Perspectives on the Role of JAEA towards Industrial Application of HTGR

OECD/NEA WS High temperature reactor and industrial heat application
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Document Overview

- HTTR Technical Features, Operation & Licensing Experience, Future Tests
- Perspectives on the role of JAEA towards Industrial Application of HTGRs
HTTR: High Temperature Engineering Test Reactor

The only prismatic-type High Temperature Gas-cooled Reactor (HTGR) in operation in the world

**Major Specifications**
- Thermal power: 30 MW
- Fuel: Coated fuel particle / Prismatic type
- Core material: Graphite
- Coolant: Helium
- Inlet temperature: 395°C
- Outlet temperature: 950°C
- Pressure: 4 MPa

**Major Achievements**
- First criticality: November, 1998
- Full power operation: December, 2001
- 50 days continuous 950°C operation: March, 2010
- Obtain permission of changes to reactor installation in conformity to: June, 2020
- New Regulatory Requirements: July, 2021
- Restart operation: July, 2021
Technical Features of HTTR

- **Capable to supply high temperature heat**
  - 50 day continuous operation at 950°C reactor outlet temperature demonstrated
  - Maximum 905°C, 10MW high temperature heat can be supplied by modification of the secondary helium cooling system

- **HTGR safety feature demonstration tests licensed by regulator**
  - Key safety features of HTGR can be demonstrated by actual test
    - intrinsic shutdown without control rod insertion, passive decay heat cooling from outside of reactor, etc.

**Diagram**

- Reactor Containment Vessel
- Vessel Cooling System
- Primary Cooling System
- Auxiliary Cooling System
- Main Cooling System
- Water pump
- Air cooler

- **IHX**: Intermediate heat exchanger
- **PPWC**: Primary pressurized water cooler
- **AHX**: Auxiliary heat exchanger
- **GC**: Gas circulator
- **SPWC**: Secondary pressurized water cooler

- High temperature heat of 905°C, 10MW can be supplied

- 50 day continuous operation at 950°C reactor outlet temperature demonstrated
- Maximum 905°C, 10MW high temperature heat can be supplied by modification of the secondary helium cooling system

**Notes**

Licensing Experiences of HTTR

- Following the nuclear accident at the TEPCO’s Fukushima Daiichi nuclear power station on March 11, 2011, revised regulatory requirements were issued by the Nuclear Regulation Authority (NRA) in July 2013.
- **JAEA had submitted the application** including evaluation results satisfying the New Regulatory Requirements to the Nuclear Regulation Authority (NRA) on **November 26, 2014**.
- Through many discussions with the NRA, **on June 3, 2020, JAEA obtained the permission** by the NRA for changes to Reactor Installation of the HTTR.
- **HTTR has restarted its operation on July 30, 2021**.

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Safety characteristics of the HTTR
Because of the inherent characteristics of basic elements, i.e. refractory coated fuel particles, inert, single-phase helium coolant and graphite moderator with large heat capacity, the HTTR can maintain in a stable state under loss-of-cooling and/or reactivity control conditions.

Obtained permission from NRA to reclassify seismic classification of SSCs to lower class
- Core heat removal: S class to B class
- Reactor internal structure: S class to B class.

HTTR safety demonstration test
- Initial power 30% (9MW)
- Reducing core flow rate to zero by tripping all circulators
- VCS operation maintained
- No scram operation (No CR insertion)

- Reactor intrinsically shut down as soon as the core cooling flow rate to zero.
- Reactor is kept stable long after the loss of core cooling
Licensing Experiences of HTTR - BDBA -

The NRA review concluded that (1) significant core degradation including core melting may not occur by postulated BDBAs* and (2) specific SSCs are not required to cope with BDBAs*

- HTTR has restarted its operation without significant additional reinforcements due to the inherent safety features
- Safety design established through the licensing can be used in commercial HTGR

Remaining items
Establishment of safety standards for commercial HTGR including requirements for coupling heat application system to the nuclear facility and the use of PRA in safety management
High expectation OECD/NEA CSNI/WGRISK activities related to advanced reactors

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HTTR Future Tests

HTTR

- Safety demonstration tests, Other tests
- Other tests

HTTR Heat Application Test

- HTTR modification design/modification
- H₂ plant design/construction

Commissioning → H₂ production test

2022 -

- Restart operation

2029 -

HTTR Safety Demonstration Test (OECD/NEA CSNI LOFC Project)

- Development of safety analysis code system
- Demonstration of HTGR safety features
  - Loss of forced cooling test (All HGC tripped, 100% power)
  - Loss of core cooling test (All HGC + VCS tripped, 30% power)

HTTR-heating Application Test

- Development of coupling technology between HTGR and H₂ plant
- Demonstration of nuclear hydrogen production
  - Continuous H₂ production test
  - Transient simulation test

Diagram: HTTR (left) and H₂ plant (right) with heat removal, water cooling, and primary helium gas.
Perspectives on the role of JAEA

Role of JAEA
- Develop key technologies needed by commercial HTGR
- Provide R&D test beds of unique experimental and computational capabilities, as well as knowledge and databases to industry
- Promotion of international standardization of technologies and standards through international collaboration

**Experiment capabilities**
- HTTR
- H₂ test facility
- HTTR-H₂ system

**Computer capabilities**
- Core neutronic analysis
- Core thermal-fluid analysis
- Fuel performance analysis
- Safety analysis
- Core seismic analysis
- System analysis

**IPs, Knowledge, Databases**
- Core design
- Safety design
- System design
- Fuel design
- Reactor seismic design
- Component design specific to HTGR, He-GT, H₂ plant
- Operation and maintenance

**Validated code systems**
- HTGR vendors

**Commercial HTGR cogeneration plant**

*1: Fuji electric, Fuji Electric Journal, 93(2), 122 (2020).
The HTTR is the only prismatic-type HTGR in operation in the world.

The HTTR can provide valuable data including coupled neutronic/thermal-fluid characteristics, integrated nuclear and chemical plants characteristics, etc. that can be used for validation of safety analysis tools and demonstration of key technologies needed by commercial HTGR.

JAEA established safety design through licensing process by NRA for changes to Reactor Installation of the HTTR in conformity to the New Regulatory Requirements.

JAEA can provide R&D test beds of unique experimental and computational capabilities, as well as knowledge and databases to industry.