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Heat Transfer Analysis in the Hydraulic Transfer System

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1. Introduction

The HTS (Hydraulic Transfer System) in KJRR (KI JANG Research Reactor) is a facility to produce radioisotope by irradiating the target remotely. The HTS will be designed according to the ASME code [1]. The pipe is installed between the TTS (Target Transfer Station) and the ITA (Irradiation Tube Assembly) as shown in Fig 1. The targets inside the pipe is transferred by hydraulic force due to pump operation. The ITA is installed in the reflector of the reactor core, and the targets are irradiated in the ITA. The speed of targets shall be limited not to exceed the specified reactivity insertion rate. Because the speed of target can be controlled by the drag force and the hydraulic force, the selection of the inner diameter of the pipe is the key factor to design the HTS.

During irradiation, the heat is generated from the targets; therefore, the heat transfer analysis shall be carried out for evaluating whether boiling water occurs or not. This deign requirement is also involved in determining the inner diameter of the pipe. Thus, the selection of the pipe size shall be taken into account from the viewpoint of the target speed and the heat transfer. The paper is only focused on the heat transfer, and the heat conduction analysis is conducted for the conservative design.

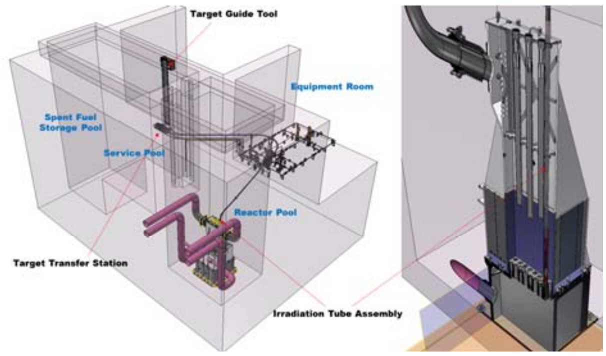
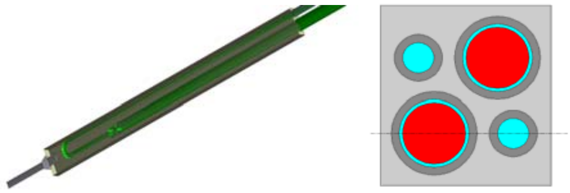


Fig. 1. HTS Layout

2. Heat Transfer Analysis

The cross-section of the ITA is as shown in Fig. 2, and three targets are irradiated in the large hole. In Fig. 2(b), the red color is the target, the grey color corresponds to the reflector, and the water gap exist between the pipe and the target. During irradiation, the water inside the pipe does not flow. The coolant outside the reflector always flows, and its mass flow rate is about 0.335 kg/s. Other System will maintain the temperature of coolant inlet at 35℃ and the temperature of coolant outlet at about 39℃. In this situation, the temperature of the side walls of the reflector will approach about 70℃, and the convective heat transfer coefficient will be about 3033 W/ m^2·K. Meanwhile, it is predicted that the internal heat generation due to the targets will be about 1.438 × 10^6 W/m^3, and all the materials are aluminium.



a) ITA geometry b) Cross-Section

Fig. 2.Configuration of the ITA

The ambient temperature is assumed to be 70℃. The surrounding conditions are applied to the FE model the boundary conditions, and they are shown in the Fig 3. The maximum water temperature inside the pipe is estimated by the heat transfer analysis considering the only thermal conduction with varying the water gap.

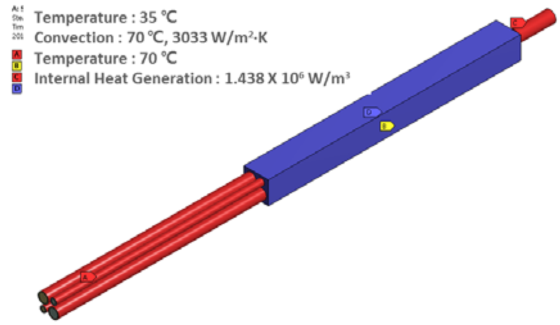


Fig. 2.Boundary Conditions on the FE Model

3. Results and Discussion

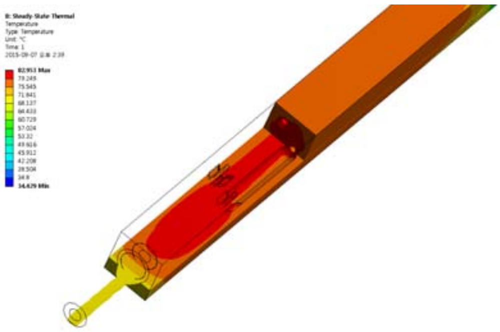
Firstly, when the inner diameter of the large hole is 30 mm and the targets is not loaded in the ITA, the maximum water temperature is found by using ANSYS [2]. The ambient temperature 70℃ corresponds to the severest condition, and the maximum water temperature is listed in Table 1 as the ambient temperature is varied.

When the inner diameter of the large hole is 29 mm; that is, the water gap between the target and the pipe is 0.5 mm, the temperature field are examined by using

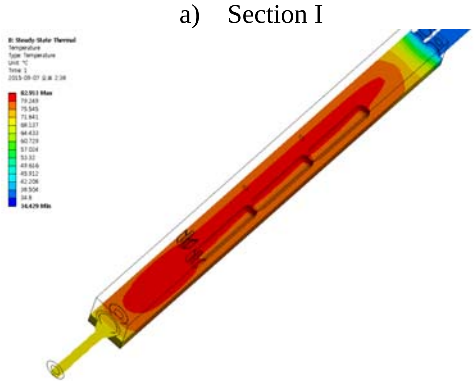
ANSYS [2] as shown in Fig. 3. Because the internal heat is generated from the target, the high temperature is distributed around the targets, and the maximum temperature is 82.95℃.

Table 1: Max. Temperature with Varying the Ambient Temperature

Ambient Temperature	Max. Temperature
70 ℃	83 ℃
65 ℃	78 ℃
60 ℃	73 ℃



a) Section I



b) Section II

Fig. 3. Temperature Field

The temperature field are analyzed according to the water gap, and the maximum water temperature is summarized in Table 1. When considering the thermal conductivity, it is predicted that boiling water will not occur. Therefore, when operating the HTS, the coolant will not be needed to remove the heat generated by targets during irradiation.

Table 1: Max. Temperature with Varying the Water Gap

I.D.	*Gap*	*Max. Temperature*
29 mm	0.5 mm	82.95 ℃
30 mm	1.0 mm	85.44 ℃
31 mm	1.5 mm	87.01 ℃
32 mm	2.0 mm	89.63 ℃

When the water gap between the target and the pipe is 0.5 mm, the transient heat analysis is also carried out, and it takes about 10 minutes up to reach the state-steady.

Based on these results, the pipe size can be determined by only considering the target speed in the vertical section [3].

4. Conclusions

In this study, only the thermal conduction in the heat transfer analysis is considered for the HTS to be designed conservatively. If the force convection caused by the flow outside the reflector is considered, the maximum water temperature will decrease. Because the boiling does not occur in any cases, the operation mode for cooling targets in the HTS will not be included.

5. Acknowledgement

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REFERENCES

[1] ASME B&PV Committee, 2004, ASME B&VP Code, SEC. III, Division 1, Appendices N
[2] ANSYS User Guide for Release 2015, 2015
[3] Hydrodynamic Control of the Motion of a Capsule Conveyed by Liquid in a Pipe, 2015, The Transactions of the Korean Society of Mechanical Engineers Autumn Meeting.