IAEA High-Temperature Gas-Cooled Reactor Activities

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Abstract. IAEA activities on high temperature gas cooled reactors are conducted with the review and support of Member States, primarily through the Technical Working Group on Gas Cooled Reactors (TWG-GCR). This paper overviews current and planned activities through a review of Co-ordinated Research Projects (CRPs), meetings, conferences and workshops.

1. Introduction

International interest in HTGR technology has been increasing in recent years due to a growing recognition of the potential of HTGR designs to provide high efficiency, cost effective electricity generation appropriate for the conditions in developing countries, and in the longer term to provide a source of high and low-temperature process heat. The international exchange of information and co-ordination of HTGR research through the IAEA has helped to establish the foundation for the future development and deployment of HTGR technology. The gas cooled reactor activities of the IAEA are conducted with the active participation and advice of the Technical Working Group on Gas Cooled Reactors. An overview of HTGR technology, and IAEA technical documents are available online on the IAEA HTGR knowledge base.

2. Technical Working Group On Gas Cooled Reactors

The Technical Working Group on Gas Cooled Reactors (TWG-GCR) is a continuing working group whose purpose is to advise the IAEA on promoting the exchange of technical information in the field of gas cooled reactors. Created in 1978, the group promotes international cooperation related the development of gas-cooled reactors for electricity and process heat applications. The latter involve high-temperature applications such as hydrogen production and low-temperature applications such as seawater desalination and district heating.

The TWG-GCR currently includes participants from the following countries:

China	France	Germany
Indonesia	Japan	The Netherlands
Russian Federation	South Africa	Turkey
UK	US	

The last meeting (the 18th) was held in June 2003 in Istanbul, Turkey. More information can be found here.The next meeting is scheduled for Jan. 17-19, 2005 at the VIC in Vienna, Austria.

3. Coordinated Research Projects

Research efforts supported by the agency are normally carried out within the framework of Co-ordinated Research Projects (CRPs). CRPs are developed in relation to a well defined research topic on which a number of institutions agree to collaborate, and represent an effective means of bringing together researchers in both developing and industrialised countries to solve a problem of common interest. Each CRP is essentially a network of 5-15 national research institutions mandated to conduct the research within the countries concerned, each being represented by a Chief Scientific Investigator (CSI). Find out more information and the procedure for joining a CRP .

Advanced HTGR designs currently being developed promise a high degree of safety with substantially reduced safety related demands on plant operations and licensing oversight through reliance on inherent safety features. These anticipated benefits derive largely from the ability of the ceramic coated fuel particles to retain fission products under normal and accident conditions, the neutron physics behaviour of the core, the chemical stability of the core and the ability of the design to dissipate decay heat by natural heat transport mechanisms without reaching excessive temperatures. In support of licensing and commercial deployment of advanced HTGRs, these features must be demonstrated under experimental conditions representing realistic reactor conditions, and the methods used to predict the performance of the fuel and reactor must be validated against experimental data. Currently, two CRPs are ongoing, one on HTGR performance evaluation (CRP-5) and one on advances in HTGR fuel technology (CRP-6). A new CRP on fresh water co-generation using HTGRs is also under consideration. A brief overview of the three CRPs follows:

3.1. *CRP on Evaluation of High Temperature Gas Cooled Reactor Performance (CRP-5)*

The CRP, initiated in October, 1997 and scheduled to be completed in October, 2004, has the following Member States as participants: China, France, Germany, Indonesia, Japan, the Netherlands, the Russian Federation, South Africa, Turkey and the United States The following scope has been defined for the project:

- Reactor physics benchmark analysis
- Thermal hydraulic transient benchmark analysis
- Demonstration of HTGR safety characteristics.

Benchmark problems have been defined for the purpose of comparing analytical results with experimental data from HTR-10, HTTR, as well as the PBMR and HTGR projects. Four research coordination meetings have already taken place and an IAEA technical document containing part I of the results is being published. More information can be found in the CRP5-RCM4 meeting report.

3.2. *CRP on Advances in HTGR fuel technology (CRP-6)*

The CRP involves institutes from 8 Member States - China, France, Germany, Japan, the Republic of Korea, Russia and the United States. The first meeting was held Dec. 9-11, 2002 at the VIC in Vienna and the following topics were discussed

- Previous work, current issues and planned activities
- Topical area 1: Fuel design, fabrication, QA/QC & licensing

- Topical area 2: Fuel irradiation, testing, operation performance & spent fuel disposition

- Topical area 3: Fuel characterization and performance modeling

A work plan and schedule for the CRP has been worked out and the next meeting is planned for 2004. More information can be found in the CRP6-RCM1 meeting report.

