§16. First Plan of the Divertor Component Arrangement and the Divertor Pumping Scenario for FFHR-d1

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Main function of the divertor in fusion reactors is exhaust of helium ash and unreacted fuel particles. The latter has to be sent to fueling system as soon as possible to reduce tritium inventory in the fusion plant. In this report, the first plan of the divertor component arrangement and the divertor pumping scenario for FFHR-d1 is proposed.

In FFHR-d1, in which 3 GW fusion output is generated, the fusion reaction rate in the core plasma is ~$2x10^{21}$ /s, and that is the exhaust rate of the helium ash. On the other hand, the exhaust rate of the unreacted fuel particles is much larger than that of the helium ash. Recent estimation of the fueling rate with ice pellet injection shows that the necessary fueling rate is $1x10^{23}$ molecules/s[1)]. The divertor component arrangement and pump system have to satisfy the exhaust condition.

The first plan of the arrangement is depicted in Fig. 1. The divertor plates are installed beside of the helical coil cans. The baffle plates are installed to separate the divertor room and the main chamber, and the neutral pressure in the divertor room can be risen. The helium ash and unreacted fuel particles are exhausted from the pumping ducts. As shown in Fig. 2, the pumping ducts are beside the blanket in the top and horizontal ports. The width is around 50 cm. To prevent the neutron streaming, the ducts are not straight.

Figures 3 and 4 show the schematic view of the pumping and fueling system. C1 and C2 are conductance from the main chamber to pumping manifold and from the manifold to the pump, respectively. C1 can be estimated to be ~ 60,000 m^3/s for 10 toroidal sections with the assumption of the neutral pressure around the duct to be 1 Pa and the pressure drop is 0.5 Pa [2)]. C2 can be estimated to be ~10,000 m^3/s [2)]. As the result, total conductance of C1 and C2 is ~8,000 m^3/s and it is enough larger than the necessary pumping flux of unreacted fuel particles, ~400 m^3/s. As shown in Fig. 4, the neutral particles in the divertor are pumped from the top, bottom and horizontal ports at 10 toroidal sections. The pumping pipes from the ports connect to the pumping manifold which is surrounding the FFHR torus. And there are some vacuum pump systems. About the vacuum pump itself, we have not decided the type of the pump.

The divertor plates are shielded by the blanket from the main plasma in which the high energy neutron generated in FFHR-d1. That means the 14 MeV neutron flux to the divertor plates could be much smaller than that in tokamak-type fusion reactor. It can be an advantage from the viewpoint of the maintenance. The time for replacement can be longer than that in tokamak-type reactor.

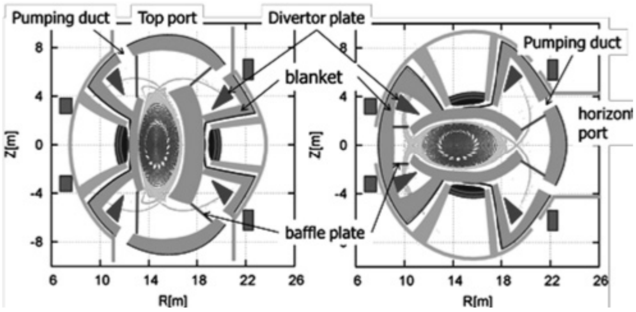

Fig. 1. First plan of the divertor component arrangement.

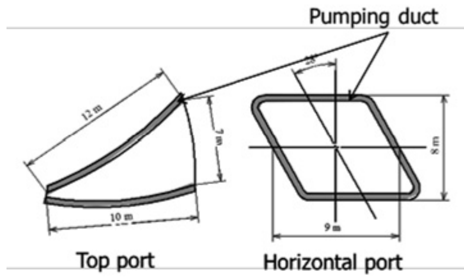

Fig. 2. Pumping duct (green colored parts) in the top and horizontal ports.

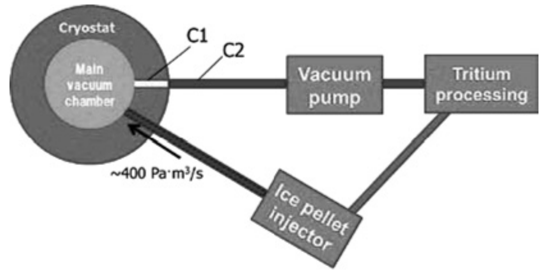

Fig. 3. Schematic view of the pumping and fueling system.

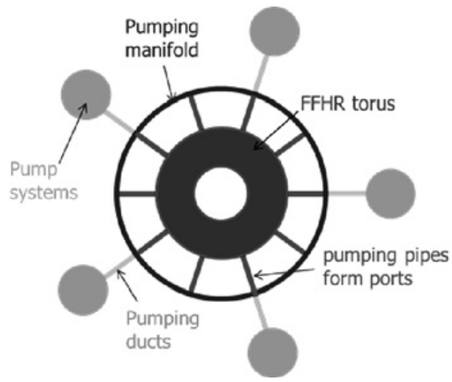

Fig. 4. Schematic top view of the pumping system.

1) Sakamoto, R.: NIFS-MEMO-64 (2013) 45.
2) Masuzaki, S.: NFIS-MEMO-64 (2013) 123.