Transactions of the Korean Nuclear Society Autumn Meeting
PyeongChang, Korea, October 25-26, 2007

An Optional Study for an AHR Core with 3 In-core Irradiation Sites

Hak-Sung Kim, Chul-Gyo Seo and Hee Taek Chae
Korea Atomic Energy Research Institute
1045 Daedeok-daero, Yuseong-gu, Daejeon 305-353, KOREA
haksung@kaeri.re.kr

1. Introduction

An advanced HANARO research reactor (AHR), a 20 MW multi-purpose research reactor, is being developed based on the HANARO experiences through its design to utilization for the future needs of research reactors [1]. A compact core model with 1 in-core irradiation site has been analyzed as a reference core model of AHR [2]. As the neutronic characteristics are strongly dependent on the number of in-core irradiation sites, core models with more in-core irradiation sites have been studied [3,4]. In this paper, several kinds of core configurations with 3 in-core irradiation facilities have been considered by using improved design concepts and the preliminary analyses were carried out to establish the highest performance concept.

2. Core Models

2.1 Fuel

Two kinds of fuel assemblies are used as shown in Fig. 1. A 36-element fuel assembly is composed of 36 fuel rods with a hexagonal array and it is loaded into the hexagonal flow tubes in the core. An 18-element fuel assembly consists of 18 fuel rods with a circular array and is loaded into the cylindrical flow tubes. U_3Si_2-Al with a density of 4.0gU/cc is used as the reference fuel, and its enrichment is 19.75 wt%.

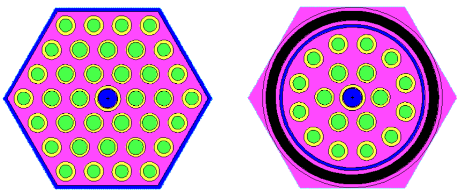

Fig. 1 Cross sectional view of AHR fuel assemblies

2.2 Control Absorber Rod

A Control Absorber Rod (CAR) is a hollow cylinder type which is made of natural Hf with a 4.0 mm thickness and 70 cm in length. As shown in Fig. 1, it is moving up and down while embracing an 18-elements fuel assembly when it controls and trips the reactor. The AHR adopted the concept of using control rods sharing for both the Reactor Protection System (RPS) and the Reactivity Control System (RCS). Even with this common control rods concept of the AHR, the RPS and RCS are independently separated from each other in terms of an instrumentation and control.

2.3 In-core Irradiation Sites

The core has two types of dummy assemblies, which consists of 36 and 18 Al dummy rods with a hexagonal and an annular array, respectively. These two types of dummy assemblies are for reserving 3 in-core irradiation sites which can be used for the fuel and material irradiation tests and a RI production that require high fast and thermal neutron fluxes. The general arrangements of the both dummy assemblies are shown in Fig. 2.

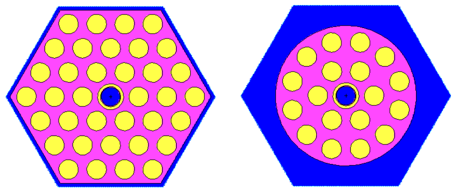

Fig. 2 Cross sectional view of AHR dummy assemblies

2.4 Core Concepts

The basic concept of the AHR is similar to that of the HANARO. The AHR core is composed of 23 hexagonal shape lattices and its active length is 70 cm. The heavy water reflector tank of 200 cm in diameter and 120 cm in height surrounds the core.

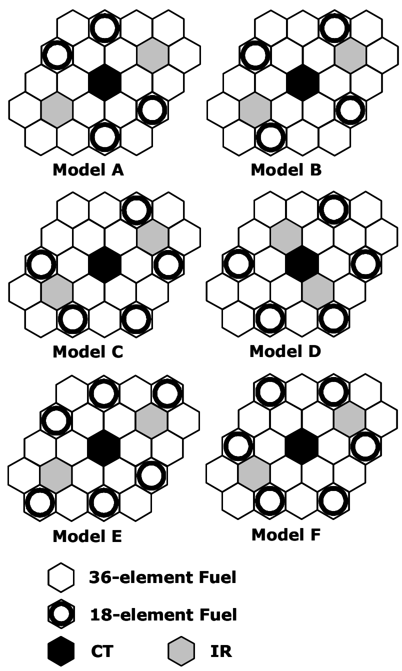

Fig. 3 Various core models by the number of CAR/SOR

Various core models with different number of CAR/SOR were considered to achieve the highest performance. Fig. 3 shows conceptual models according to the number of CAR/SOR. The basic analysis of the each core characteristics were performed for the fresh and unperturbed core condition in which all the fresh fuels with a temperature of 300 K were loaded. In this study, MCNP calculates the criticality of the AHR core and the neutron flux at the region of interest using a continuous energy library based on ENDF/B-VI.

