Assessment of Critical Issues for Solid Wall Blankets

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NFC Steel Compatibility with Pb

Summary by Rich Mattas

- Test temperatures on ferritic steel limited to <550C mainly due to mechanical properties
- Going to temperatures >550C for ferritic steel may be difficult from the concern that the formation of wusite is favored over magnitite resulting in poorer adhesion and less corrosion resistance
- For the purpose of design studies it might be expected that means can be found to operate at T ~600C

Information from Dr. A. V. Lopatkin (ENTEK-RUSSIA)

- Recommended temperature limit is 620C based on corrosion tests performed in support of Pb cooled submarine reactors and BOR-60 loops for BREST-OD-300
- Operation at 700C requires very close control of O2. If the O2 is too high there is intergranular attack, if it is too low there is dissolution. The window is very small and difficult to control

Information from Dr. V.G. Markov (CRISM-PROMETEY)

- It was reported by S. Malang that he visited in ~1991 a laboratory near St. Petersburgh where they have tested ferritic steel at 700C successfully with O2 control
- The laboratory in question is in Gatchina near St. Petersburgh and the corrosion work is done under Dr. Markov. He reports that ferritic steel corrosion loops with Pb have been operated at 550C where the concentration of O2 resulting in a passive condition was established
- There is no mention on work at 700C
- He said he is willing to perform tests on NCF steels up to 600C for anyone on the loop CRISM "Prometey"
- Two references were given, all in Russian, which we failed to obtain. I asked him to send me copies but he will be on vacation for 4 weeks

Information from Eric Leweon (INEEL)

- Semi-static corrosion tests of HT-9 and 410 steel at T= 500-700C for a period of 1000 hours with oxygen control. O2 is bubbled through the melt and O2 concentration is monitored
- Samples at 700C are presently being taken out for analysis and will be published soon
- Preliminary results have shown lower corrosion rates than in the LANL samples tested in OBNINSK

NFC Steel Compatibility with Be
(R. Mattas, ANL)

- Ferritic steel in contact with Be forms a discontinuous brittle superficial layer adherent to the steel with a concomitant generation of holes in the Be

- The allowable temperature at the Be/steel interface will depend upon the rate of layer formation

For 25920 hours (3 FPY) as a function of temperature the layer is:

Temp. (C)	Layer Thickness (μm)	Layer Thickness (cm)
500	16	0.0016
600	61	0.0061
700	225	0.0225
800	724	0.0724
900	1932	0.1932

Spiral Blanket Design Issues

MHD Effects

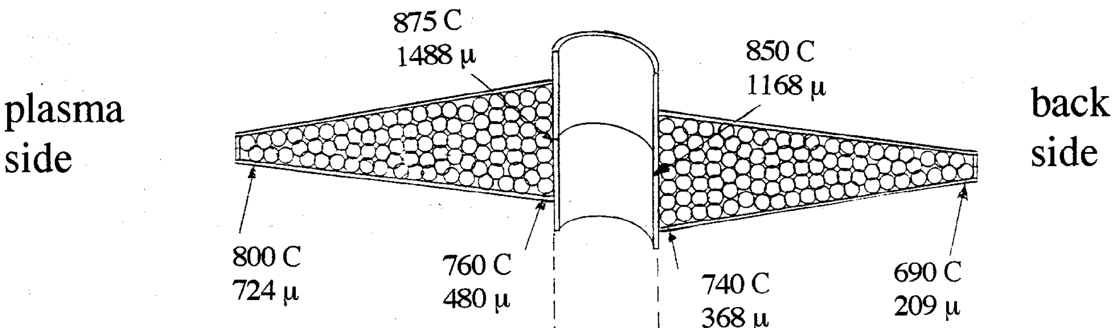
- Calculations by Sergey Smolentsev show that at the first wall where the magnetic field is parallel to the coolant flow, suppression of turbulence and effect on heat transfer is negligible

- In the side channels where the field is perpendicular to the flow, heat transfer coefficient is reduced by a factor of two. But here the only heating is volumetric nuclear heating. Therefore, it is not a concern