3.3. Proposed CRP on fresh water co-generation using High Temperature Gas-Cooled Reactors (CRP-7)

3.3.1. Background

Process heat has always been one of the potential applications of Modular High-Temperature Gas-Cooled Reactors (MHTGRs), in co-generation with electricity. Applications such as hydrogen production and coal gasification require high-temperature steam, which could be made available by this reactor type. Understandably, the emphasis in the past has been mostly on these high-temperature applications. However, with recent developments in HTGR and desalination technologies, the potential for low-temperature heat applications such as seawater desalination using MSF (Multi-Stage Flashing) or MED (Multi-Effect Distillation) technologies is unfolding as a cost-effective solution to the energy-intensive process of fresh water production. Since then, and with the switch to advanced gas-turbine designs, HTGRs offer virtually cost-free energy at the heat sink boundaries of the pre-cooler and inter-cooler, and importantly so, at the desired range of temperatures needed by the distillation process (100 – 120 ºC). Since energy costs represent 30-50 % of overall desalination costs, the incentives for using HTGRs for potable water production are compelling. Preliminary studies point to the potential for cutting the projected water costs by up to 50%. Another potential benefit would be the boosted co-generation efficiency. Operating an HTGR in cogeneration mode would help boost the plant energy utilisation efficiency to 80% or more, with no significant effect on electrical efficiency.

In the late eighties, The Metropolitan Water District of Southern California commissioned a study, which involved General Atomics, Bechtel and the Gas-Cooled Reactor Associates (GCRA), examining the feasibility of coupling a steam cycle MHTGR to an MED plant for seawater desalination, in co-generation mode with electricity. More recently, some preliminary investigations have been made on the merits of using gas-turbine HTGR designs for fresh water production. In this context, three papers from France, Turkey and Russia have been submitted to the Marrakesh conference on nuclear desalination (Oct, 2002).

3.3.2. Proposed CRP Objective

The objective of this CRP will be to investigate the prospects of using High-Temperature gas-cooled reactors for fresh water production with emphasis on coupling design aspects, safety and economics.

3.3.3. Proposed CRP Scope

The scope of this CRP will cover the relevant design and coupling aspects of HTGR-based nuclear desalination plants, emphasising the following aspects:

- Detailed technical design, including thermal process sheets, coupling schemes and safety analysis of MSF or MED desalination units, integrated with current HTGR designs of the PBMR or prismatic type and referring to site-specific cases.

- Detailed economic analysis of electricity and fresh water co-generation with HTGRs, using realistic and site-specific cases.

4. Workshops, topical meetings and conferences:

4.1. Workshops

- *IAEA-HTGR-Workshop-2003 (ICTP, Trieste, Italy - July 7-11, 2003)*

An IAEA Workshop on the status of HTGR Technology was hosted by the ICTP center in Trieste, Itlay (July 7-11,2003) with 23 participants attending from 12 Member States. The 5-day workshop included lectures on gas-cooled reactor design, market potential, fuel aspects, core & power conversion unit design, fuel cycle and safety aspects. Real-time core temperature viewgraphs for a 600 MWt HTGR nuclear power plant undergoing a forced loss of cooling accident with depressurisation, were communicated daily to the participants to illustrate the large thermal constant of this particular design and its effect on plant safety

4.2. Topical meetings:

- *Topical meeting on HTGR modeling, fuel & graphite behavior (Istanbul, Turkey - June 16, 2003)*

A topical meeting was held in conjunction with the meeting of the Technical Working Group on HTGRs in Istanbul, Turkey (June 16-18, 2003). The topics include results from the ongoing coordinated research project on HTGR performance evaluation, HTGR simulation and modeling as well as fuel & graphite behavior. More information can be found here.

4.3. Conferences:

- *HTR-2002 (Petten, NL - April 22-24, 2002)*

In April 2002, the Agency cooperated with the European Union's High-Temperature Reactor Technology Network (HTR-TN) on their HTR-2002 conference held in Petten, the Netherlands, by sponsoring the attendance of some delegates from developing countries and also publishing and distributing the conference proceedings. The next conference is planned in 2004.