OTTO cycle Small Pebble Bed Reactor with Rock-like fuel elements
(4) Burnup performance in molten salt coolant

*Hai Quan Ho[1], Toru Obara[2]
[1]Department of Nuclear Engineering, Tokyo Institute of Technology, Japan
[2]Research Laboratory for Nuclear Reactors, Tokyo Institute of Technology, Japan

Abstract

A small 120 MW_{th} pebble bed high-temperature gas-cooled reactor (PBR) with uranium rock-like oxide (U-ROX) fuel was proposed. The neutronic calculation was performed to show the possibility of applying molten salt coolant in U-ROX fuel PBR.

Keywords: Pebble bed reactor, rock-like fuel, OTTO cycle, molten salt coolant, high burnup.

1. Introduction A small ROX fuel PBR was proposed to achieve the high discharged burnup [1] [2]. However, the low heat capacity of helium coolant made the reactor power limited. Fluoride salt coolant (Flibe) can increase the reactor power with much higher heat capacity than that of helium gas coolant. The purpose of this study was to show the possibility to apply flibe coolant in the ROX fuel PBR system. The temperature reactivity coefficient for the ROX fuel core with fluoride salt coolant was also estimated to ensure the negative feedback during steady-state operation.

2. Method The reactor designs and fuel material are shown in the **Table 1**. The cylindrical core based on PBMR design while the TRISO particle is the same as AGR-1 design. In the first step, the infinite calculation was performed, by randomly distributing fuel pebble in an infinite geometry, to confirm that whether ROX fuel in flibe coolant can achieve high burnup or not. The MVP-BURN code was used for neutronic calculation. As in second step, the whole core calculation was carried out by using MCPBR code [3] with JENDL-4.0 cross section library. Finally, the core composition at equilibrium state was used to estimate the temperature coefficient of the PBR with flibe coolant.

Table 1. Reactor designs

Core	
Core diameter [m]	3
Core height [m]	10
Reflector thickness [m]	1
Top cavity [m]	1
Coolant	LiF-BeF_2
Fuel Pebble	
Pebble diameter [cm]	6
Fuel zone diameter [cm]	5
Graphite density	1.74
TRISO particle	
Kernel diameter [μm]	350
Fuel material	U-ROX
Coating material	C/C/SiC/C
Layer thickness [μm]	100/40/35/40

3. Results **Fig. 1** shows the burnup value of the ROX fuel as a function of HM/pebble when the k_∞ equal to unity in infinite calculation. It can be seen that the burnup value increased with increasing HM/pebble; and reached maximum at 4.5 g HM/pebble with 20% enrichment of uranium. From whole core calculation, the reactor power could increase from 120 MW_{th} (in previous study with helium gas coolant) to 200 MW_{th} without decreasing burnup performance much. The flibe coolant PBR also presented the negative temperature coefficient required for the passive safety feature of the reactor. The results suggested that it is possible to apply the liquid salt flibe as coolant in the ROX fuel PBR to increase the reactor power without decreasing the burnup performance a lot.

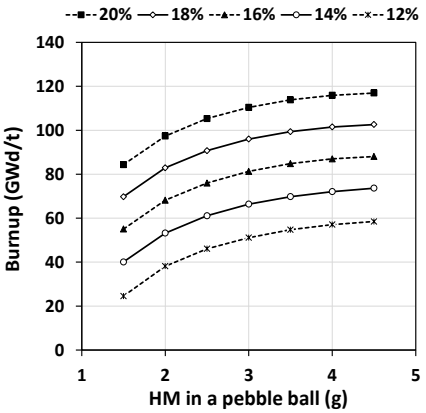

Fig. 1 Burnup in infinite calculation

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