TWG-GCR 19 Meeting Report

19th Meeting of the Technical Working Group on Gas-Cooled Reactors

Jan. 17-19, 2005
University of Manchester, UK`

○

Status of International GCR Programmes

- **China** (Xu)

The HTR-10 reached the full power in 2003. In all, six safety demonstration tests were carried out, The results show that the HTR-10 has inherent safety features and computer codes for the design of the HTR-10 are validated.
The project of the HTR-10 with a gas turbine cycle (HTR-10GT) was set up. INET and OKBM (Russia) jointly completed the conceptual design of the power conversion unit in 2002 . The basic design was completed in 2003. The main components are under manufacture and are scheduled for operation in 2006.
A demonstration plant-of the pebble bed modularreactor (PBMR) type (HTR-PM) is being proposed by three parties, namely China Huanneng Group, China Nuclear Engineering and Construction Corporation and Tsinghua University. The parties signed the investment agreement to build the HTR-PM on 16th of December 2004. Meanwhile an EPC company (Chinergy Co.) was established to be responsible for building the HTR-PM. The pre-feasibility study for selection of the site was carried out. The project proposal will soon be submitted to authorities for approval. The location of the HTR-PM will be decided following completion of the pre-feasibility study. Start of construction is foreseen for 2007 and first criticality may be reached in 2010.
It is long tern, China is also interested in nuclear hydrogen production and research on in the chemical process has already started, INET has also established a joint research center for nuclear hydrogen production with KAERI .

- **Indonesia** (Hastowo)

Nuclear Energy in Indonesia is considered as a part of the Energy Mix policy in order to realize security of the energy supply and long-term sustainable development. Based on results of the energy planning study done together with IAEA (Comprehensive Assessment of the Difference Energy Sources for Electricity Generation in Indonesia 2001 - 2002, INS/016/2002) , a medium – large Nuclear Power Plant (NPP) could be accomodated in the Java-Bali electricity grid around 2016, while smaller units could be installed on the other islands, after 2020. The small NPPs could be operated as cogeneration systems in order to provide process heat for other purposes, such as desalination and oil recovery, which is needed in Indonesia. In this regard, a High Temperature Gas cooled Reactor (HTGR) could be selected as a potential NPP.

- **Japan** (Takeda)

The High Temperature Engineering Test Reactor (HTTR), which is the first High Temperature Gas-cooled Reactor (HTGR) in Japan with the thermal power of 30 MW and the reactor outlet coolant temperature of 950 °C maximum, was constructed at the Oarai Research Establishment of the Japan Atomic Energy Research Institute (JAERI) for the purpose of establishing and upgrading technologies of HTGRs as well as nuclear heat utilization.

JAERI have three major HTGR development program, Hydrogen production technology development, reactor technology development and advanced design and gas turbine technology development. The reactor technology can be mainly developed through the HTTR reactor operations.
Since 2002, we have be conducted the control withdrawal tests, gas circulators trip test. After 2006, we have plan to do the loss of forced cooling test, vessel cooling system stop test simulating the all black out condition and depressurization accident simulation test. These tests plan is in the process of licensing approval.
Hydrogen is clean and efficient energy source in the 2020s. We have been developing hydrogen production technologies more that a decade. Especially, a hydrogen production system by water splitting using high temperature heat from the HTGR is carbon emission free ultimately clean system. JAERI has been demonstrated continuous production of hydrogen by thermo-chemical water splitting method, Iodine and sulfur (IS) technology using the bench scale test rig and, and started to design and manufacture a pilot scale IS process test facility.
Advanced HTGR system design and related technology development is one of the major research items in JAERI. The gas turbine electric power generation HTGR GTHTR300 has a highly efficient and economically competitive due to unique features such as horizontal GT layout, usage of LWR material for the RPV.

- **Russian Federation** (Sukharev)

The main field of HTGR's activity in Russia is the joint US/Russia GTMHR design with direct gas turbine cycle. Currently the GTMHR deign is developed for surplus weapons plutonium disposition. For commercial use the GTMHR reactor of 600 MWth power will use low enriched uranium fuel (14%).
The GT-MHR project coordinating committee decided that before final design development starts, all efforts and funds should be concentrated on technology demonstration. A commercial design is foreseen as an effective heat source for hydrogen production.

