Analysis of Heat Transfer Performance of a Fork-End Heat Pipe Using MARS-KS

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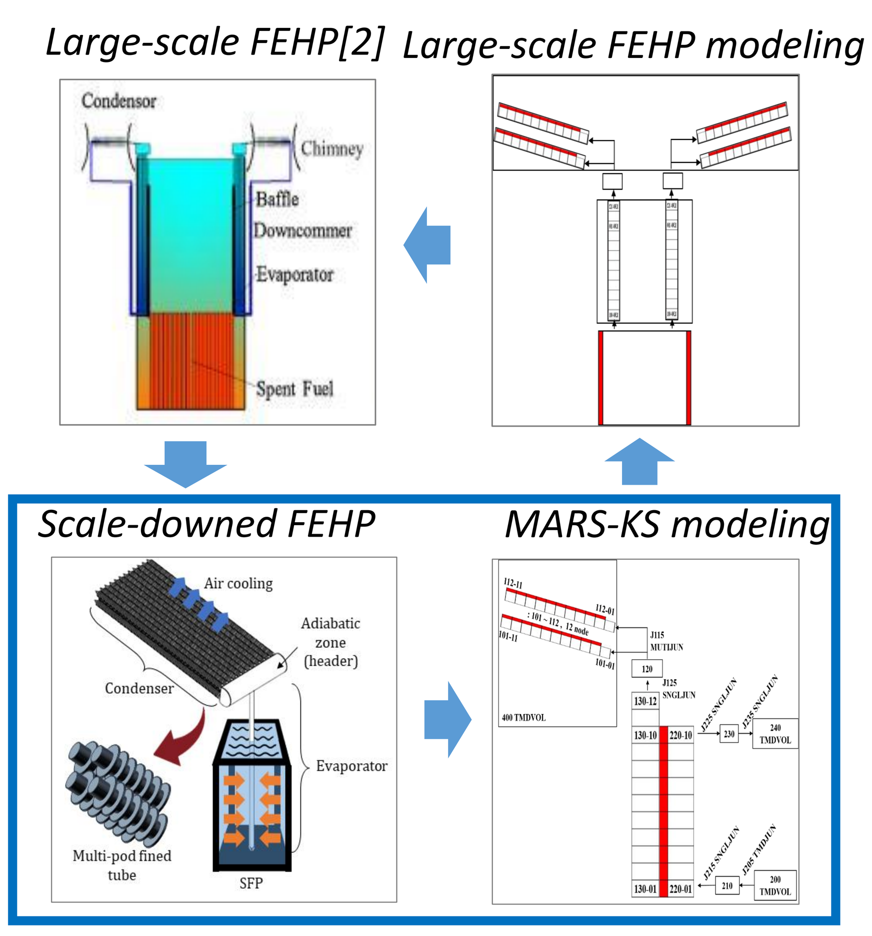
MOTIVATION AND OBJECTIVE

Motivation

- Lim and Kim [1] proposed a new concept of a large-scale fork-end heat pipe (FEHP) system for passive cooling and experimentally examined heat transfer performance of a scale-downed FEHP.

[1] Changhwan Lim, Hyungdae Kim, Experimental Study on Heat Transfer Characteristics of a Multi-Pod Heat Pipe, Transactions of the Korean Nuclear Society Autumn Meeting Gyeongju, October 26-27, Korea, 2017.



- Small-scaled FEHP is either decompressed or vacuumed.

[2] Z. Xiong, H. Gua, M. Wang and C. Ye, The thermal performance of a loop-type heat pipe for passively removing residual heat from spent fuel pool, Frontiers in Heat Pipes, Volume 4, No. 1, 2013, pp. 1-6.

