§20. Feasibility Study of LiPb-He-SiC High Temperature Blanket Concept

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1. Introduction

High temperature blanket for efficient and attractive energy conversion is one of the most important subjects in fusion technology. Blanket concepts based on the combination of LiPb breeder/coolant, SiC and helium are of particular interests for high efficiency blankets applied in many DEMO reactor blanket designs. It is expected to be feasible in near term targets such as ITER/TBM, and by staged development strategy it would eventually achieve high operating temperature for near future machine, including helical reactor concept, that is expected to have better performance beyond current fission reactors are operated. In the past, we obtained the datanof tritium behavior in SiC-LiPb system such as solubility and diffusivity. This report describes the achievement of the results of the study under the LHD collaboration that confirmed the feasibility of the concept from the aspect of tritium processing..

2. Blanket design

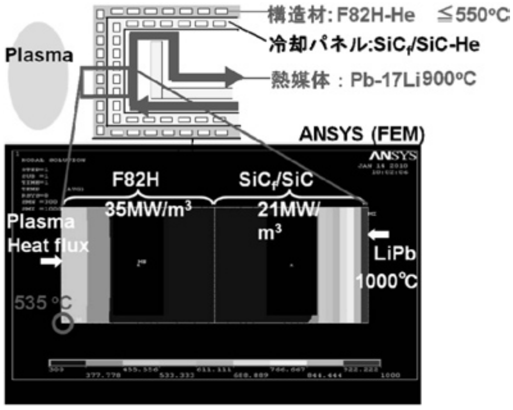
Proposed structure and its thermal performance of the cooling panel made of SiC composite, that can actively cool and thus achieves controlled isolation between LiPb and ferritic steel is shown in the figure 1. The outer vessel is made of ferritic/martensitic steel cooling panel with proven technology. The tritium breeder and multiplier is LiPb eutectic to be slowly circulated to recover the fusion heat. While temperature of the RAFM is kept below 550 degree, the product LiPb can be obtained at the temperature of 1000 degree C. MHD pressure drop is calculated and shown in the Fig. 2. It was found pressure drop will not require significant power for circulation.

3. Tritium recovery system

Based on the data of the permeability of deuterium through SiC/SiC material and solubility in LiPb both obtained in this work conducted last year, tritium recovery system was designed based on vacuum sieve tray concept. Because tritium accompanies with heat transfer media, recovery ratio requirements for the device is obatained as the function of tritium permeability through the heat exchanger material. If permeation is small, tritium concentration in the coolant could be larger. As shown in the fig. 3. recovery ratio around 40% is sufficient, and the experiments supports the design. Approximately 1mm diameter of the LiPb droplets were made in the experiment, and tritium release was estimated by diffusion data.

4.Conclusion

This study covered the feasibility evaluation of the new concept of high temperature SiC-LiPb blanket. We designed the concept of the blanket structure, and analyses on heat transfer, neutronics, MHD, and tritium transfere were made. Some are supported by experiments. As the conclusion, feasibility of the concept was confirmed, and the concept of this blanket is attractive while technically possible with the current studies in the near future.



Fg.1 Thermal analysis of the cooling panel structyre of the SiC-LiPb blanket.

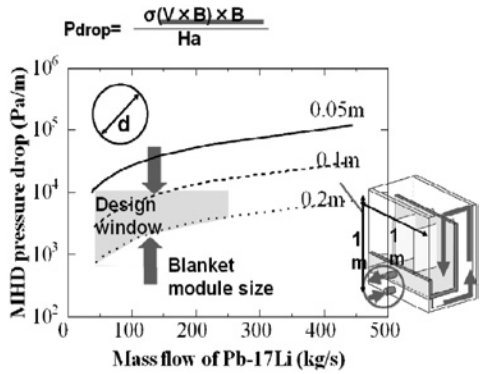


Fig.2 MHD pressure drop analysis of LiPb in the blanket module.

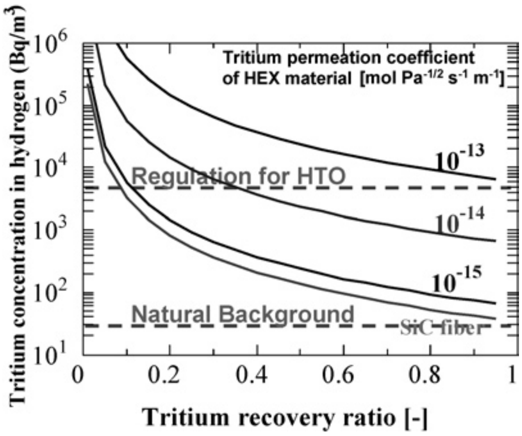


Fig.3 Required tritium recovery ration for the vacuum sieve tray as the function of tritium permeability through the SiC used for heat exchanger.