- **South Africa** (Nicholls)

The project to construct the PBMR Demonstration Plant on the Koeberg site near Cape Town has now been approved with a planned fuel load date of April 2010. The South African Government has announced the intention to include some 4000MW to 5000MW of PBMR plants in the new construction program. The design of the PBMR turbine plant has been revised following a review of the availability of dry gas seals (that allow conventional oil bearings) and compact, high performance, gearboxes. Both these technologies were not commercially available when the original Power Conversion Unit was laid out and with their availability the revised lay out now is a horizontal, single shaft design. The compressors and turbine run at 6000rpm with a 2:1 gearbox allowing a generator speed of 3000rpm.

- **Rep. of Korea** (Chi)

The KAERI VHTR program, ie, Nuclear Hydrogen Development and Demonstration (NHDD) project, was introduced focusing on the R&D on fuel, materials and nuclear graphite after a brief review of the purpose, key technologies, project plan, short term objective(2004-2005) and project organization of the NHDD project
For 2004-2005 the four following R/D works on nuclear graphite are being planned & performed:

1. Preliminary selection of graphite grades for KAERI VHTR conceptual design
   Application for the membership of IAEA international Database on irradiated Nuclear Graphite properties
2. Participation to the ASTM nuclear graphite fracture toughness test (Round Robin)
3. Study of radiation effects on Nuclear Graphite by using an ion accelerator. Some of the results of oxidation studies were introduced focusing on the advantage of accelerator irradiation especially for the study of graphite oxidation.

- **France** (Barbier)

The French program on GCR's is oriented on 2 GEN4 concepts: VHTR & GFR.
For VHTR, the program focus on the following major items to recover the technology in order to be able to propose a commercial plant up to 2017(AREVA; EdF & CEA):

- Fuel triso UO2/SiC particle fabrication is underway and the first French UO2 compacts will be irradiated in 2007. Innovative fuel are also studied to fulfil the high temperature and burn up of VHTR.
- Tests on specific materials are planned : 9Cr steel for reactor vessel, innovative material for IHX above 1000 °C as C/C composite.
- A whole graphite characterization (oxidation, corrosion & behaviour under irradiation).
- Helium test benches: tribometer, thermal barriers, seals, purification loop.
- A 1 Mw helium technological loop (starting construction in 2006) to test components as recuperator, IHX, valves…
- A waste management strategy dedicated both to decrease the hugh mass of contaminated graphite and to fuel reprocessing (Preliminary flowsheets in 2007).
- A development of I/S & EHT processes with inherent safety rules for the reactor-H2 plant coupling.

For the Gas Fast Reactor supported by the French Atomic Energy Commission (CEA), the R&D program is actually focus on selection of a reference design and alternatives: 600 Mwth & 2400 Mwth cores. For a preliminary viability report in 2007, some parameters test on fuel in a critical reactor is planned in 2005 as the viability of the active systems for heat decay removal.
In 2007, the decision of constructing the 50 MWth Experimental Technological Demonstration Reactor will be taken in order to qualify the assembly concept in a first phase then the core concept in the second phase. This will leads to a prototype of GFR construction expected for 2025.

- **Germany** (Von Lensa)

The german government has decided to phase out of nuclear energy. This implies to keep competence especially on safety and waste issues for the safe operation of existing plants and management of wastes.
GCR related activities are mainly adversing:

- decommissioning of AVR
- code validation for safety analysis
- management of spent HTR fuel

Most R&D on GCR is embedded into the EURATOM- Framework Program.

- **Netherlands** (Van der Laan)

The Netherlands government remains with 'no regret' policy on nuclear energy.
Most GCR activities are framed in European Union RTD policies and international collaborations (links to Gen4 through Euratom), with EU co-funding.
The Netherlands R&D activities concentrate on V/HTR Core Physics, Safety Technology, Components Technology, Materials and Fuels (including extensive irradiation testing programmes), as well as some GFR core physics.
New activities are on nuclear hydrogen technologies and system studies for HTR applications in NL and EU energy markets.

- **UK** (Marsden, McDermott)

Nuclear electricity production in the UK stands at about 20%, with 23 operating reactors, including 8 Magnox, 14 AGRs and 1 PWR. Both BNFL and BE are set for restructuring and a new decommissioning authority is being established. Notable activities in decommissioning included the removal and packaging of WAGR graphite core and the removal of the graphite core from GLEEP.
Current and future GCR R&D activities in the UK are focused around contributions to the EC framework programmes (FPs) and the GEN-IV initiative, with the aim of retaining nuclear skills. The UK is taking part in current FP6 projects, including the irradiation project V/HTR-IP, the materials project ExtreMat-IP and the GCFR-STREP project, which addresses gas fast reactor prospects for sustainable energy. At the Materials Performance Center (Nuclear Graphite Research Group) of the University of Manchester, research is focused on nuclear graphite microstructure and radiation damage studies. In addition theoretical and experimental studies are being undertaken on HTR fuel particle coating.

