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Effect of Heat Transfer at the Upper Guide Structure on Natural Circulation

Abdullah A. Rawashdeh[a,b,*], Young J. Chung[b]
[a] *University of Science and Technology, 217 Gajungro, Yuseong-gu, Daejeon, 305-333, Korea*
[b] *Korea Atomic Energy Research Institute, 1045 Daedeok-daero, Yuseong-gu, Daejeon, 305-353, Korea*
[*] *Corresponding author: abdullah.rawashdeh@yahoo.com*

1. Introduction

In research reactors, plate-type fuel elements are used in general due to its high neutron power density, research reactors with low power in general cooled by forced downward flow at steady-state, but natural circulation flow during transient cases [1]. Therefore, the natural circulation is important in the nuclear safety analysis especially in measuring Minimum Critical Heat Flux Ratio (MCHFR) and maximum fuel cladding temperature.

The UGS is designed to provide the flow path for the primary coolant and supports for the guide structures of control absorber rods and second shutdown rods. It is modeled to be above the core; hot and other fuel assemblies.

In this paper, natural circulation has been studied find the effect of the UGS (Upper Guide Structure of core) with and without considering Heat Structure (HS) model, using ***RELAP5 mode3.3*** Code. The natural circulation flow during the training operation mode of a research reactor was studied [2].

2. Modeling and Input parameters

A 5 MW and open-pool type reactor is considered in this study .The flow direction is downward when the flow is forced. In the training mode, the primary cooling pumps are turned off and the reactor core coolant is circulated by natural convection with upward direction, which is enough to cool the core [3][4].

As shown in Table 1, the power is only 1.0% of the full power. Thermal conductivity, pressure, temperature described Table I.

Table I: Main Input Parameters and Descriptions for JRTR Training Mode

Reactor data	**Values & type**
Core power	52.5 KW
Pressure	0.173 MPa
Pumps	Turned off
The upper guide structure (UGS)	aluminum alloy
Initial coolant temp. in the UGS & hot fuel assembly	312.2 K

3. Result and Discussions

Fig.1 through Fig.3 are heat flux and inlet and outlet coolant temperatures at the hot channel and the reactor core, there are no significant differences between the cases with and without heat transfer across the UGS

After the result of mass flow rate showed that there is no significant difference for the flow rate of hot channel and for core as in the Fig. 4 and Fig. 5 so the difference between two cases could be known as minor difference at this mode.

Fig. 4 and Fig. 5 show the flow rates at the hot channel and the core inlet, respectively. The differences between two cases are minor.

Fig. 6 and Fig. 7 show the maximum fuel cladding temperatures and critical heat flux ratios, respectively. There is no difference of critical heat flux ratio but the maximum temperatures show a little bit difference, this difference shown also in Fig. 8:

$$Residual\ \ differnece\ for\ maximum\ fuel$$

$$temperatures\ = |Twith - Twithout|\ ;$$

$$Twith : Max.Fuel\ Temp.of\ UGS\ with\ HS$$

$$Twithout :\ Max.Fuel\ Temp.of\ UGS\ without\ HS$$

4. Conclusions

It is indicated that there is a minor effect of UGS model on the maximum fuel cladding temperature during training operation mode in this small research reactor. It does not lead to any significant difference of any safety parameter. The maximum residual error for Maximum hot fuel cladding temperature is about 2.5%.

REFERENCES

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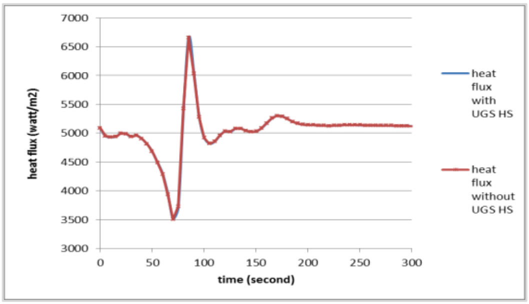

Fig. 1. Heat flux at the middle of Hot Channel.

