§10. Conceptual Design of Heat Engine of Fusion Reactor

Kondo, M., Nakajima, Y. (Tokai Univ.),
Chikaraishi, H., Tanaka, T., Sagara, A.

The conceptual design of heat engine in liquid breeder type demonstration (DEMO) fusion reactor was performed. In the present work, the reactor power was given as 1GW, and the input to the blanket system was 0.8GW and that to the diverter was 0.2GW. The energy gain in the blanket was given as 1.3, and the energy output of the blanket was 1.04GW.

The design of the coolant system of the fast reactor MONJYU was investigated in detail, and the applicability to the DEMO fusion reactor was investigated. Then, the blanket system was designed with four-loop blanket system with the MONJYU type helical coil heat exchanger. The energy efficiency of the heat exchanger was 0.97. Liquid breeder Li, Pb-Li or Flibe was applied to the primary coolant. The coolant in the secondary loop was pressurized water. Then, the flow rate of the coolant and the temperature conditions in the primary and secondary loops were evaluated based on the energy balance. The results were summarized in Table 1 and Table 2. In this condition, the plant efficiency of DEMO fusion reactor was roughly estimated as 22%.

Table 1 Flow rate of coolant and temperature conditions of primary coolant system

	Reactor power[GW]	Coolant in primary loop	Number of cooling loops	Core inlet temperature [K]	Core outlet temperature [K]	Mass flow rate (kg/s)/ (m^3/s) at core outlet
MONJU	0.714	Na	3	670	802	$3.15x10^3$ / 3.83
Fusion DEMO	Blanket output			Inlet temperature of fusion blanket	Outlet temperature of fusion blanket	
Case 1	1.04	Li	4	673	823	$1.65x10^3$ / 3.43
Case 2	1.04	Pb-17Li	4	673	823	$36.9x10^3$ / 3.86
Case 3	1.04	Flibe	4	781	823	$2.91x10^3$ / 1.47

Table 2 Flow rate of coolant and temperature conditions of secondary coolant system

	Evaporator inlet temperature [K]	Superheater outlet temperature [K]	Mass flow rate (kg/s)	Log mean temperature difference in heat exchanger [K]	Coefficient of overall heat transfer [W/m^2K]
MONJU	513	760	$1.03x10^3$ / 7.47	43.2	$4.18x10^3$
Fusion DEMO	Evaporator inlet temperature [K]	Superheater outlet temperature [K]	Mass flow rate (kg/s)	Log mean temperature difference in heat exchanger [K]	Coefficient of overall heat transfer [W/m^2K]
Case 1	513	760	$0.317x10^3$ / 10.4	104	$1.89x10^3$
Case 2	513	760	$0.317x10^3$ / 10.4	104	$1.89x10^3$
Case 3	513	760	$0.317x10^3$ / 10.4	141	$139x10^3$