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

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i). 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.. This report describes the achievement of the third year activity under the LHD collaboration.

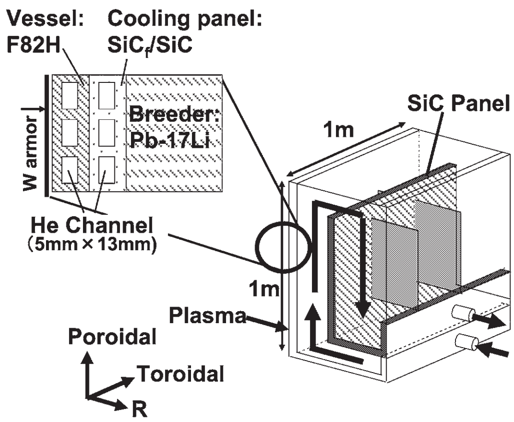
2. Outline of the study

We proposed to use the cooling panel made of SiC composite, that can actively cool and thus achieves controlled isolation between LiPb and ferritic steel as 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 at the tempeture above 900 degree C. Neutronics and thermal hydraulics calculation and the design based on them was made.

Fabrication of SiC/SiC cooling panel shows the feasibility of fine structure for helium flow channel as shown in the figure. This technique is developed and being tested in the high temperature ceramic heat exchanger program, that also enables the energy utilization such as high efficiency generation or hydrogen production at above 900 degree C. High temperature LiPb loop is operational above 900 degree C for experiments on heat transfer, material compatibility, MHD pressure drop, and hydrogen transport under the program of the heat exchanger development, that is applicable for this research. Hydrogen behavior in SiC materials and the information on chemical equilibrium with LiPb are identified to hare significant impacts on the blanket design.

3. Permeation and LiPb-T system

We measured permeation of hydrogen isotopes through SiC composite as well as raw materials powder and fibers, and found various permeation paths; bulk, grain boundary and other phases such as additives or carbon coating on fiber make different consequences. Figure2 shows the difference of the diffusion coefficient of various SiC materials. It was found that fiber has the lowest diffusivity, and permeation is dominated by the interface



Fg.1 Concept of the high temperature SiC-LiPb blanket.

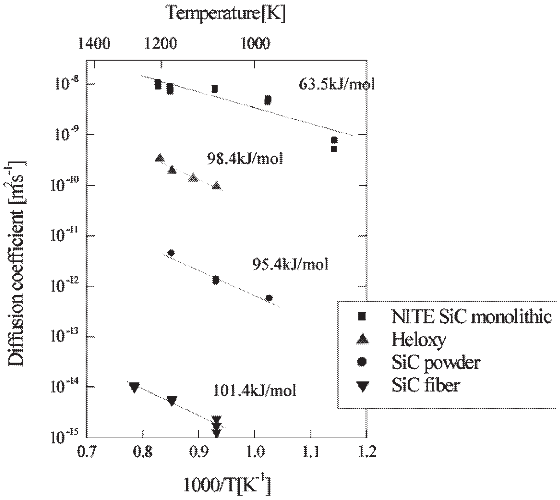


Fig.2 Tritium breeder blanket system

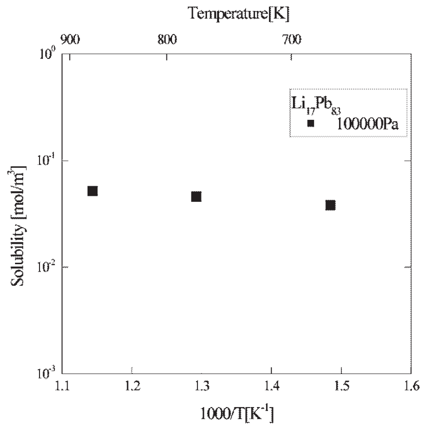


Fig.3 Solubility of deuterium in LiPb

layer on the fiber. Solubility of deuterium in LiPb was also measured.

4.Conclusion

Based on the results, we can design LiPb-SiC high temperature blanket with satisfactory tritium inventory, and permeation loss problem.