithium is ready for publication.

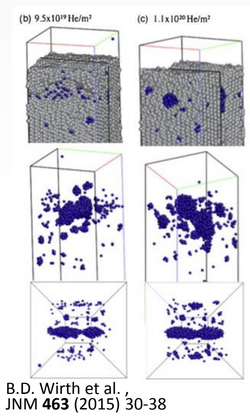
White papers and presentations available on the web from the FES-PSI Workshop in 2015 cover the main points.

Additive manufacturing is an essential element in the combined solution for a robust PFM-PFC solution.



To realize robust PFCs .....

- suitable **materials architecture** for PFMs,
- **engineered micro-features** (microjets for gas cooling),
- **advanced manufacturing methods**, and a
- new vision of the R&D path for materials and PFCs.



B.D. Wirth et al. , JNM **463** (2015) 30-38

PFM-PFC Performance

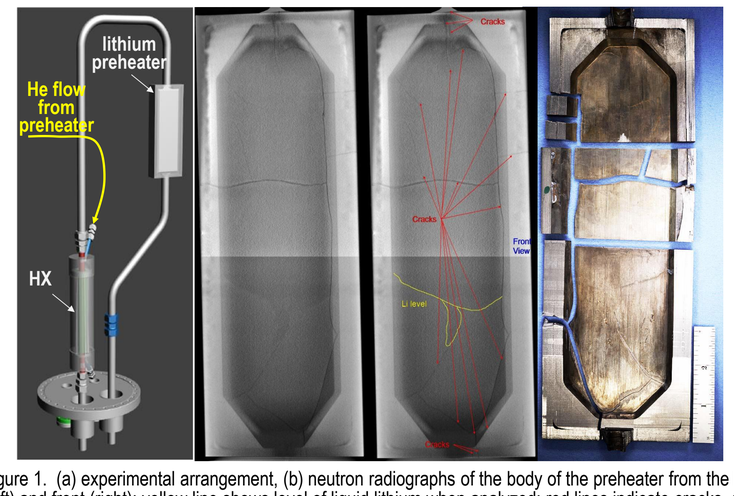


Figure 1. (a) experimental arrangement, (b) neutron radiographs of the body of the preheater from the back (left) and front (right); yellow line shows level of liquid lithium when analyzed; red lines indicate cracks, and (c) photograph of the inside of the failed unit. The separation into pieces resulted from sectioning for evaluation

IOP Publishing | Royal Swedish Academy of Sciences Physica Scripta
Phys. Scr. **00** (2015) 000000 (5pp)

Integration of liquid surface PFCs into DEMO or FNSF

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Table 1. PFC-Blanket Cases

Fast Flow FW/Div.			Blanket				
FW	*Div.*	*Press.*	*breeder*	*coolant*	*P*	*structure*	
Li	Li	L	Li-Pb	He	H	RAFS	1
Li-Pb	Li	L	Li-Pb	He	H	RAFS	2
Li	Li	L	Li-Pb	He	H	RAFS +SiC	3
Li	Li	L	solid	He	H	RAFS	4
Li +HX	Li	H (HX)	solid	He		RAFS	5
Ga	Ga	L	solid	He	H	RAFS	6
salt	salt	L	salt	salt	L	RAFS	7
Fast Flow FW/Div.			Blanket				
Li-CPS	He	H	solid	He	H	RAFS	8

from 22-page NME paper under review for publication

2. Critical Issues for LM PFCs

What is the potential of liquid surfaces? The approach .....

Can these provide viable solutions for PFCs for a fusion reactor, or at least for a fusion component test facility (CTF)? The path forward ....

What must a liquid surface PFCs do? PFCs must ....

What would confirm that a suitable physics regime can be realized? What technology must be developed and its performance confirmed?

....PSI effects that would degrade confinement,...

prepared for submittal to journal

Failure of a Lithium-filled Target and Some Implications for Fusion Components

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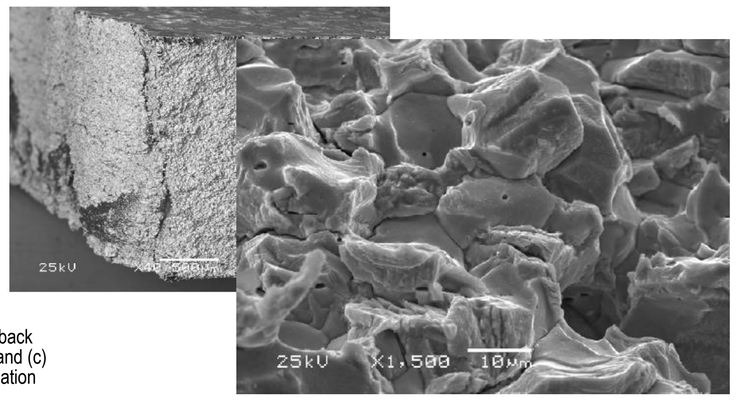
Sandia National Laboratories, Albuquerque, New Mexico, US

In preparation for testing a Li-He heat exchanger, unexpected rapid failure of the mild steel Li preheater occurred when Li at ~400 °C flowed into the preheater then at ~200 °C. This happened before the He system was pressurized or heating with electron beams began. We attribute the failure to liquid metal embrittlement. ...

Fractographs from edge of failed preheater



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National Nuclear Security Administration