10 **PRESENT STATUS OF RESEARCH ON AND DEVELOPMENT OF HTGR TECHNIQUES IN THE PEOPLE'S REPUBLIC OF CHINA**

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I. Introduction

China is a developing country rich in coal, petroleum and hydropower resources. In the past ten years, energy production in China has had a large increase. But along with the development of economy, energy demands increase even more rapidly. Many problems exist in China's energy system, the main ones are:

* The uneven distribution of energy resources. About 60% of coal mine are located in North China - Innermongolia and Shen Xi Province. More than 70% of hydropower are concentrated in South-west China. In the well developed and densely populated region - South-east sea shore - the energy resources are poor.

* Long distance transportation of energy sources. Recently, about 50% of railway capacity are used for coal transportation. Even so, a lot of coal are stored near the mining area.

* Serious pollution problems caused by burning coal. At present, the main energy source consumed in China is coal. Direct burning of coal (coal fired electric power stations, industrial boilers, central house heating stations and small stoves) in the urban area leads to serious environmental problems.

Considering the large energy demand in the near future and long-term energy strategy, China has already decided to develop nuclear power gradually. The first several nuclear power stations are being and will be built in the South-east sea shore region. Two 900 MW PWRs (from France) and one 300 MW PWR (home made) are now under construction at Daya Bay (Kwangton Province) and Qin Shan (Zhejiang Province). The succeeding PWR power plants are being planned. PWR nuclear power station has been selected for the beginning of China's nuclear power plan.

For large scale utilization of nuclear power in the next century, the development of advanced reactor type with good safety and economy performances and high uranium utilization rate (uranium resources in China is not rich enough) is strategically important. HTGR, due to its inherent safety characteristics, high heat efficiency, flexible fuel system and wide application fields, is a prospective advanced reactor type. Research and development on HTGR have already been included in China's national technical development program and are going on smoothly.

II. Research and Development on HTGR in China

In China R&D on HTGR began in mid seventies. The Institute of Nuclear Energy Technology (INET), Tsinghua University, engaged in the design of a 100 MW (t) two region pebble bed thorium HTGR. In this connection, a series of experimental research was carried out which included the preparation of coated fuel particles, the characterization of graphite, the reprocessing of thorium containing fuels, the loading and unloading of spherical fuels, reinforced concrete vessel technique etc. Since 1980 the collaboration of INET with Kernforschungsanlage Jülich (KFA), West Germany, has been established. The feasibility of introducing modular HTGR technique into China for heat supply in viscous oil recovery and petrochemical processes have been studied. These activities have been supported by related Chinese and German industrial companies.

The present Chinese R&D program on HTGR includes the techniques for the preparation of coated fuel particles and spheric fuel elements; the development and characterization of HTGR grade graphite and other metallic, non-metallic materials; helium techniques and installations; thorium-uranium fuel cycle and reprocessing techniques; loading and unloading technique for spherical fuel elements and the development of computer program for design and safety analysis of HTGR. The institutions which take part in this program are INET, Beijing Institute of Nuclear Engineering (BINE), South-west Center of Reactor Research (SWCR), Shanghai Institute of Nuclear Research (SINR) and others.

In order to introduce and develop the modular HTGR technique in practise, INET, Siemens-Interatom GmbH (West Germany) and KFA Jülich are planning to build a 10 MW HTGR module jointly in China. The main object of this test module is to verify the characteristics of modular HTGR on a real nuclear test facility. Reactor with its main components (graphite core structure, steam generator, helium blower, fuel

loading and unloading installation etc.) will be tested. Safety features of HTGR (negative temperature coefficient of reactivity, temperature limit under accidental conditions, behaviour of fuel elements under high temperatures etc.) will be observed and verified. Different applications of HTGR will be tested: electricity generation; heat generation and utilization (1st stage); high temperature technological heat supply (2nd stage).

The main parameters of test HTGR module are as follows:

maximum thermal power	20 MW
average thermal power	10 MW
primary He pressure	30 bar
secondary steam pressure	35 bar
helium temperature (cold/hot)	250°C/700°C
steam temperature	435°C
core volumn	5 M^3

Main data of the core:

thermal power	10 MW
power density	2 MW/M^3
core diameter	190 cm
core height (average)	176 cm
height/diameter ratio	0.93
number of fuel element	27,000
heavy metal content	5 g/fuel element
burn-up (average)	80,000 MWd/t
time in core of fuel element	1078 EFPD (efficient full power day)
loading scheme	OTTO (once through)

Test module HTGR (10 MW) will take 5 years for design, construction, installation and commissioning. We believe the success of this joint effort will effectively promote the development and utilization of HTGR techniques in China.

China's R&D program on HTGR is a long-term plan. International cooperations are beneficial for its accomplishment.

III. Study on the application of HTGR

The object of this study is inquiring into the technical and economical feasibility of HTGR application in the electricity and heat supply in China. HTGR can not only improve the efficiency of electricity production (to about 40%) but also supply high temperature technological heat and vapor. The potential of HTGR marketing is large. In the progress of China's economy, petroleum supply will become more and more important and effective measures have to be taken to increase the production of liquid fuel and decrease the self-consuming oil in the petroleum industry. Among these measures are: vapor injection thermal recovery of viscous oil, tertiary oil recovery, production of oil from oil shale, liquefaction and gasification of coal. All these measures consume large amount of heat. If nuclear heat would be used instead of conventional heat, large amount of fossile fuel could be saved. HTGR can supply heat with temperature up to about 950°C, it can meet the requirements for heating in most technological processes.

Results of preliminary investigations show that in the near future, thermal recovery of viscous oil, energy supply for petroleum refining and electricity supply in special energy-deficient region might be among the first choice of HTGR application in China. Presently, feasibility studies on the following three topics are carrying on:

1. modular HTGR used for the viscous oil recovery at the Shengli Oil Field
2. HTGR thermal-electric power station used in a petrochemical factory
3. modular HTGR electric power station compatible with medium and small capacity electric network in special energy deficient regions.

International cooperation has played an important role in these studies.