- **US** (Feltus)

The US HTR program is currently focused on fuel design, fabrication and qualification. Termed the Advanced Gas Reactor (AGR) program, it consists of 8 stages, including a shakedown of the reference German design, test fuel fabrication, characterization, irradiation and testing, as well as fuel performance and fission product transport modeling. Participants include INEEL, ORNL and BWXT, with INEEL in charge of the design and irradiation setup at the ATR reactor, BWXT in charge of kernel manufacturing and ORNL of coating and characterization. The fuel will be qualified for high temperature, burnup and fast fluence, as corresponds to the NGNP design and irradiation acceleration will be moderate. The fuel selected is of the UCO type, in order to limit CO and amoeba effects.

- **EU** (Casalta)

Under the 5th framework program (FP5, 1998-2002), 10 HTR projects, co-funded by the European Commission (EC), have dealt with fuel technology, components, core physics, fuel cycle, materials, licensing and educational training. Under the FP6 program (2002-2006), an ambitious integrated VHTR project (V/HTR-IP), with a consortium of 35 partners worldwide, is due to start in 2005 for a period of 48 months. With a total budget of 20 Million Euros 9 of which are contributed by the EC, the project will cover reactor physics, safety, fuel technology, fuel cycles, materials, components and VHTR plants design. A special attention will be given to education & training with organization of two Eurocourses. A link will also be established between V/HTR-IP and other projects such as GCFR on fast gas reactors, ExtreMat-IP on high-temperature materials and HYTEC on hydrogen production.

- **NEA** (Caron-Charles)

The Nuclear Energy Agency (NEA) is an international organization, part of the Organization for Economic Cooperation and Development (OECD) in Paris. Seven technical committees cover nuclear energy aspects, under the aegis of the Steering Committee for Nuclear Energy (twenty eight member countries).
Two working parties of the Nuclear Science committee are involved in Reactor studies and in fuel cycle studies, including activities for advanced high temperature gas cooled reactors.
In parallel to these projects, NEA holds the technical secretariat for Generation IV International Forum (GIF). GIF is a technological project that aims to license new energy systems. The contributing countries and parties will share information.

- **International database on graphite** (Wickham)

Current members include the US, UK, Germany, NL, Japan and Lithuania. The Rep. of Korea has expressed its intention to join. Two meetings have been held since the last report. During the second meeting, a new version of the database software was demonstrated. Participants also expressed strong views regarding quality assurance of the data input to the database.

- **IAEA** (Methnani)

IAEA HTGR activities continue to focus on coordinated research projects (CRPs), information exchange and educational training. Current CRPs include one on benchmarking codes used in HTGR core physics and thermal-hydraulics (CRP-5). With the participation of 10 international institutes, the CRP has made use of data from HTR-10, HTTR, ASTRA and the South African pebble bed micro model (PBMM) facilities, in addition to PBMR & GT-MHR calculations. In their last meeting, participants have expressed the need for a 2-year extension of the CRp, due to close early 2005, to finish 2 additional sets of benchmarks.
The second CRP (CRP-6) is focused on advances in coated fuel particle technology, including design and fabrication, irradiation and testing, performance modeling as well as quality assurance and licensing issues. 9 institutes are currently participating in the work. A new CRP on HTGR potential for co-generated process heat applications is being planned for 2006.
In the area of information exchange, cooperation continues with the HTR-TN network on the HTR bi-annual conferences, the last being HTR-2004, held in Beijing, China (Sep. 2004). In the area of educational training, two workshops were held, one hosted by ICTP, Trieste, Italy (July 2003) and the second hosted by Tsinghua University, Beijing, China (Sep. 2004).

Meeting recommendations

1. CRP-7 should look at other cogeneration applications such as oil recovery, oil shales & coal gasification, in addition to hydrogen & fresh water production.

2. CRP-7 should examine the issue of tritium migration in HTGR-coupled applications.

3. A technical meeting should be held on plutonium, spent fuel & minor actinide management using HTGRs (in cooperation with fast reactor group).

4. Gas fast reactor activities should be considered in cooperation with the fast reactor group.

5. Lessons should be learned from UK & other gas reactor operation, maintenance & monitoring experience.

6. Special attention should be given to heat transfer emissivity monitoring on operating reactors.

7. A technical meeting should be held on graphite waste issues (impurities,C-14, waste minimization). Participants from the industry should be invited.