Performance Comparison of RHR Systems with Different Pump Performance Curves

Dongkyung Sohn[a], Dong Hun Lee[a], Gong-Hee Lee[b],*

[a]Department of Reactor System, Korea Institute of Nuclear Safety
[b]Department of Regulatory Assessment, Korea Institute of Nuclear Safety
[*]Corresponding author: ghlee@kins.re.kr

Introduction

❖ *Why This Study?*

- **Pump component is one of the most significant components** to determine the performance of an active safety system
- **Pump component is often treated as a boundary condition** rather than an actual pump model in the thermal-hydraulic analyses [3-4]
- However, **the assumption might not be appropriate** in the case where **the system resistance varies during operation**
- **The Residual Heat Removal (RHR) system is the typical case** in which the system resistance varies during its cooling operation

❖ *What I have Done?*

- **the performances of the RHR systems were compared.** The systems **have different pump performance curves** which have the different gradients but the same rated point.
- The comparison of the system performances **can help determine whether it is important to model the pump as its own performance curve**

Methods and Results

❖ *The Reactor and the Residual Heat Removal System*

- For this study, **a light water reactor with a RHR system were modeled**
- **The major specification** of the pipe and pump is as below

Reactor	
Design Power (MW_{th})	3983
Decay Heat (% of the design power)	1.0
Total Coolant Volume (m^3)	453
RHR Pump	
Rated Flow rate (m^3/s)	0.342
Rated Differential Pressure (m)	140.2
RHR Heat Exchanger	
Effective Area (m^2)	776.9
Shell Mass Flow Rate (kg/s)	691.7
Inlet Temperature (K)	305

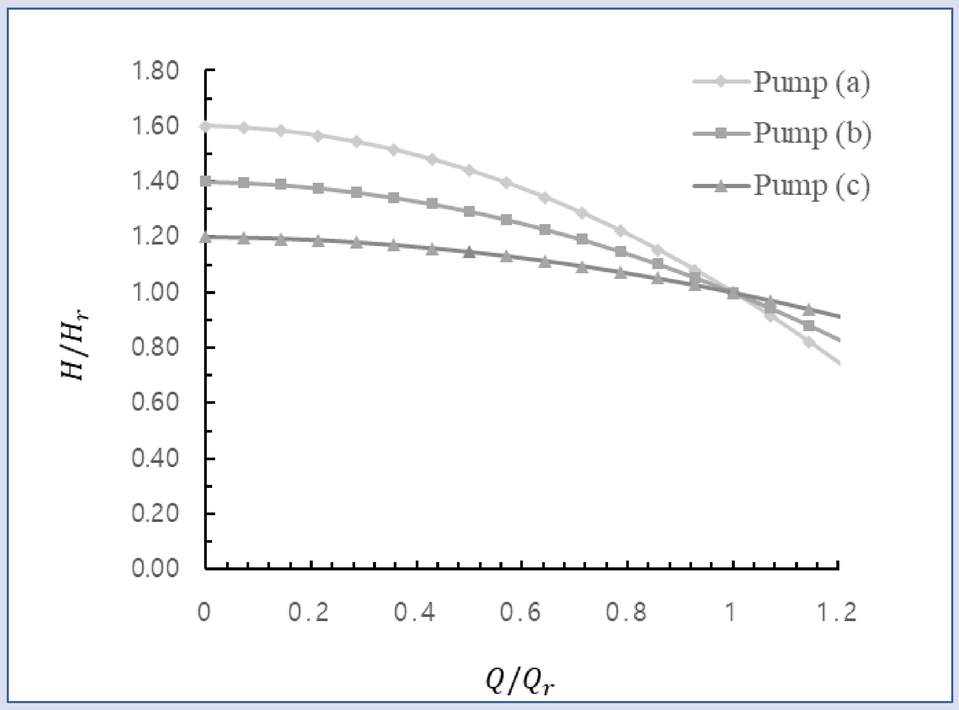
- **The initial condition** of the calculation were based on **the condition 14 hours after the reactor trip**

❖ *The Performance Curves of the RHR Pumps*

- For the comparison, **three pumps with different performance curves** were considered
- The curves have **different gradients** but **the same rated point**: the same rated flow rate and the same differential pressure

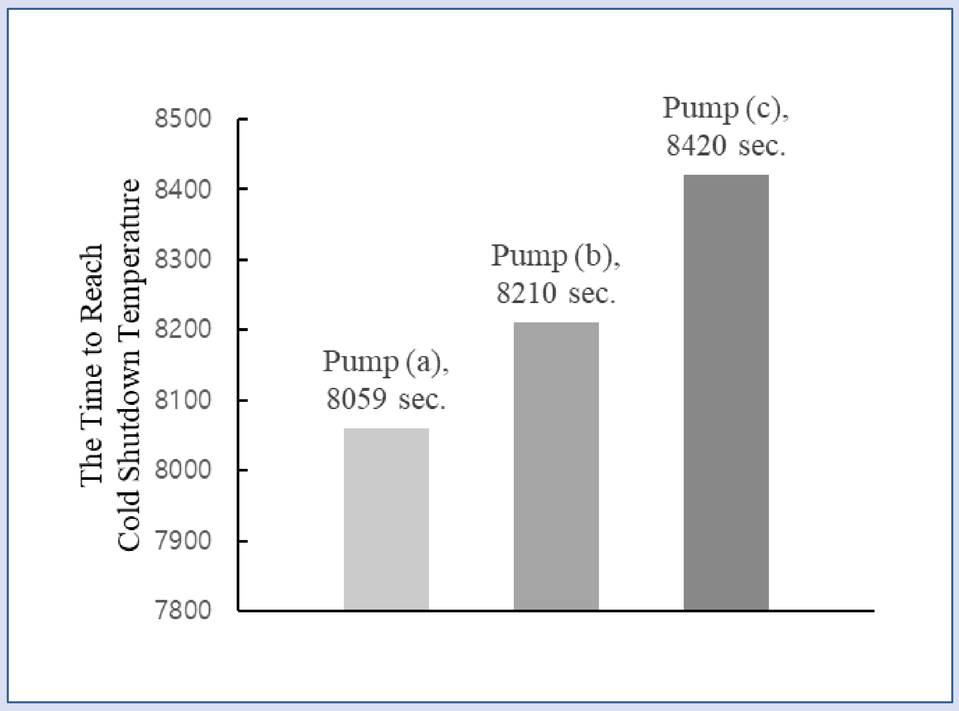
❖ *The Performance Curves of the RHR Pumps(Cont.)*

- **(a) the relatively steep gradient curve, (b) the reference gradient curve, and (c) the relatively gentle gradient curve.**



❖ *Performance Comparison of the RHR Systems*

- the performances of the RHR systems were represented as **the cooling time from 449.7K to 372.0K based on the system temperature**



Conclusions

- the performance results of the pumps showed up to the difference of **4.52% depending on their performance curve gradients**
- These results mean **that the performance curve of the pump has a substantial effect on the performance of the RHR system**
- And it indicate that **modeling the pump as its rated flow might not be appropriate** to properly reflect the behavior of the pump.
- **in order to properly simulate the behavior of the RHR system with the pump, modeling the pump as its own performance curve might be required**

DISCLAIMER
The opinions expressed in this paper are those of the author and not necessarily those of the Korea Institute of Nuclear Safety (KINS). Any information presented here should not be interpreted as official KINS policy or guidance.

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