§14. Hydrogen Production by 1 GW Electric Power of the FFHR

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To assess the technical potential of the FFHR operation style, dedicated hydrogen production from electrolysis by the electric power of 1GW is investigated [1]. Schematic illustration of co-generation of electricity and hydrogen is shown in Fig. 1. Gaseous hydrogen of 700 tons per day can be produced. The steam of 6,354 tons per day at 150 °C is necessary in this case. In FFHR, about 300 MW of thermal power is delivered via the scrape-off layer plasma to the divertors with double-null structure. The divertor may be one of the potential heat sources to produce the steam for the electrolysis.

Hydrogen has to be packaged by compression or liquefaction, transported by trailer or pipeline, stored, and transferred to the end users. The compression of gas requires the energy, and the compression works depends on the thermodynamics of the compression process. The energy consumption of a multi-stage hydrogen compressor is about half-way between the two theoretical limits of an isothermal and adiabatic compression process. About 17.4 MW of electrical power are needed for the compression of 100 ton per day of hydrogen from 0.1 MPa to typical pressure of 50 MPa. Even more energy is needed to compact hydrogen by liquefaction. Required power of the helium compressors is about 2.7 times larger than that of the hydrogen compressors. The total power consumption of the hydrogen liquefaction system of 100 tons per day is estimated to 26 MW. According to the scaling law, the power consumption of the hydrogen liquefaction of 700 tons per day is estimated to be 182 MW. The relationship between electricity and hydrogen production as a function of fraction to electrolysis is shown in Fig. 2.

Figure 3 gives power flow diagram from fusion output to power generation and electrolysis. The four different styles of plant outputs are investigated: (A) pressurized hydrogen of 625 tons per day, (B) liquid hydrogen of 574 tons per day, (C) 1 GW of power generation, and (D) 0.824 GW of electricity production plus 100 tons per day of liquid hydrogen. Case (A) and case (B) are dedicated hydrogen production and these cases are desirable as the infrastructure for the future fuel cell society. Case (C) is suitable for a largely constant level of power demand as well as a nuclear fission power plant. Case (D) has the flexibility in plant operation. Electrical power to the grid can be modulated if the excess electricity were used for the hydrogen production, at the constant power generation. This fraction rate of case (D) is also appropriate for the levelization between on-peak and off-peak demand.

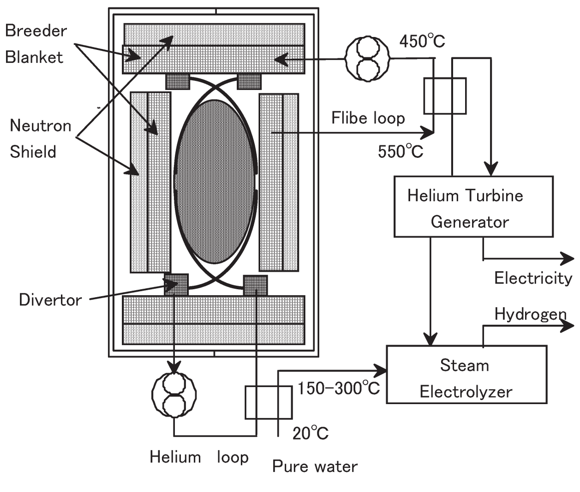

Fig. 1. Schematic illustration of co-generation system of hydrogen and electricity.

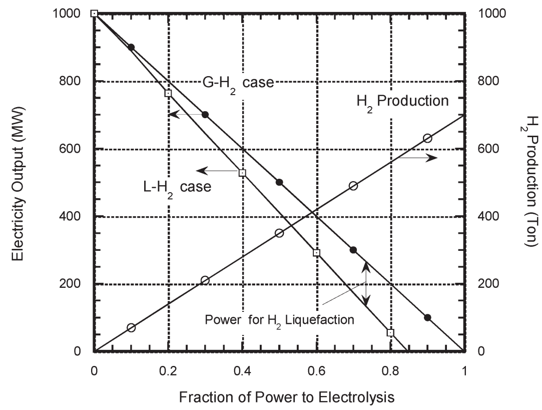

Fig. 2 Electric power and hydrogen production vs. fraction of power to electrolysis.

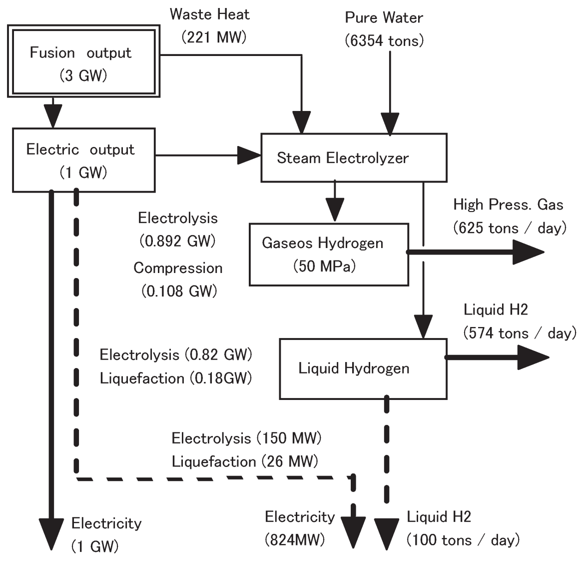

Fig. 3. Power flow from fusion output to power generation and electrolysis.

Reference

1) S. Yamada et al: presented at 24th SOFT, Warsaw, Poland, 11-15 Sept. 2006, P3-J-333.