Feasibility study of low power HTGR for long-term operation

*Hai Quan Ho[1], Nozomu Fujimoto[2], Shimpei Hamamoto[1], Satoru Nagasumi[1], Etsuo Ishitsuka[1]
[1]Japan Atomic Energy Agency, [2]Kyushu University

Abstract

In this study, feasibility study for a low-power HTGR with long-term operation based on the HTTR design was carried out. The fuel enrichment and burnable poison were optimized to achieve 30 years operation with reactor power of 5MW.

Keywords: HTTR, MVP, neutronics calculation, reactor power, long-term operation.

1. Introduction The aim of this study is to propose a nuclear reactor for multipurpose heat applications with excellent safety feature, long-term operation without refueling the fuel. The image thermal applications of this proposed reactor are shown in Fig. 1. These heat utilizations do not require very high temperature as in conventional HTGR design. Therefore, the reactor power in this study was set to 5MW with the expected operation time of about 30 years.

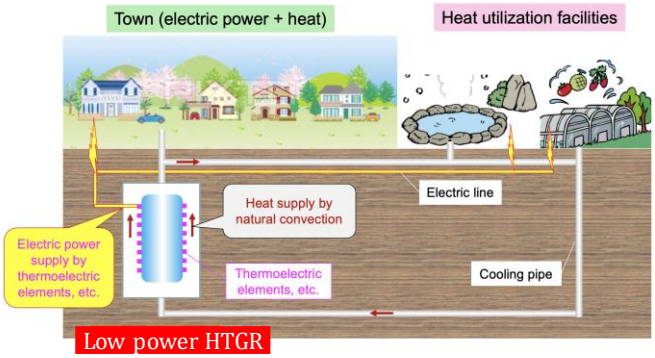

Fig. 1. Useage image of low power HTGR

2. Method The core configuration is based on the original HTTR design with 2.9m in height and 2.3m in diameter. The reactor power was set to 5MW and the uniform temperature of 800K was assumed for neutronic calculation. The criticality and core burnup calculations were performed by MVP code with JENDL-4.0 neutron cross-section library. In the first step, the enrichment of uranium was changed from 6 to 20% without the existent of the burnable poison rod. As in the second step, the burnable poison rod was added and optimized to reduce the exceed reactivity

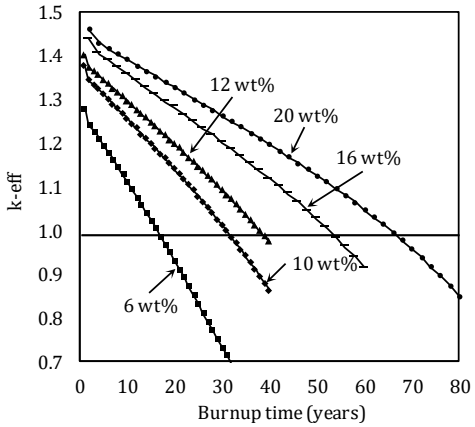

Fig. 2. Change of k-eff with different enriched U235

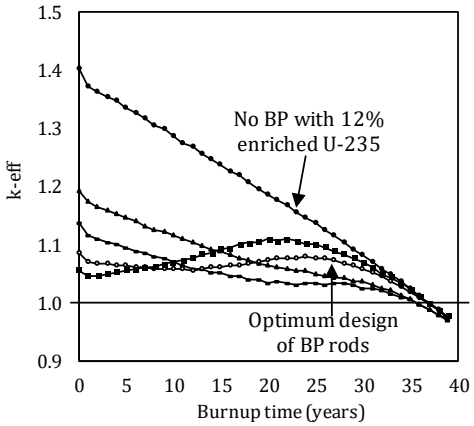

Fig. 3. Change of k-eff with/without BP rods

3. Results and discussion In the first step, the k_{eff} was calculated by changing the enrichment of uranium. The change of k_{eff} with different uranium enrichment is shown in Fig. 2. It can be seen that the operation time could be more than 30 years if the uranium enrichment is 10 wt% or more. The case of 12 wt% was selected as a reference design for the optimization of burnable poison design. The diameter and concentration of boron in burnable poison rod were changed to determine the optimum design in which the exceed reactivity is small during long-term operation. Fig. 3 shows the change of k_{eff} for various design of BP rod. The optimum design was 1.5cm in diameter and 2wt% of boron concentration.