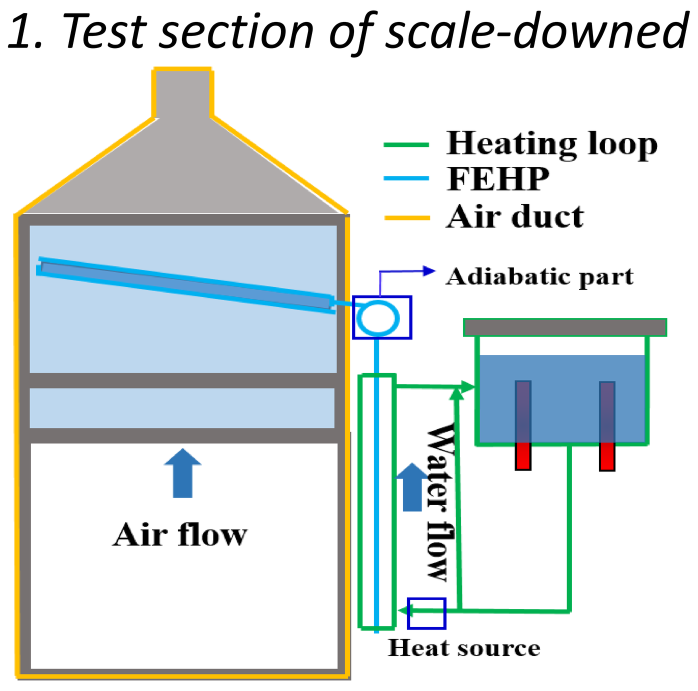
- MARS-KS is calculated mainly at high pressure, but it is also checked that the calculation is correct at low pressure.
- Therefore, it is necessary to check the performance of scale-downed FEHP theoretically by using the thermal-hydraulic code, MARS-KS.

Objective

- To analyze heat transfer performance of the scale-downed FEHP using the thermal-hydraulic analysis code, MARS-KS.

