## §28. Conceptional Design of Fusion Power Plant

Nagayama, Y., Tanaka, Y. (Nagoya Inst. Tech)

A concept of fusion power plant has been designed. Schematic view of the fusion power plant is shown in Fig.1. In the plasma, fusion reactions of deuterium and tritium nuclei make 14 MeV neutrons and 3.5 MeV alpha particles. In the blanket, nuclear reaction of $^9$Be with high energy neutron doubles the neutron and loses particle energy, and nuclear reaction of $^6$Li with low energy neutron produces tritium and energy. Here $^9$Be is heated by the kinetic energy of 14 MeV neutrons. The tritium breeding ratio (TBR) and the performance of neutron shield are calculated by using the neutron transport code "MCNP-4C2" and the nuclear database "ENDF/B". The plasma confinement system is super-conducting spherical tokamak reactor JUST[1], which have a blanket replacement system for neutron damage, a steady state operation with high bootstrap current fraction, and a liquid divertor for high heat flux. The neutron power is 1.9 GW and the neutron flux on the mid plane is 4.5 $MW/m^2$. The 80cm thick inboard side blanket consists of the 75 cm thick water cooled iron and the 5 cm thick $TiH_2$ reflector. This reduces the high energy (>100 keV) neutron flux less than $1.4\times10^{14}$ $m^{-2}$.

Cross-sectional view of blanket is shown in Fig.2. The coolant of blanket is liquid lithium. As the beryllium is heated by the 14 MeV neutrons, the beryllium is cooled directly by the liquid lithium. The blanket of natural lithium and beryllium has TBR=1.43. The coolant carries the heat from the blanket to the heat exchanger and tritium from the blanket to the tritium separator. In the heat exchanger, which is shown in Fig.3, the heat is transferred to the steam to drive the turbine generator by using the mercury vapor. In order to transfer the thermal energy of 2.2 GW, mercury of 8 ton/sec is vaporized. The chamber is evacuated, as no tritium leak to the water is allowed. Suppose the thickness and the area of heat exchanging wall are $t_w$=2 mm and $A_w$=5000 $m^2$, respectively, the flow rate of lithium coolant is 2 m/s. The temperature of this power plant is shown in TABLE 1. The wall temperature is so high that lithium vapor does not attach the wall but comes back to the lithium pool in the divertor. F82H steel is useful at this temperature (820 K). The efficiency of electric power generation is 33.5%, assuming Rankin cycle.

TABLE 1. Temperatures in the fusion power plant.

| Reactor Components | Temperature (K) |
|---|---|
| Blanket (Be ball, wall) | 820 |
| Li coolant in blanket | 682(in) – 767(out) |
| Mercury in Heat Exchanger | 630 |
| Steam | 620(in) – 320(out) |

1) Nagayama, Y., Shinya, K., Tanaka, Y.: IEEJ Trans. FM, **132** (2012) No.7.

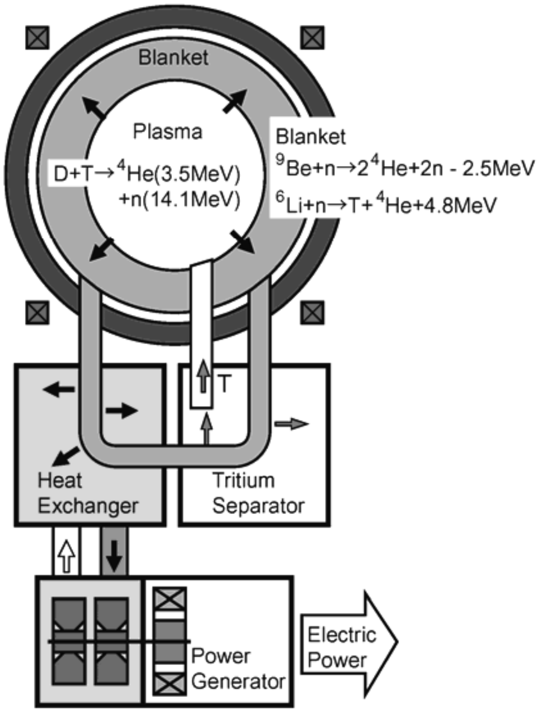


Fig.1. Schematic view of a fusion power plant.

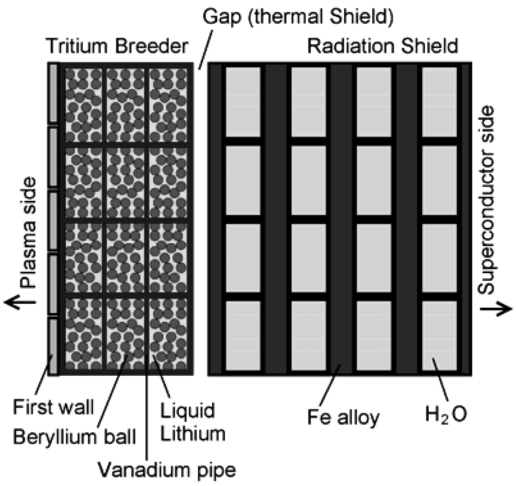


Fig.2. Cross-sectional view of blanket.

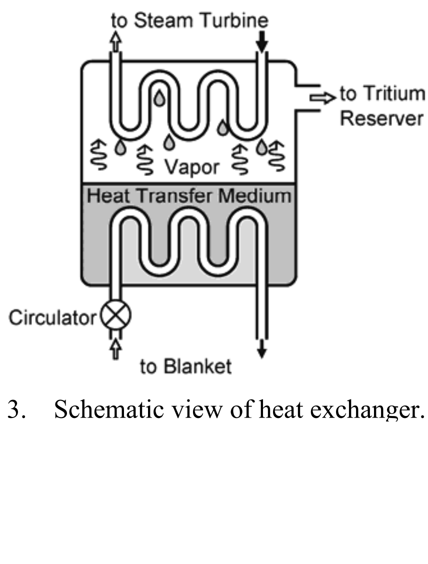


Fig. 3. Schematic view of heat exchanger.