

## **Summary of Chapter 9: Li<sub>2</sub>O Particulate Flow Concept**

The APEX (Advanced Power Extraction) (1) and ALPS (Advanced Limiter-divertor Plasma-facing Systems)(2) are two new programs in the US to investigate advanced, high performance blanket and divertor concepts. One of the goals is to be able to handle very high neutron wall loading and surface heat flux. One possible concept is to allow the coolant/breeding material facing directly to the plasma.

The desirable material properties of the coolant/breeding material are,

1. Low vapor pressure at high temperature
2. Low activation
3. Good tritium breeding capability
4. Low electrical conductivity
5. High thermal conductivity
6. Low tritium solubility

The selection of the coolant/breeding material is a compromise among all these requirements. After reviewing the potential candidates of the available coolant/breeding materials, the solid breeder Li<sub>2</sub>O was identified has good potential to fulfill most of the requirements.

Since the coolant will be facing the plasma, the low vapor pressure requirement becomes most important. Based on ITER assessment (3), the total vapor pressure over Li<sub>2</sub>O is very low. At 1000C, the combined vapor pressure of all the possible components is about 10(-5) torr. Therefore, the Li<sub>2</sub>O can be heat up to a very high temperature without worrying about plasma containment. Thus, a high temperature blanket design is possible, which can be used to develop a high thermal converting efficiency system. For comparison, the vapor pressure of lithium is 40 torr at the same temperature.

Figure xxx shows the concept design of the system. The Li<sub>2</sub>O particulate will be fed to the reactor system through a feed tube by gravitational force. After the particulate enters the reactor, it will be directed toward the inner and outer blanket regime by a solid baffle, made by SiC. Upon entering the IB and OB regime, the Li<sub>2</sub>O flow will be divided into two separate streams. The stream facing the plasma will free drop down by gravitational force, while the flow of the stream in the blanket will be restricted by an opening at the bottom of the blanket regime to slow down the flow. It is important to reduce the flow velocity of the blanket coolant to achieve a high coolant DT for optimum power conversion. A computer code has been developed to simulate the flowing of solid particles in a gravitational flow. (4)

Both Li and O are low activation materials. The only activation product from lithium is tritium, which is required for the fuel of the D-T plasma. The activation from oxygen is very low. The only activation is from the structural material inside the blanket,

and from the shielding behind the blanket. All the structural materials are qualified for class C waste disposal (5).

Li<sub>2</sub>O has good tritium breeding potential. This is partially due to the high lithium density in the Li<sub>2</sub>O, which is higher than the lithium density in the pure lithium. This is only one of the few breeding material, which has the potential to sufficient tritium without neutron multiplier. With the low structural fraction in the APEX type design, the tritium breeding will not be a serious issue. Neutronics calculations confirmed the tritium breeding capability (6).

Li<sub>2</sub>O has very low electrical conductivity. Therefore, MHD will not have severe impact of the flow of the Li<sub>2</sub>O stream.

The thermal conductivity of Li<sub>2</sub>O is rather low. This causes problem on removing surface heat, which will be the issue on the divertor and the first wall of the blanket. The heat transfer issue can be alleviated due to the high allowable surface temperature of the Li<sub>2</sub>O. Also, increase of the Li<sub>2</sub>O velocity will increase the heat removal capability of the Li<sub>2</sub>O flow.

The tritium solubility in the Li<sub>2</sub>O is rather low (3). The solubility reduces as the temperature of the Li<sub>2</sub>O increases. Therefore, for high system like APEX, the total tritium inventory in the blanket is calculated to be less than 10 g.

Many issues remained to be resolved: The more critical issues are

1. Cooling of the solid baffle.
2. Impact of oxygen contamination to the plasma.
3. Material erosion and attrition issues.
4. Solid material transport.
5. Solid to gas heat exchanger design with the solid in vacuum.