

## MEETING REPORT

### 18<sup>th</sup> Meeting of the Technical Working Group on Gas Cooled Reactors (TWG-GCR-18), Istanbul, Turkey

16-18 June 2003

21 participants attended the meeting from 11 Member States, of which one was an observer. Mr Osman Kadiroglu of Turkey chaired the meeting and Mr Mabrouk Methnani represented the IAEA as scientific secretary.

#### **Member States:**

France  
Germany  
Indonesia  
Japan  
The Netherlands  
Korea, Rep. of (observer)  
Russian Federation  
South Africa  
Turkey  
United Kingdom  
United States

#### **Overview**

Discussions and presentations held during the meeting point to a sustained level of activities in several Member States in support of gas cooled reactor development since the last TWG-GCR meeting of Nov. 2001 in Cape Town, South Africa.

The first day was reserved for 3 topical sessions covering HTGR code benchmarks, simulation and modelling, as well as fuel and graphite aspects. On the second day, participants from various Member States reviewed the status and progress of their HTGR national and international projects. On the third day, IAEA related activities were discussed, including actions on recommendations from the 17<sup>th</sup> meeting, current coordinated research projects, as well as recommendations to the Agency on future HTGR-related activities.

#### **Recommendations**

1. The TWG has recommended that the IAEA organize a Technical Meeting on emerging HTGR plants and applications.
2. The TWG has voiced strong support for a fifth Research Coordination Meeting (RCM) for the CRP on HTGR performance evaluation (CRP-5), provided enough new benchmarks are made available by participants.
3. The TWG has underlined the importance and urgency of issuing safety and design standards specifically addressing gas-cooled reactors and especially in areas where current provisions have no reference to them.
4. The TWG has voiced support for knowledge preservation in the area of HTGR technology.

#### **Next TWG Meeting**

It was agreed that the 19<sup>th</sup> TWG meeting will be held at the VIC in Vienna, in the period of Jan. 17-19, 2005.

## SESSION HIGHLIGHTS

### **I Topical Sessions**

#### **1. Session 1: HTGR code benchmarks**

Brey & Methnani gave an overview of the ongoing CRP on HTGR performance evaluation (CRP-5). The CRP involves reactor physics and thermal hydraulic benchmarks where code predictions are compared to experiments performed at the HTR-10 and HTTR reactors. Discrepancies in the code-to-code physics calculations could be partially explained by the range of methods used, from diffusion to transport to detailed Monte Carlo and by variations in the library data. A Technical Document (TECDOC) on the benchmarks analysed and the code results obtained has been prepared and is currently under printing. Additional benchmarks have been promised by CRP participants and may lead to a 5<sup>th</sup> RCM and a second TECDOC.

#### **2. Session 2: HTGR simulation & modelling**

Brey presented an overview of the Oak Ridge simulation tool GRSAC (Graphite Reactor Severe Accident Code). The code which models slow transients typical of HTGRs, is fast-running and has been extensively validated. No provision is however included for fast transient analysis and the balance of plant is not modelled, according to Syd Ball, the code's author.

Sokman presented components of an HTGR simulator including core, turbine and compressor models. The Matlab-based tool is the result of a thesis done at Hacettepe University in Turkey, and could form a basis for a future plant simulator. He also presented an overview of a three-dimensional pebble flow simulator, based on a system of springs and dampers.

Methnani presented an overview of the scope and specifications for an HTGR educational simulator tool, currently being contemplated by the IAEA. The tool should be able to model operational as well as accident events and should include features of speed, reasonable accuracy and platform-independence (preferably Java-based).

#### **3. Session 3: HTGR Fuel & Graphite Issues**

Methnani went over the status of the new CRP on "Advances in HTGR fuel technology" and the task layout. Emphasis will be on updating information on fabrication, irradiation and test performance data, as well as on fission product and fuel failure modelling.

Marsden overviewed different methods to model the temperature dependence of graphite thermal expansion and Haag treated its thermal conductivity variation due to fast neutron damage.

Wickam in his turn went over the status of the international graphite database and how it functions.

### **II National & International Programs Status**

#### **China**

- **HTR-10:**
  - Full power of 10 MWt (2.5 MWe) was reached on Jan. 26, 2003.
  - Three safety demonstration tests were successfully performed at 3 and 10 MWt, including
    - Loss of helium flow
    - Turbine trip
    - Loss of offsite power

- All safety demonstration tests to be completed by 2003, including Anticipated Transients Without Scram (ATWS) tests.
- INET and OKBM of the Russian Federation continue to cooperate on the gas turbine cycle for HTR-10. The system, producing 2 MWe, is expected to be operational by 2006.
- **HTR-PM:**
  - The conceptual design of a 300-400 MWt HTR-PM, a pebble-bed steam-cycle Nuclear Power Plant (NPP) has been completed and construction may start in 2006.

### **Indonesia**

- The nuclear option may become a viable ingredient in the energy mix during the next decade, due the continued increase in demand and the limited fossil resources. A first NPP may be foreseen for the year 2016.
- Co-generation aspects of HTGRs are attractive for applications such as Enhanced Oil Recovery (EOR).

