9 Nuclear Hydrogen and Heat Application Research

Research on a Naturally Safe HTGR for a Low-Carbon Society

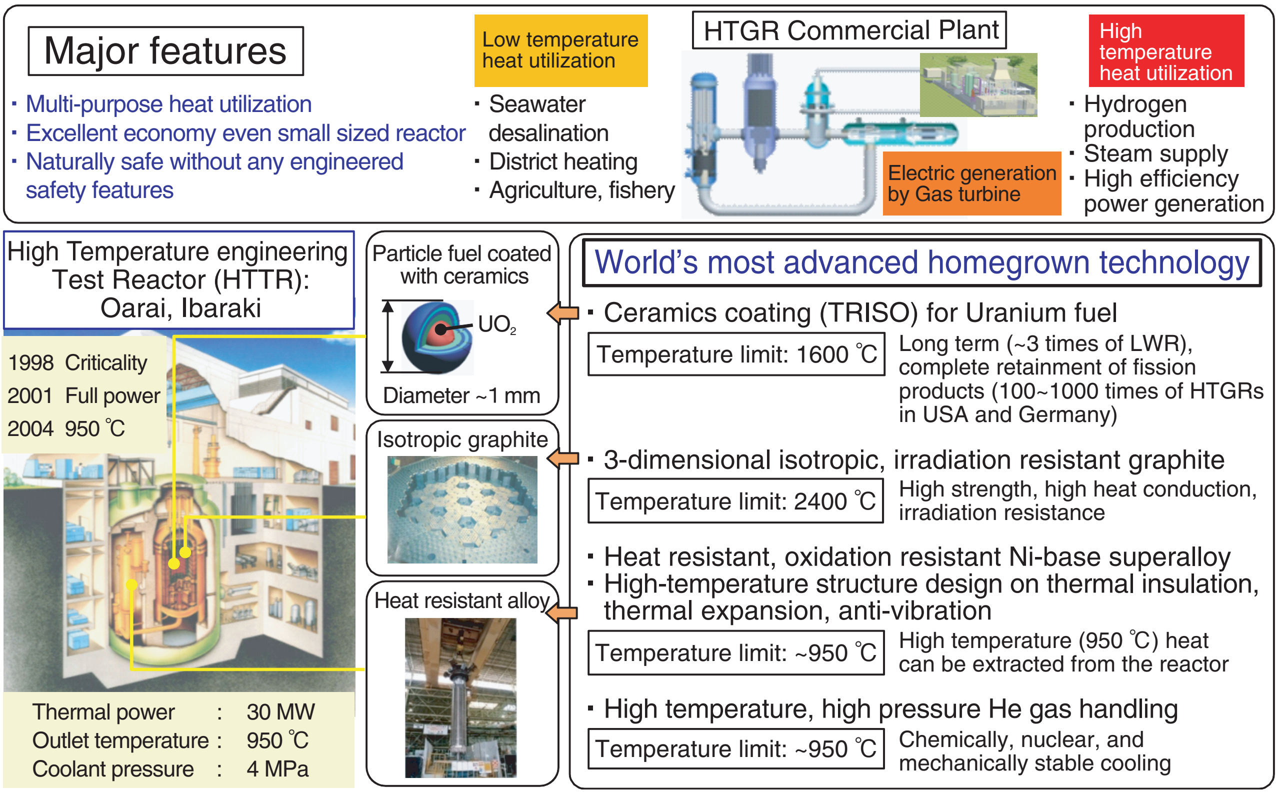

Fig.9-1 Outline of HTGR: features, heat utilization, major specifications, and technologies of HTTR
The HTGR is thermal-neutron reactor that is cooled by helium gas and is moderated with graphite. It can meet various heat production requirements; in particular, the HTGR can be a naturally safe nuclear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

We have been conducting research on a naturally safe high-temperature gas-cooled reactor (HTGR) and its applications toward building a low-carbon society.

The HTGR can supply heat at temperatures of 950 ℃; this exceeds the 300 ℃ heat currently provided by light water reactors (LWRs). This is accomplished using inert helium gas, instead of water, as the coolant. When high-temperature heat is obtained from a nuclear reactor, the same amount of fission energy from uranium can produce greater quantities of electricity and hydrogen.

Three other cutting-edge Japanese technologies, developed at the JAEA, make it feasible to obtain such high temperatures from an HTGR. The first is a fabrication technology for producing ceramic-coated fuel particles of approximately 1 mm diameter. Ceramics remain stable even at 2500 ℃ and provide superior heat-resistant coatings that can contain radioactive fission products within fuel particles. The second is a fabrication technology for isotropic and irradiation-resistant graphite blocks. Generally, graphite is non-isotropic; that is, material properties of graphite, such as strength and thermal conductivity, are dimension-dependent, and materials having dimensionally dependent properties are typically avoided for reactor construction. The third is a manufacturing technology for a heat-resistant and oxidation-resistant superalloy whose contents have been carefully controlled. With these major technologies, together with further developments of know-how for high-temperature structural design and helium-gas handling, we used the HTGR to successfully produce high-temperature heat at 950 ℃. This was done in 2004, for the first time in the world. (Fig.9-1).

The heat from the HTGR is useful for power generation, for hydrogen production in car fuel cells, for direct-reduction ironmaking, and for steam supply to various industries. Waste heat can be used for district heating and desalination. The thermal discharge to the environment can be drastically reduced from 67% using an LWR to less than 30% using an HTGR.

HTGRs have inherent self-regulating features that, in any accident, prevent a harmful release of radionuclides to the environment and surrounding populations. Specifically, no engineered safety features are required to prevent accidental overheating, oxidation of fuel-coating layers, and generation of explosive gases. This unique safety advantage of HTGRs is expected to regain "the public trust" in nuclear power following the accident at the Tokyo Electric Power Company, Incorporated Fukushima Daiichi Nuclear Power Station (Topics 9-1, 9-2, 9-3).

Elsewhere in the world, national projects are being carried out for constructing commercial HTGRs. China has started construction of the first unit. The US has completed the conceptual design of a Next Generation Nuclear Plant and has proceeded to the next design stage. Kazakhstan is planning a feasibility study on HTGR construction.