9 Nuclear Hydrogen and Heat Application Research

Research and Development on Naturally Safe HTGR and Nuclear Heat Application Technologies

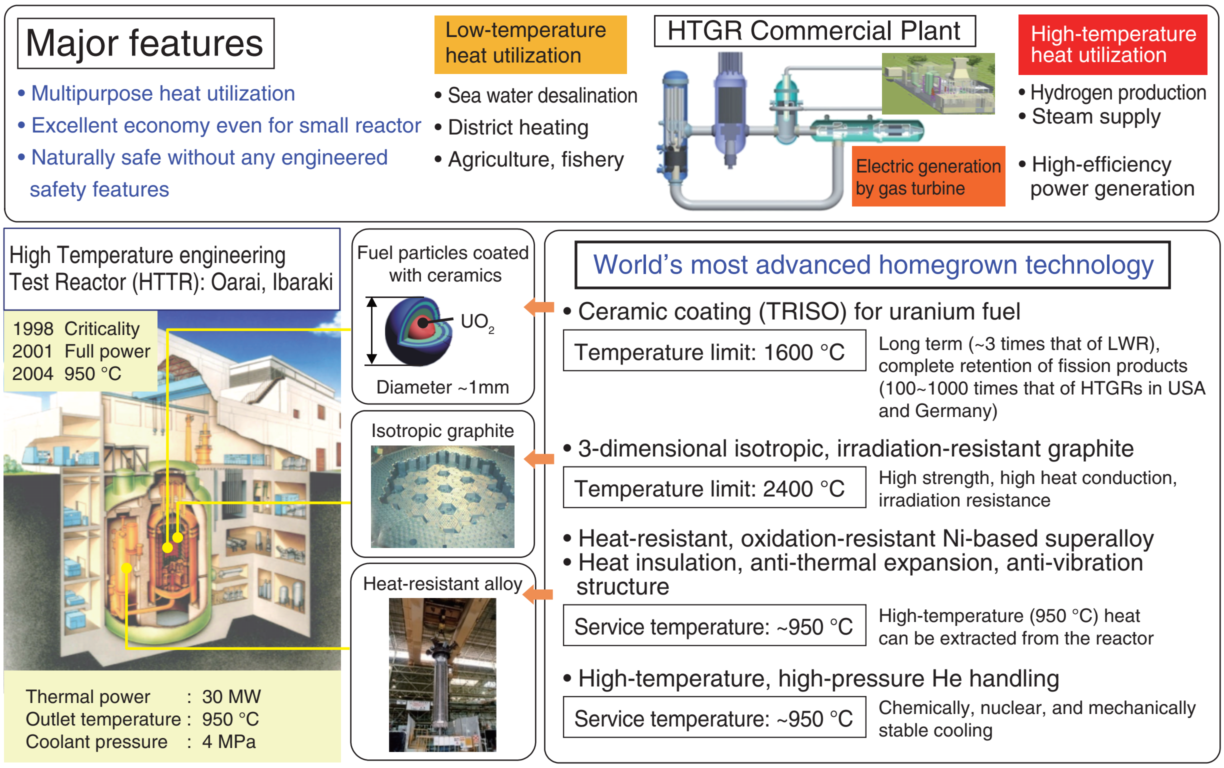

Fig.9-1 Outline of HTGR with features, heat utilization, major specifications, and technologies of HTTR
The HTGR is a thermal neutron reactor, helium gas cooled and graphite moderated, and can meet various heat production requirements. In particular, the HTGR can be a naturally safe nuclear reactor, and it is strongly expected to regain the public trust in nuclear power.

We have been conducting research on the naturally safe High Temperature Gas-cooled Reactor (HTGR) and its applications in our contribution to building a low-carbon society.

The HTGR can supply high-temperature heat at 950 °C, well exceeding the 300 °C of current light water reactors (LWRs), by using inert helium gas instead of water as a coolant. The same amount of fission energy from uranium can produce a greater quantity of electricity and hydrogen when higher temperature heat is obtained from the reactor.

Three other cutting-edge Japanese technologies that make it feasible to obtain such high-temperature heat in the HTGR have been developed by the Japan Atomic Energy Agency. The first is fabrication technology for ceramic-coated fuel particles about 1 mm in diameter. Ceramics remain stable even at 2500 °C and provide superior heat-resistant coating layers to contain radioactive fission products within the fuel particles. The second is fabrication technology for isotropic and irradiation-resistant graphite blocks. Graphite is generally non-isotropic in that its material properties such as strength and thermal conductivity are dimension-dependent, which is to be avoided in reactor construction. The third is a manufacturing technology for heat-resistant and oxidation-resistant superalloys with careful composition of the alloy content. With these major technologies and further development of expertise in high-temperature structural design and helium gas handling, we successfully produced high-temperature heat at 950 °C from the reactor in 2004 for the first time worldwide (Fig.9-1).

The heat from the HTGR is useful not only for power generation but also for the production of hydrogen for fuel cell cars and direct reduction iron-making, and of a steam supply for industry. The waste heat can be used for district heating and desalination. The thermal discharge to the environment can be dramatically reduced to less than 30%, compared to 67% for an LWR.

It is feasible to prevent accidental overheating and oxidation of the fuel coating layers and explosive gas generation using physical phenomena without any engineered safety features. The self-regulating features assure no harmful release of radionuclides to the general population and the environment in any accident. It is this unique safety advantage of the HTGR that is expected to regain the public's trust in nuclear power, which is strongly needed after the accident at the Tokyo Electric Power Company, Incorporated Fukushima Daiichi Nuclear Power Station.

The conceptual design of a small HTGR that has excellent safety and economic potential has been completed, and the first draft of the safety design philosophy for the HTGR hydrogen production system has been presented. Furthermore, research on improving the efficiency of the thermochemical iodine–sulfur process is ongoing (Topics 9-1, 9-2, 9-3).