2.5 Results

The performances of each core model focused on the excess reactivity, neutron flux and absorber worth. Table 1 shows the basic neutronic characteristics of each core model according to the number of CAR/SOR. As shown in Table 1, core model F shows the highest neutron flux result. For a clean, unperturbed core condition such that the fuels are all fresh and there are no irradiation holes in the reflector region, the fast neutron flux ($E_n \geq 1.0$ MeV) reaches 1.76×10^{14} n/cm^{2}s and the maximum thermal neutron flux ($E_n \leq 0.625$ eV) reaches 5.36×10^{14} n/cm^{2}s in the core region. In the reflector region, the maximum thermal neutron flux is estimated to be 4.21×10^{14} n/cm^{2}s.

The total absorber worth of each core model was also calculated for both all rods in and all rods out conditions. The reactivity effect by the irradiation facilities was already estimated to be 20.2 mk at the ARO condition. So the total absorber worth of all the core models is more than 200 mk. As the AHR core has a large excess reactivity and enough absorber worth, it has good characteristics from a reactor safety and a fuel economy point of view.

3. Conclusion

We analyzed basic neutronic characteristics of various core models with 3 in-core irradiation holes but a different number of CAR/SOR. Each conceptual core model provide a high neutron flux, large excess reactivity and enough absorber worth. As a core design is dependent on a user's requirements, we are preparing various core models. These analysis results will be usefully used for the determination of an AHR core concept.

Acknowledgements

This work has been carried out under the nuclear research and development program by MOST.

REFERENCES

[1] C. Park, "Design Approach to the Development of an Advanced HANARO Research Reactor", Proc. of International Symposium HANARO 2005, HANARO 2005 (2005)
[2] C.G. Seo, et al., "Conceptual Core Design of a 20 MW Research Reactor Using the HANARO Fuel Assembly," Proc. of the KNS Spring Meeting, Kangchon, Korea, 2006.
[3] C.G. Seo, "Calculation Results for Core Models with More than 3 In-core Irradiation Sites," Internal Presentation Material, 2005.11.29.
[4] C.G. Seo, et al., "Conceptual Nuclear Design of the AHR Core with 2 In-core Irradiation Sites," HANARO Symposium, Daejeon, Korea, 2007.

Core model		A	B	C	D	E	F
Number of F.A. (36/18)		16 / 4	16/4	15/5	15/5	14/6	14/6
Number of CAR/SOR		4/0	4/0	4/1	4/1	4/2	4/2
Avg. linear power(kW/m)		41.5	41.5	42.7	42.7	43.9	43.9
Max. linear power(kW/m)		103.6	103.6	106.6	106.6	109.7	109.7
Criticality	ARO	1.25826	1.25551	1.24440	1.23736	1.24144	1.23495
	300mm	1.14505	1.14052	1.12112	1.11033	1.10195	1.09535
	ARI	1.02778	1.01576	0.98885	0.96238	0.92541	0.90973
Total absorber worth(mk)		178.3	187.9	207.7	230.9	275.1	289.5
Max. flux (ARO)	Reflector	3.97E+14	3.99E+14	3.97E+14	3.91E+14	4.05E+14	4.08E+14
	Core(thermal)	3.76E+14	3.77E+14	3.87E+14	4.00E+14	3.90E+14	3.86E+14
	Core(fast)	1.19E+14	1.23E+14	1.24E+14	1.09E+14	1.27E+14	1.24E+14
Max. flux (300mm)	Reflector	3.94E+14	4.04E+14	3.76E+14	3.82E+14	4.23E+14	4.21E+14
	Core(thermal)	4.48E+14	4.50E+14	4.19E+14	5.07E+14	5.26E+14	5.36E+14
	Core(fast)	1.46E+14	1.51E+14	1.62E+14	1.42E+14	1.73E+14	1.76E+14

Table 1. Basic neutronic characteristics of each core model by the number of CAR/SOR