Constitutive Equations Improvement Methodology of Reactor Safety Analysis Code using Experimental Data: Application to SUBO Experiment

NQe Department of Nuclear & Quantum Engineering

ChoHwan Oh[a], Doh Hyeon Kim[a], Jeong Ik Lee[a]*

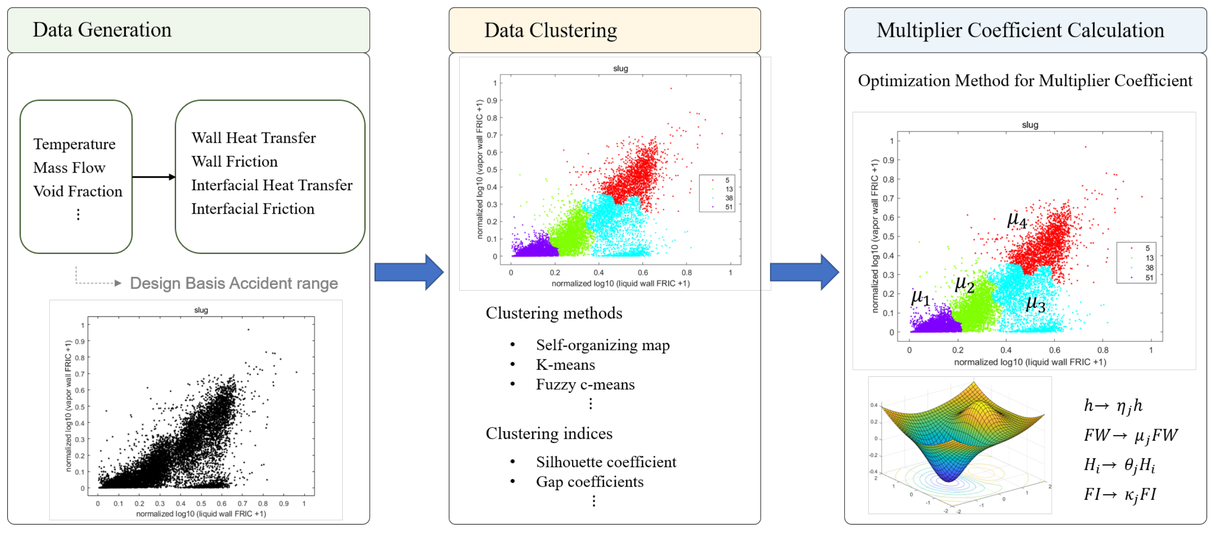
[a]*Dept. of Nuclear & Quantum Engineering, KAIST, 373-1, Guseong-dong, Yuseong-gu, Daejeon, 305-701, Republic of Korea*

Email: jeongiklee@kaist.ac.kr

Introduction

▣ There are many uncertainties and errors in the modeling of reactor accident phenomena even though many thermal hydraulic experiments and researches have been conducted for five decades.

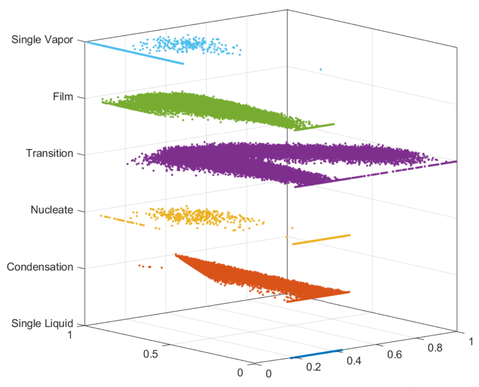
▣ In this study, following methods are proposed to improve accuracy of the reactor safety analysis code with the IET data directly: Data Generation, Data Clustering, and Multiplier Coefficient Calculation.

