Maximum Allowable Power Levels in HANARO Fuel Channels

Heetaek Chae, Choong Sung Lee, Jong Hark Park, Heonil Kim
HANARO Center, Korea Atomic Energy Research Institute
P.O.Box 105, Yuseong, Daejeon, Korea, 305-600, htchae@kaeri.re.kr

1. Introduction

HANARO is a light-water-cooled and heavy-water-reflected research reactor designed and operated at a full power of 30 MW_{th}. The compact core is composed of 23 hexagonal and 16 circular flow channels. Each hexagonal flow channel, formed by a hexagonal flow tube, is loaded with a hexagonal fuel bundle which has 36 fuel elements. The circular flow channel formed by a circular flow tube is loaded with a circular fuel bundle which has 18 fuel elements. In the thermalhydraulic design of the HANARO, the design limit values for the three design parameters were determined using the statistical thermal design method[1,2]. The design basis is that for the normal operation and the operational occurrences, the physical phenomena like as CHF (Critical Heat Flux) or ONB(Onset of Nucleate Boiling) would not occur with the 95% of probability and the 95% confidence level as illustrated in Figure 1. In this paper, the maximum power levels satisfying the design limits were obtained and the safe operational ranges were made for the four different fuel channels.

2. Thermal Margin Evaluation

A subchannel analysis code MATRA_h was used to calculate the core thermal margin and all power distributions from the initial core to the estimated equilibrium core were taken into account to get conservative results. All the fuel channels were divided into the four groups according to the shapes and functions as R(Hexagonal), CAR(Control Absorber Rod), SOR (Shut Off Rod), OR(Outer Rig). The axial power distributions to evaluate the thermal margin were selected based on the hot channel factor(F_Q) over 80% of the maximum F_Q and the sum to peak(STP) representing the axial power shape effects. The selected axial power distributions are shown in Figure 2.

There are three thermalhydraulic design parameters i.e., the ONB margin, the MCHFR and the fuel centerline temperature, and their limit values are listed up in Table 1.

3. Results and Discussions

The maximum power level which satisfies the design limits was obtained through the iterative calculations of the thermal margin with increasing the linear power. Figure 3 shows the maximum allowable powers to be inversely proportional to the STP. The lower areas of the stepped lines mean the safely operable areas. The maximum allowable linear powers are distributed from 90 to 116 kW/m. The ONB limit among the three design parameters was reached early in most of the calculation cases

4. Conclusion

The reloading core of the HANARO should be evaluated based on the reactor physics calculation results whether the design limits are satisfied or not. For the effective fuel management, the maximum allowable power levels were evaluated using the subchannel analysis code and the linear power envelopes by the fuel channels were obtained.

REFERENCES

[1] H.T.Chae et. al., "Statistical Thermal Design of HANARO Core," KAERI Technical Report(in Korean), KAERI/TR-1300/99, 1999 April.
[2] H.T.Chae et. al., "Evaluation of Design Limit CHFR for the HANARO Core," Proceeding of KNS Spring Meeting, Korea, 1999 May.

Table 1. Thermalhydraulic design parameters and limits of the HANARO core

Design parameters		Design limits	
		Steady State	Transient
ONB margin (℃)	36 element	*12.7*	-
	18 element	*11.2*	-
MCHFR	36 element	-	*1.92*
	18 element	-	*1.86*
Fuel temperature (℃)		*350*	*485*

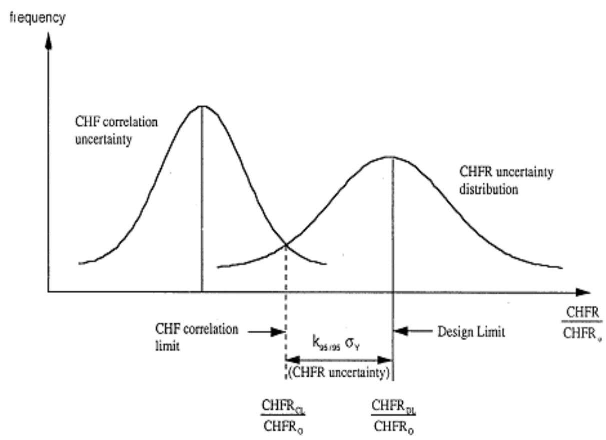
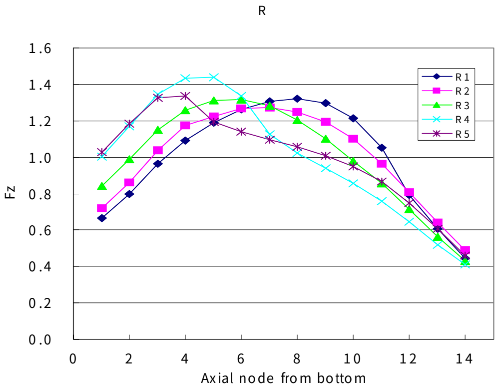
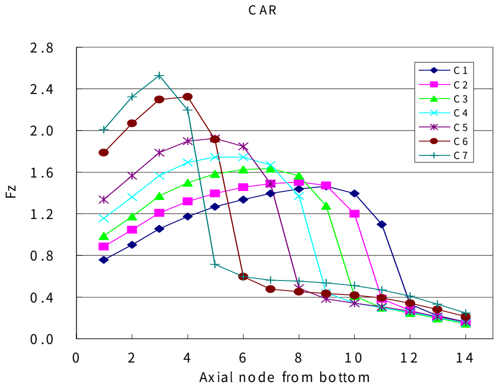


