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Progress on performances of Helium Cooled Molten Lead Ceramic Breeder, as a near-term alternative blanket for EU-DEMO

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Introduction

- Helium Cooled Molten Lead Ceramic Breeder (HC-MLCB) solid breeder blanket being developed as near-term alternative blanket for the new European DEMO (DEMO BL2017).
- Based on "fission-like fuel-breeder pin" configuration, HC-MLCB using Molten Lead as neutron multiplier, Advanced Ceramic Breeder as tritium breeder, pressurized helium as coolant, EUROFER 97 as structural material.
- Basic nuclear and thermo-hydraulic and thermo-mechanical performance are conducted and presented.

Features of Design

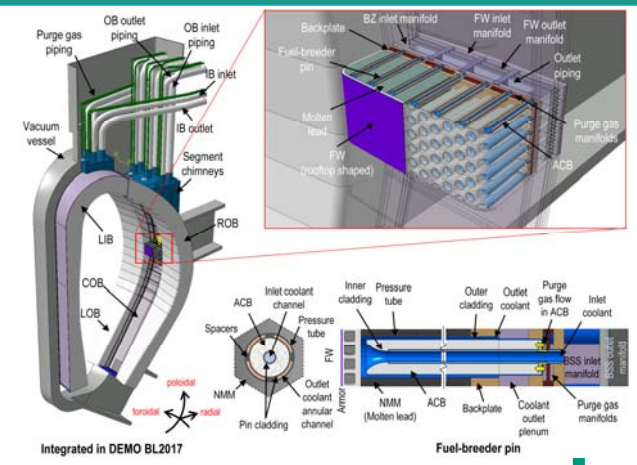

Fig. 1 MLCB integrated in EU DEMO BL2017 sector

Fabrication of fuel-pin mock-up see P4.161

Manufacturing status of gas cooled FW see P4.162

- 16 Blanket Sector in EU DEMO BL2017
- Single Module Segment (SMS), facilitates the filling and draining of the molten lead, but also increases the tritium breeding performance

- Fission-like fuel-breeder pin configuration
- Molten Lead as neutron multiplier
- Helium as coolant, inlet/outlet temperature:300/520 °C

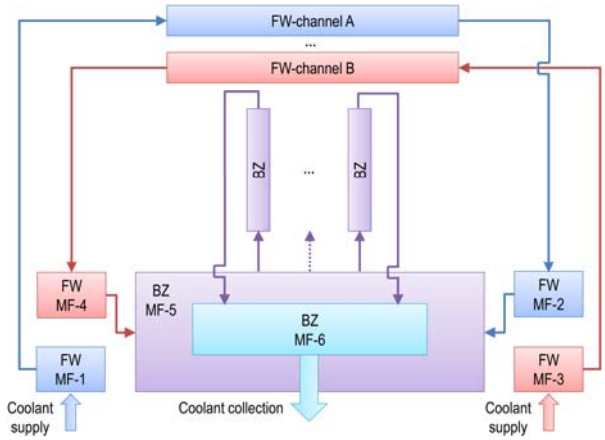

Fig. 2 Schematic flow scheme of the current MLCB

Conclusions

- The basic structure and thermal hydraulic scheme of the newly proposed MLCB breeding blanket have been described.
- Results show that the current MLCB meets the basic nuclear and thermo-mechanic-hydraulic requirements, setting the path for a consolidated design of this concept.

Results and Analysis

Fig. 3 Power densities of different materials

see P1.175

Fig. 4 Design iterations of BSS

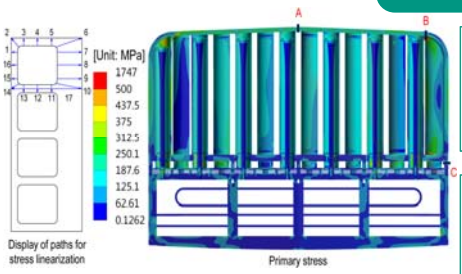

Fig. 5 Primary stress under in-box LOCA

Neutronics analysis

- IB/OB BZ radial build: 0.38/0.61 m
- Tritium Breeding Ratio: 1.17 (1.13)
- Nuclear heating in Fig. 3
- Thermal power by MLCB: 1.96 GW

TM analysis at in-box LOCA

- BSS design be iterated based on TM analysis under in-box LOCA
- Optimized BSS desgin fulfils damage modes induced by primary stresses under RCC-MRx rules

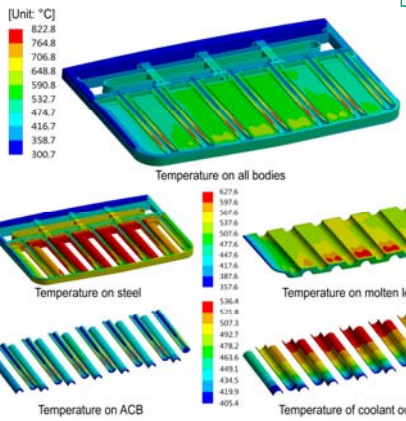

Fig. 6 Temperature distribution of typical MLCB unit slice

TH analysis at normal cond.

- Maximal temperatures are 822.8, 550.9 and 627.6 °C for ACB, EUROFER and molten lead
- Temperatures within design limits
- Temperature distribution in Fig. 6

PHTS hydraulics

- Max. pressure drop reduced to 2.9 and 3.11 bar for OB and IB
- One blower carries 3.2~4.8 MW circ. power
- Achievable based on existing High Temperature Reactor blower technology

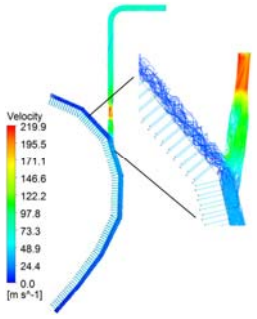

Fig. 7 Streamline at inboard BZ outlet manifold

TM analysis at normal cond.

- Robust global structural performance at FW, BZ, BSS.
- Improvement needed for connecting regions of BZ and BSS

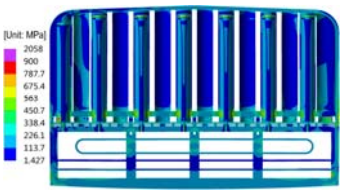

Fig. 8 P+Q stresses of typical MLCB slice

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