MARS-KS MODELING OF FEHP

1. Test section of scale-downed FEHP



Operating condition of FEHP

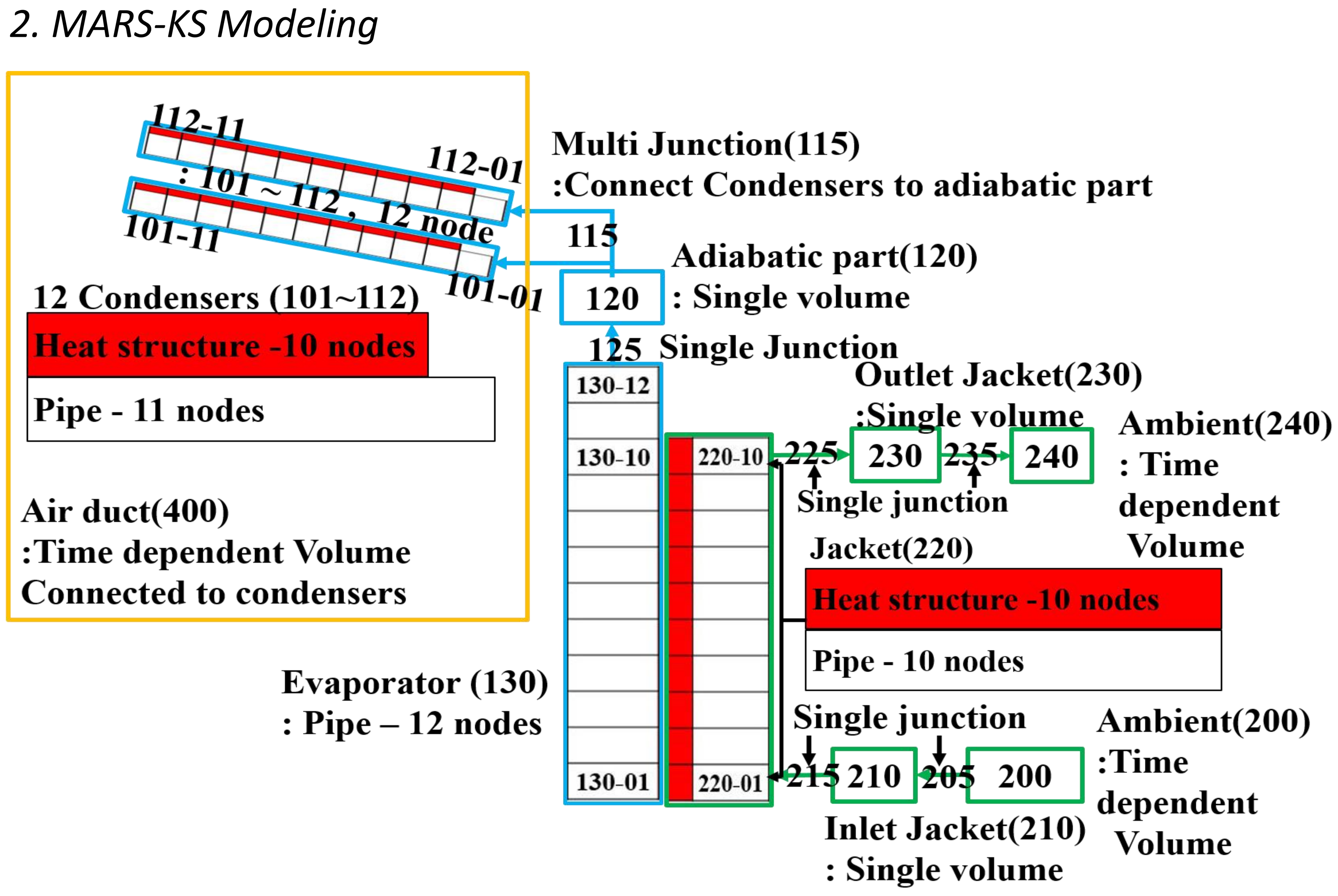
Mass flow : 0.56 kg/s

Pressure : 5500 ~ 15600 Pa

Operating Principle of Heat Pipe

The vapor generated from the evaporator rises by the density difference with the liquid, passes through the adiabatic part, reaches the condenser, and is condensed back to the evaporator along the wall by gravity.

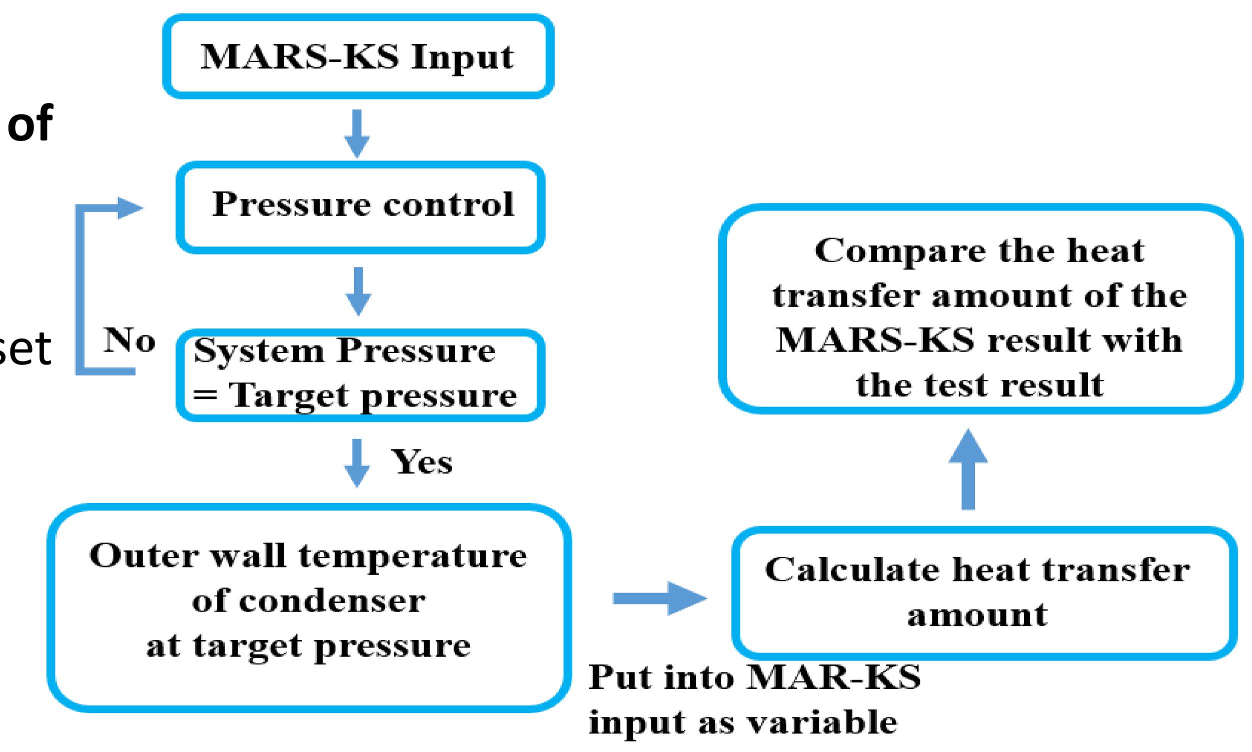
2. MARS-KS Modeling



METHODOLOGY

There is no appropriate correlation for cross-flow convective heat transfer coefficient of finned tubes in the air-cooling duct.