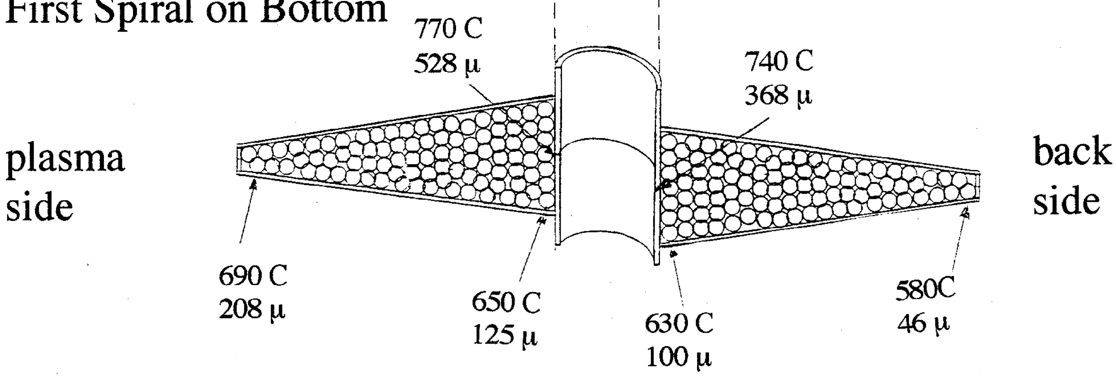
Be / NCF Steel Compatibility in Spiral Blanket

Estimated Be temperatures in contact with NCF steel:

Last Spiral on Top:



First Spiral on Bottom



- Estimated temperature of Be in contact with NCF given in C for the first spiral disc, where the coolant is at its lowest T and the last spiral disc where the coolant is at its highest T
- The calculated thickness of the intermetalic superficial layer given in microns (μ).is for a period of 25920 hrs or 3 FPY
- The thickness of the perforated disc plates is 0.2cm (2000 μ) and the thickness of the shaft is 0.5cm (5000 μ)
- The highest temperature of Be in contact with NCF steel is on the last spiral disc (875C) where it is in contact with the shaft material. The layer is 1488 μ and the shaft material is 5000 μ.

Therefore, it appears that thinning of the disc material structure during the 3 FPY does not impact its mechanical integrity.

Tritium Inventory in Beryllium of Spiral Blanket

- A concern with the spiral blanket design was the amount of tritium produced and retained in the beryllium

- Tritium production in Be calculated for expected blanket lifetime corresponding to 15 MWy/m^2 average fluence

- Volume per module:
  - 0.54 m^3 OB
  - 0.42 m^3 IB

- Number of modules:
  - 130 OB
  - 79 IB

- Total spiral blanket volume:
  - 70.8 m^3 OB
  - 33.4 m^3 IB
  - 104.2 m^3 total

- 30 cm thick Spiral Blanket:
  74.4% Flibe 18.67% Be 6.93% NCF

- 45 cm thick Secondary Blanket in OB:
  95% Flibe 5% NCF

- Total Be inventory in spiral blanket 36 tonnes

- Radial average of tritium production rate in Be of spiral blanket @ 5 MW/m^2 average neutron wall loading is 33 g/m^3 per FPY. This is 1/4 peak value near FW

- Total tritium production in Be @ 15 MWy/m^2 average fluence is 1.9 kg

- This total tritium production is smaller than in solid breeder designs due to smaller Be inventory and distributing Be over blanket thickness that results in lower average neutron flux. In the EU Demo, Be inventory is ~300 tonnes and total tritium production is 22 kg

- Tritium inventory will be much lower than the tritium production due to tritium permeation out of Be

- It is expected that tritium will come out if we heat up the blanket to 700C

- Based on experimental data, temperature at which most of tritium is released is in the range 500-700C depending on density and fluence level. Lower density and higher fluence result in lower temperature for release of tritium

- Be temperature in the spiral blanket vary over the spiral

- Be temperature distribution determined:
    - At bottom 580-770C
    - At top 680-870C