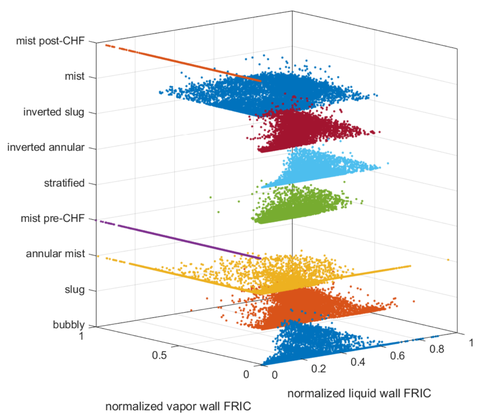


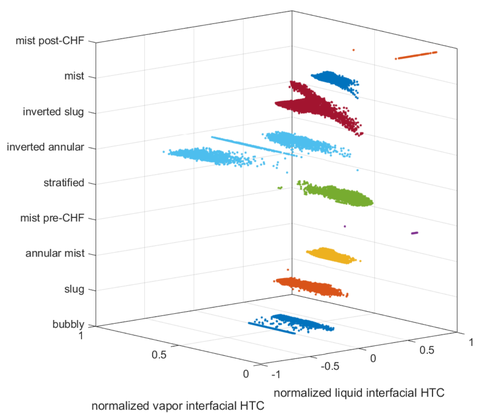
Data Clustering

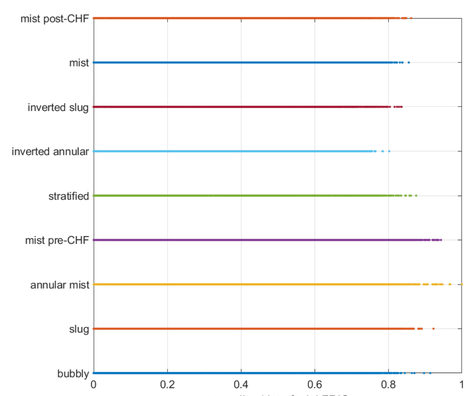
SOM training data

- wall heat transfer: liquid wall HTC, vapor wall HTC, heat regime (3D)
- wall friction: liquid wall FC, vapor wall FC, flow regime (3D)
- interfacial heat transfer: liquid interfacial HTC, vapor interfacial HTC, flow regime (3D)
- interfacial friction: interfacial FC, flow regime (2D)



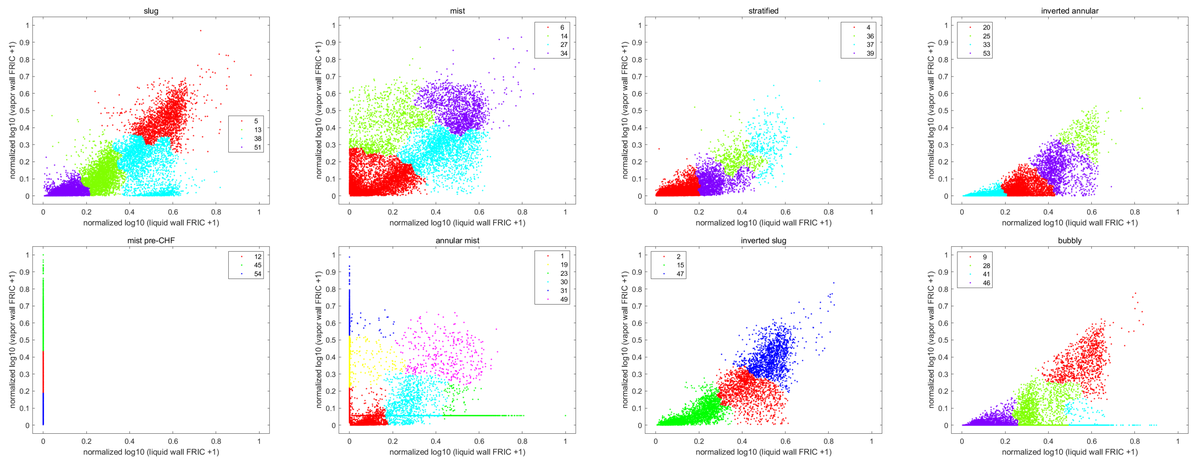






Optimal cluster number and results

	Wall Heat Transfer	Wall Friction	Interfacial Heat Transfer	Interfacial Friction
Minimum clustering number	71	55	49	51
Optimal clustering number	109	55	83	60



Multiplier Coefficient Optimization

Optimization Algorithm

Calculate the constitutive equations in modified MARS-KS (Multiplier Coefficient = 1.0 for all regime)

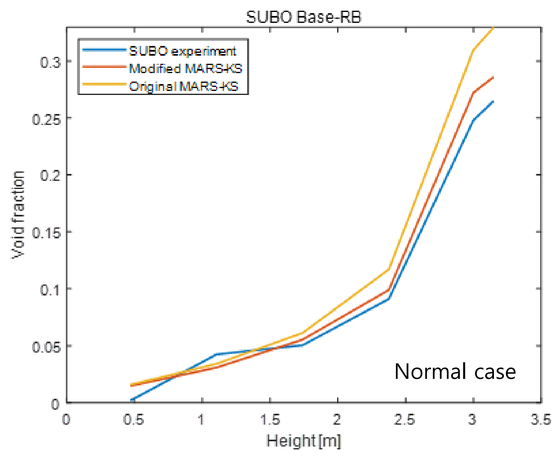
Check the contained regime in whole regime (Total number: 554)