### **Japan**

- **HTTR:**
  - HTTR has reached its rated power in 2001 (30 MWt) with a Helium outlet temperature of 950°C.
  - Safety demonstration tests are being planned in phases, including control rod withdrawal, partial and full loss of flow, as well as depressurisation tests.
- **GTHTR-300:**
  - GTHTR-300 plans are in place with emphasis on Hydrogen production. Project activities focus on three main areas: reactor technology, connection technology (steam reforming) and hydrogen production technology (Iodine-Sulphur process). For the latter two areas, out of pile and bench scale tests are under way.
  - The demonstration process may be accelerated during the next two decades by international collaboration (JAERI, US & France)

### **Russian Federation**

- **GT-MHR:**
  - Pu-burning prismatic design with multi-national support continues. Preliminary design completed in 2001.
  - Features include high-level of Pu burnup (90%), enhanced safety, proliferation resistance, economic competitiveness and minimized waste and environmental effects.
  - Activities foreseen for the next next five years will focus on R&D related to fuel, turbo-machinery and calculation methods.

## South Africa

- **PBMR:**
  - Detailed feasibility study completed. Business case & Environmental Impact Assessment (EIA) report submitted in 2002.
  - Record of Decision (ROD) by South African government expected anytime.
  - Eskom has publicly stated it is ready to proceed with the demonstration project, pending a license. The other investors, IDC and BNFL, are expected to define their future involvement in due course. PBMR is also negotiating with other potential investors.
  - IAEA safeguards approach concept to be finalized by July 2003. Conceptual design to be fixed by August 2003. Safety analysis report to be submitted to the regulator, NNR, in 2004.
  - Current design has a fixed central column of graphite and rated thermal power is 400 MWt.

## France

- Projects related to both thermal and fast gas-cooled reactors have been planned, including system and core studies, fuel cycle, high-temperature materials, helium circuit components and hydrogen production.
- Planning includes:
  - Design code development and validation
  - Fuel fabrication capacity by 2004 and irradiation by 2006
  - Material studies and helium loop tests
  - Experimental & Technology Demonstration reactor (50 MW) by 2012
  - Pre-qualification of fast GCR fuel by 2015

## Germany

- No commercial HTGR activity since 1992
- Nuclear power phase out by 2020
- New nuclear research activities are tailored towards safety and waste management.
- Support activities for PBMR & the European HTGR research program

## Netherlands

- Two main lines of activity:
  - Activities related to Accelerator Driven Systems (ADS) for actinide and fission product transmutation
  - Activities related to 4<sup>th</sup> Generation nuclear energy systems including:
    - Participation in the HTR-TN European program on physics, fuel irradiation and fuel cycle, graphite and material technology, safety and licensing aspects.

- PBMR support with code validation, benchmarks, shielding & fission product transport calculations
- Small-scale nuclear energy systems such as ACACIA, a 25 MWe pebble bed reactor with cartridge-type fuel and burnable poison
- Other exploratory projects such as fast spectrum gas-cooled reactors

### **Korea (Rep. of)**

- Need for nuclear driven by high energy demand, lack of fossil resources & desire to limit CO<sub>2</sub> emissions
- HTGR technology has potential for hydrogen production
- Feasibility study on HTGR technology launched in 2002
- Bilateral & international cooperation foreseen to develop nuclear hydrogen technology

### **Turkey**

- NPP project postponed by government in July 2000, due to economic difficulties
- Deregulation of electricity market to be in effect in 2003
- Merits seen for HTGRs in terms of economics, safety and effect on the environment
- HTGRs for Turkey may be the focus of an INPRO case study

### **UK**

- 22 % of UK electricity is nuclear, including 26 gas-cooled reactors, 12 Magnox & 14 AGRs, in addition to 1 PWR.
- Electricity trading in the UK has changed and British Energy is undergoing significant restructuring.
- A government white paper indicates a preferential policy towards renewable energy.
- BNFL is still interested in PBMR.
- Decommissioning activities continue, with WAGR being an interesting case for HTGRs.

### **US**

- A new public/private partnership aims at deploying an advanced nuclear power plant in the US by 2010, on a market-driven, cost-shared basis.
- Generation IV concepts include two gas-cooled reactor designs, the thermal VHTR and the fast GFR.
- An extensive coated fuel particle program aims at qualification of advanced HTGR fuel.
- DOE and NRC continue to cooperate on HTGR safety and regulatory issues.

### III Review Of IAEA Activities

- **CRP-5:** (Coordinated research project on HTGR performance evaluation)
  - The CRP is expected to wind up in 2004 and a TECDOC including benchmark results is currently under printing. Additional benchmarks may be made available as a basis for an additional RCM and consequently a second TECDOC part.
- **CRP-6:** (Coordinated research project on “Advances in HTGR fuel technology”)
  - A first RCM took place at the VIC in Dec. 2002 and the participants have identified several research tasks in the areas of fabrication, performance, irradiation and testing, modelling and licensing aspects. Benchmarks for fuel code validation have been proposed and a layout of the expected TECDOC has also been prepared.
- **Workshop Activities:**
  - ICTP workshop on HTGR technology planned for July 2003
  - Workshop on safety demonstration of HTGRs planned for Oct. 2003 at INET, China
- **HTGR Publications**
  - A new TECDOC on “Performance Evaluation of HTGRs” is currently under printing and will be made available as soon as it is ready. HTGR-related TECDOCS can be reached at the knowledge base of the HTGR web site <http://www.iaea.org/htgr>.
- **INPRO Project:** (International Project on Innovative Nuclear Reactors & Fuel Cycles)
  - Phase 1A, which deals with user requirements and criteria, has been completed.
  - Phase 1B is expected to focus on case studies, where specific designs are examined using phase 1A guidelines.

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