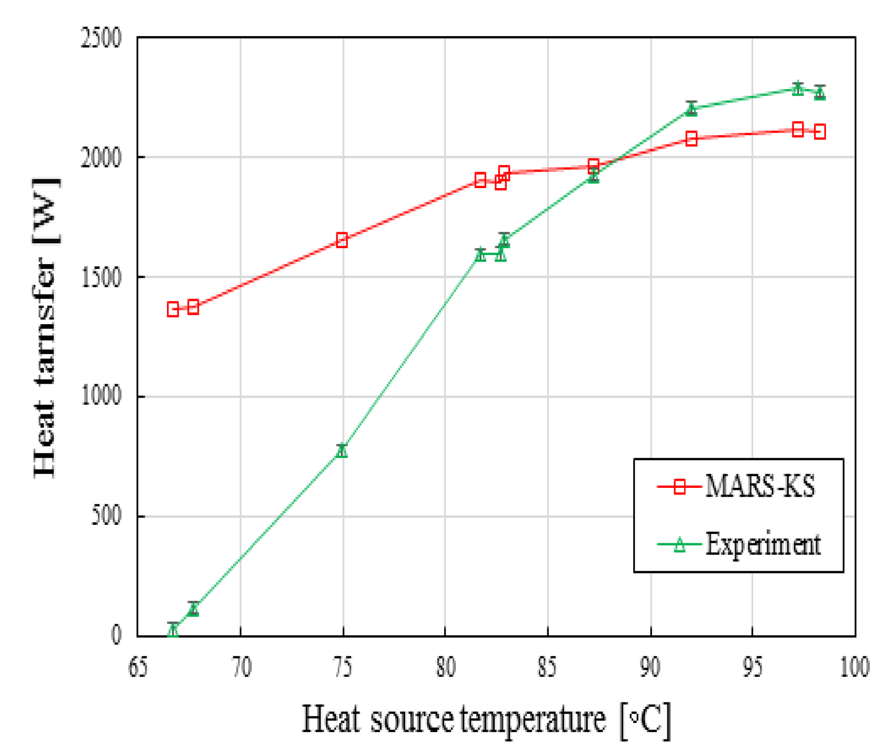
- ➢ To evaluate **the inside of the heat pipe only**
- ➢ The outer wall of the condenser tubes was set to have a high heat transfer coefficient.



RESULTS AND DISCUSSION

1. Heat transfer

1-1. Heat transfer in evaporator according to heat source temperature



When heat source temperature of the heat pipe was higher than ~ 82◦C, the simulation results of heat transfer performance in comparison with the experimental measurement showed a reasonable agreement within error of 20%.

When heat source temperature of the heat pipe was lower than ~ 82◦C, considerable errors were observed in heat transfer performance.

1-2. Boiling regimes in the evaporator of the heat pipe observed in the experiment and MARS-KS with respect to heat source temperature

Heat source temperature [◦C]	Boiling regime	
	Experiment	MARS-KS
66.7	No boiling	Fully developed boiling - nucleate boiling
67.7	Intermittent boiling - geyser	
74.9		
81.7	Fully developed boiling - nucleate pool boiling	
82.7		
82.8		
87.3		
92.0		
97.2	Fully developed boiling - falling film boiling	
98.3		Fully developed boiling nucleate boiling (1~4,10node) transition boiling(5~9node)

- ➢ At heat source temperature less than ~ 82◦C, it was observed that boiling regime is not fully developed in However, in the MARS-KS results, it was observed in a completely boiling state at all temperatures.
- ➢ The experiments have different boiling regime from the MARS-KS results ,which results in a considerable discrepancy in heat transfer between experiment and simulation.

CONCLUSIONS AND FUTURE WORK

- In the MARS-KS analysis of small-scaled FEHP, the tendency to increase the heat transfer amount as the heat source temperature increased was consistent, but there was a quantitative difference from the results of the experiment because of a difference in boiling between experiment and MARS-KS results.
- To correctly analyze heat performance of scale-downed FEHP, it is supposed that boiling regime of experiment need to be properly modelled in MARS-KS.