

# Preliminary Design of Heat Exchanger Considering in Operating Flow Rate Range in a Research Reactor

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## Introduction

- In general, a primary cooling system (PCS) is designed for the core cooling of a research reactor.
- Recently, efforts are being made to lighten the system by applying a plate heat exchanger. Compared to shell and tube type heat exchangers, the plate heat exchanger has the advantage that the heat transfer area is integrated, so that the thermal size is small and maintenance is simple.
- For this reason, the plate heat exchanger was applied to the PCS of Jordan Research and Training Reactor (JRTR), which was constructed in 2016, and is currently operating.
- Heat exchanger is designed in consideration of the design point as one operating condition. In the case of the research reactor, the temperature of the cooling water to be supplied to the core must be maintained below a limit temperature for the reactor shutdown. The heat exchanger must be designed to meet this limit temperature over the entire operating flow rate range of the actual primary cooling system.
- In this study, a design point that can satisfy the operating flow range was determined by calculation and setting a virtual model as a hypothetical study.

## Cooling system modeling

- In this study, the cooling system model of the research reactor is assumed and Fig. 1 shows a schematic of the core cooling system which is composed of the reactor pool, core, a cooling pump, heat exchanger, and piping. In this paper, all the components for core cooling are not considered but minimum components for heat transfer calculation are applied.
- For the design of a heat exchanger for core cooling in the research reactor, a virtual model of the following flow conditions was set.
  1. Core power: 15 MW
  2. Design flowrate for cooling system: 500 kg/s
  3. Operating flowrate range ( $\pm 10\%$ ): 450 ~ 550 kg/s
  4. Inlet temperature of heat exchanger primary side: 42.0°C (fixed)
  5. Flow rate of heat exchanger secondary side: 450 kg/s (fixed)

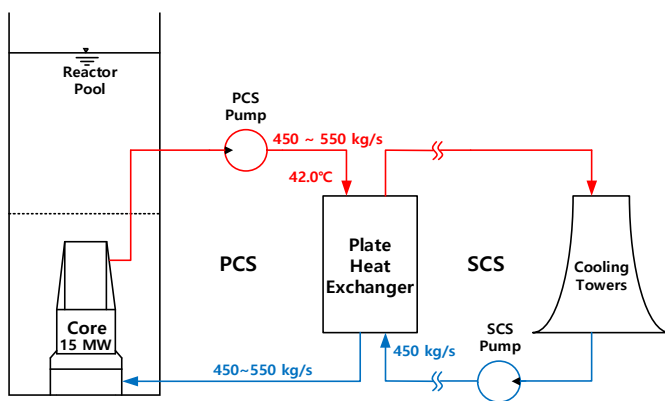


Fig. 1. Schematic of core cooling system in a research reactor.

## Result and discussion

- When selecting an initial design point of the heat exchanger, one operation condition value, such as the middle value of the operating range, is considered. The heat transfer requirement of 1.5 MW is unsatisfied at the lowest flow rate (450 kg/s) in the operating range.
- Therefore, the operating flow range of the cooling water must be considered and the design reference should be changed to be able to remove 1.5 MW of heat at 450 kg/s. Fig. 2 show the calculated results. The result is shown that the heat transfer requirements ( $\geq 1.5$  MW) over the entire flow range are satisfied and it is created margin of about 1.0 MW at the upper value (550 kg/s). In this case, the entire outlet temperature of the primary side is reduced.
- As Fig 2. Is shown, when designing the cooling system of the research reactor, the maximum temperature of the cooling water entering the core is determined in the highest flow range of the system operating flow range.
- Therefore, in order to prevent unexpected reactor shutdown due to the reactor inlet temperature of the cooling water, the maximum coolant temperature should be designed to be lower than the limit temperature to secure a stable operating margin.

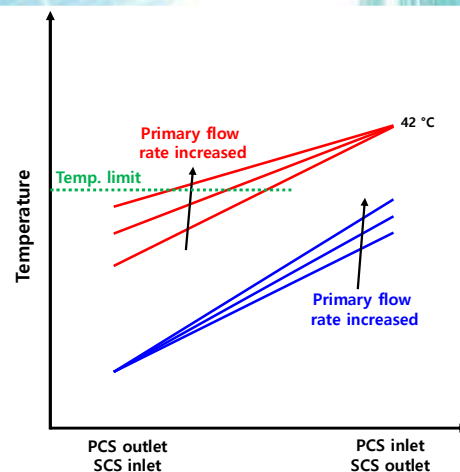


Fig. 2. Calculation results.

## Conclusions

- Design point that can satisfy the operating flow range was determined by calculation and setting a virtual model.
- When designing a heat exchanger, it is necessary to define the operating flow rate range and to calculate heat capacity at the lowest flow rate.
- As the results designed with a design reference determined at the lowest flow rate has a large heat transfer amount at a highest flow rate, and can provide outlet temperature of primary side lower than that by the design flow rate.

## References

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- [2] Flowmaster V7 New User Training (FLOWMASTER Ver. 7.9), Mentor Graphics Corp., 2012.