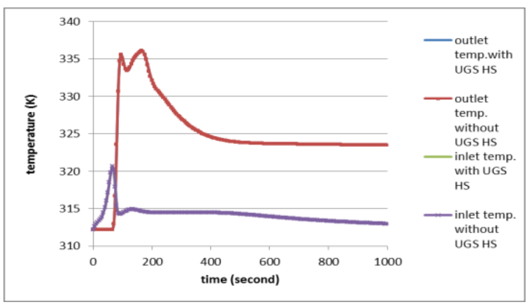

Fig. 2. Coolant Temperatures in the Hot Channel.

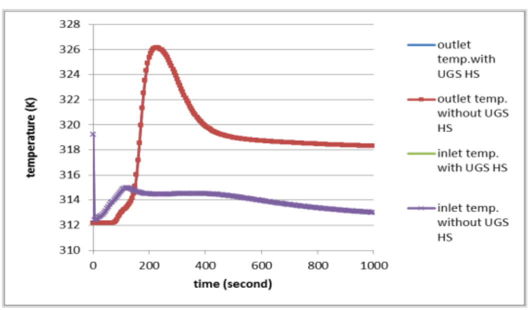

Fig. 3. Core Coolant Temperatures.

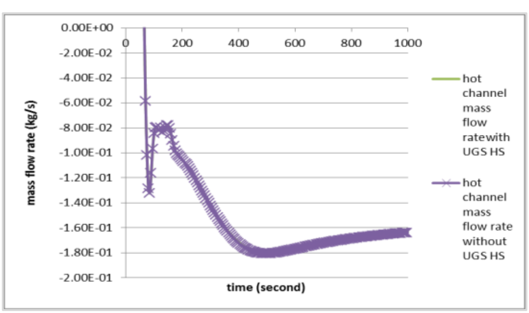

Fig. 4. Mass flow rates at the Hot Channel.

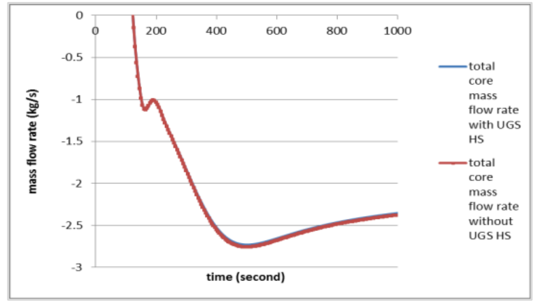

Figure 5. Mass flow rate of Core.

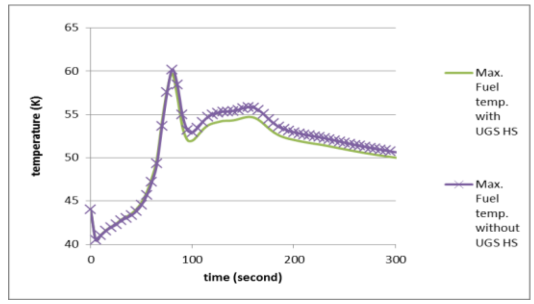

Fig. 6. Maximum hot fuel cladding temperatures.

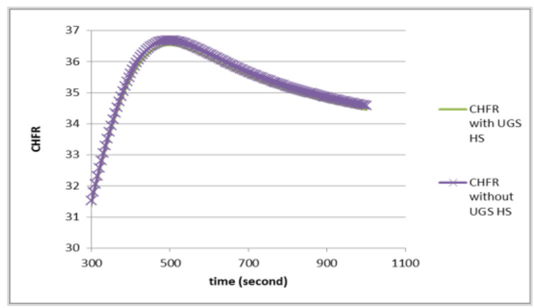

Fig. 7. Critical Heat Flux Ratios at the middle of hot fuel.

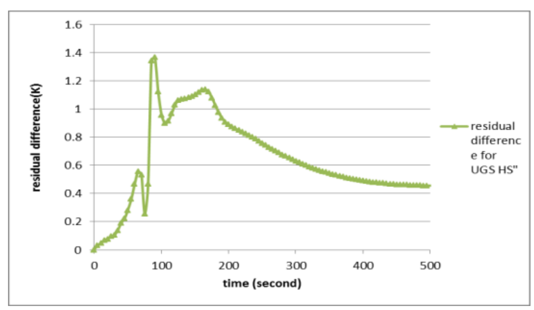

Fig. 8. Residual difference for Maximum hot fuel cladding temperature.