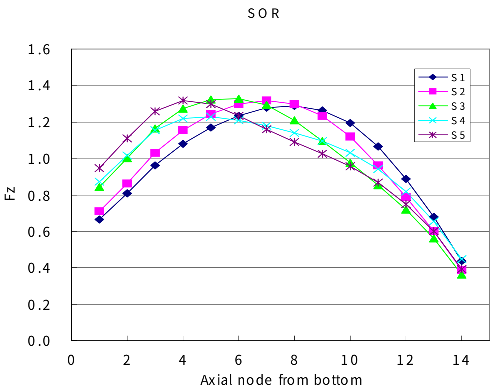
Figure 1. Schematic drawing of the design limit CHFR



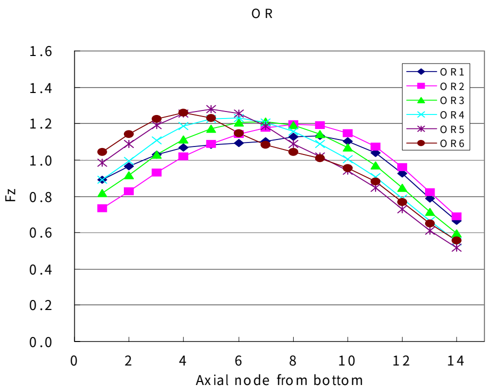
1) Hexagonal channel



2) CAR channel

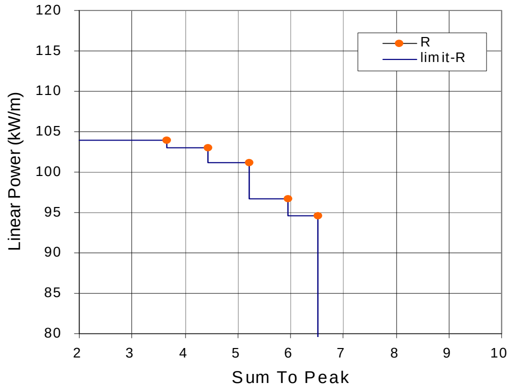


3) SOR channel

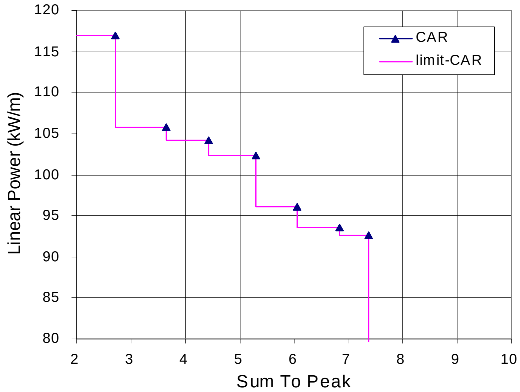


4) OR channel

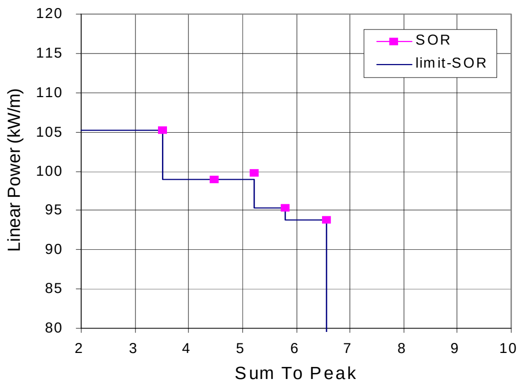
Figure 2. Axial power distributions by the fuel channels



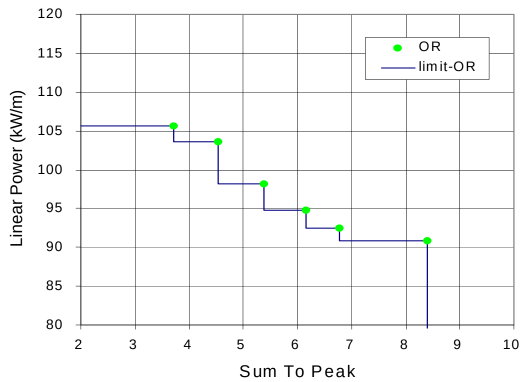
1) Hexagonal channel



2) CAR channel



3) SOR channel



4) OR channel

Figure 3. Maximum allowable power distributions along STP