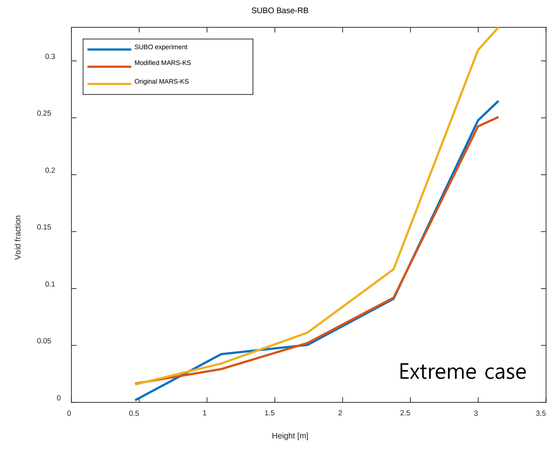
Repetition:

- Initialize Multiplier coefficient in contained regime with Latin Hypercube Sampling
- Check the uncertainty band of multiplier coefficient within 95% confidence level
- Find the multiplier coefficient that minimize the error function (Optimization Process)
- Check whether the other regime is newly contained

Optimization End

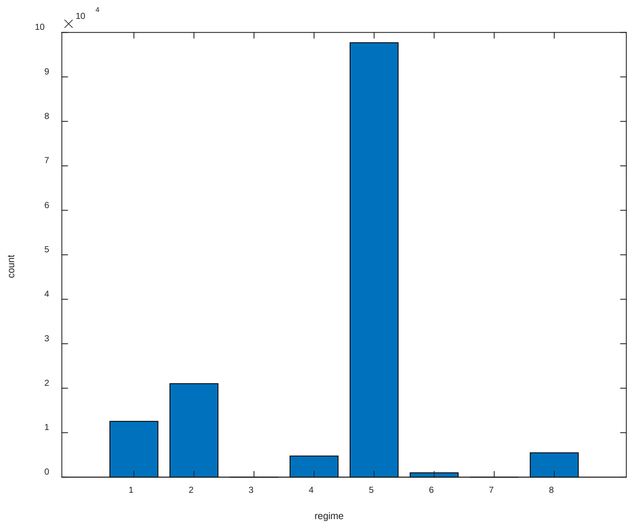
SUBO experiment optimization





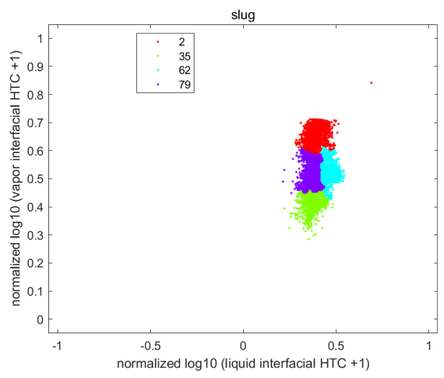
	Original MARS-KS	Modified MARS-KS (Normal Case)	Modified MARS-KS (Extreme Case)
Error	0.1852	0.0826	0.0498

Multiplier coefficient analysis



Regime	Regime Number	The number of count
1	2	12,546
2	10	21,025
3	11	18
4	21	4,750
5	35	97,691
6	40	979
7	71	19
8	79	5,472

	0.8 – 1.2 case	0.1 – 10.0 case
Multiplier Coefficient	1.0434	3.5820



Summary and Further Works

▣ In this study, a new method is being developed to directly utilize IET data to improve accuracy of the reactor safety analysis code: clustering the constitutive equations, and calculating the multiplier coefficient for each group.

▣ The error of safety analysis code has been reduced more than a half with range of 0.8 – 1.2.

▣ It can directly contribute to improving the performance of constitutive equation with experiment data in the future.

This work was supported by the Nuclear Safety Research Program through the Korea Foundation Of Nuclear Safety(KoFONS) using the financial resource granted by the Nuclear Safety and Security Commission(NSSC) of the Republic of Korea. (No. 1903002)