Methodology of Constitutive Equations Improvement in Safety Analysis Code using Experimental Data: MIT Pressurizer Experiment

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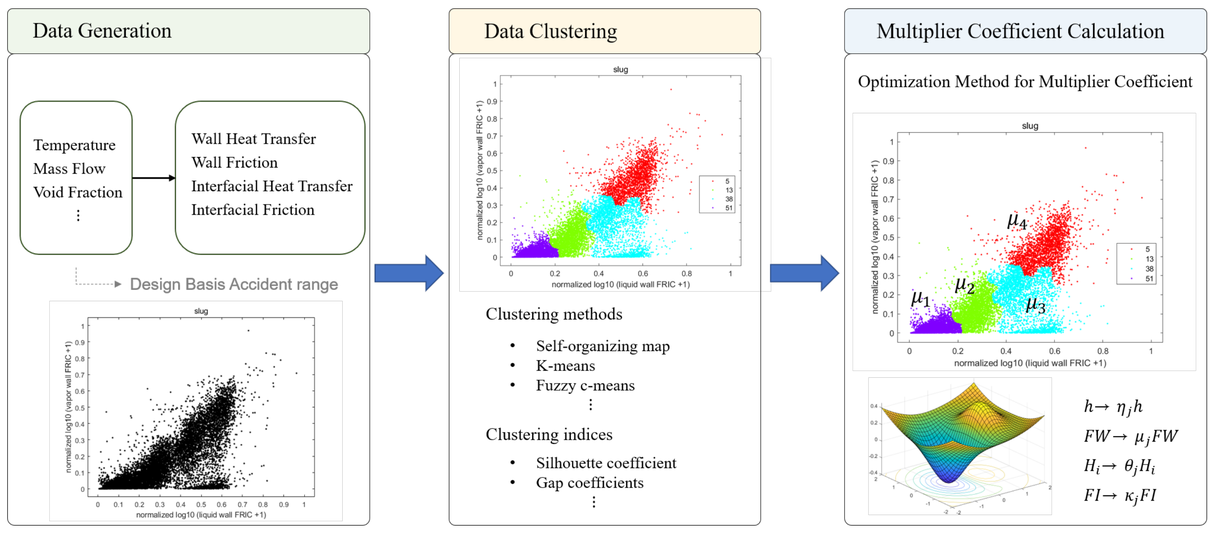
Introduction

▣ 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.

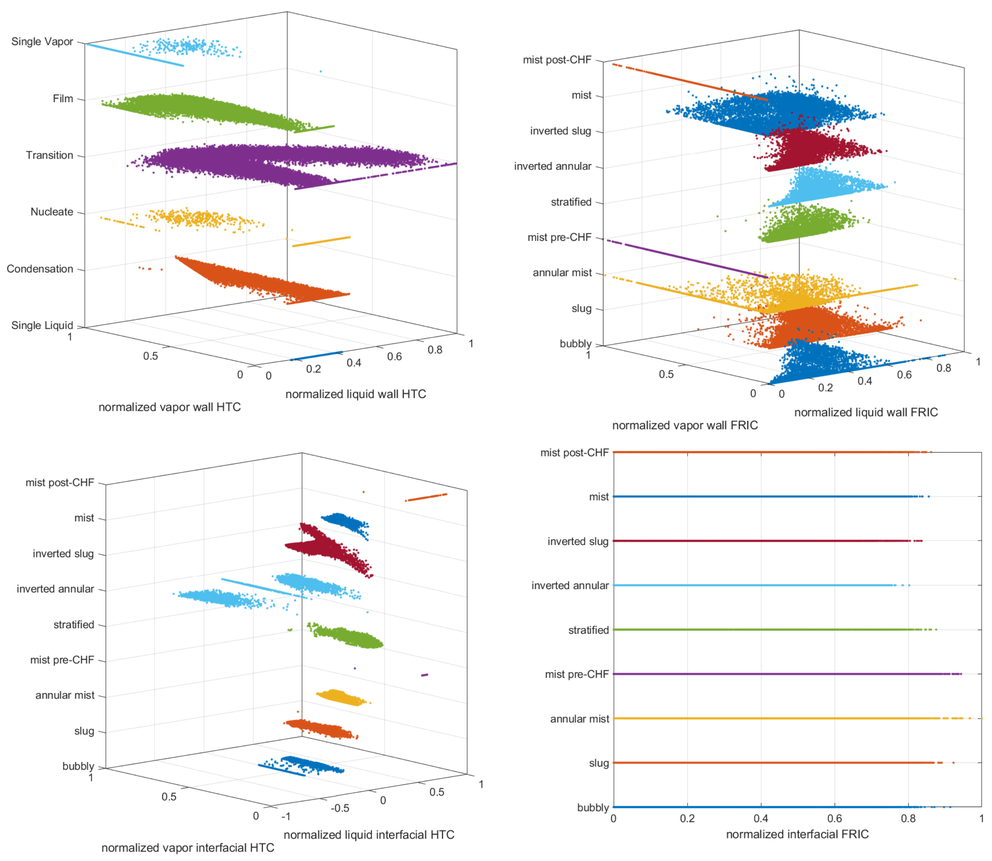
▣ In this study, following methods are proposed to improve accuracy of the reactor safety analysis code with the IET data directly: Data Generation, Data Clustering, and Multiplier Coefficient Calculation.



Data Clustering

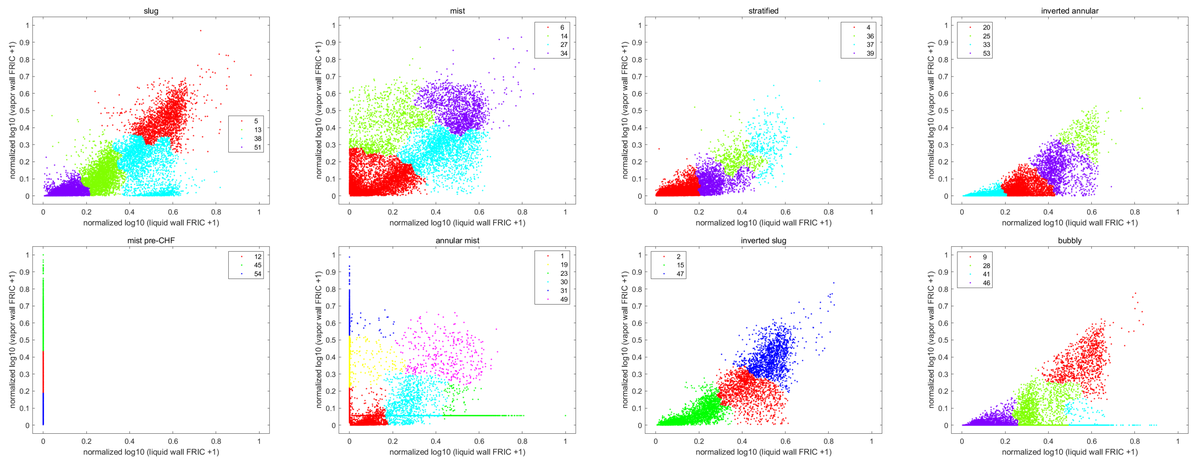
SOM training data

- 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)



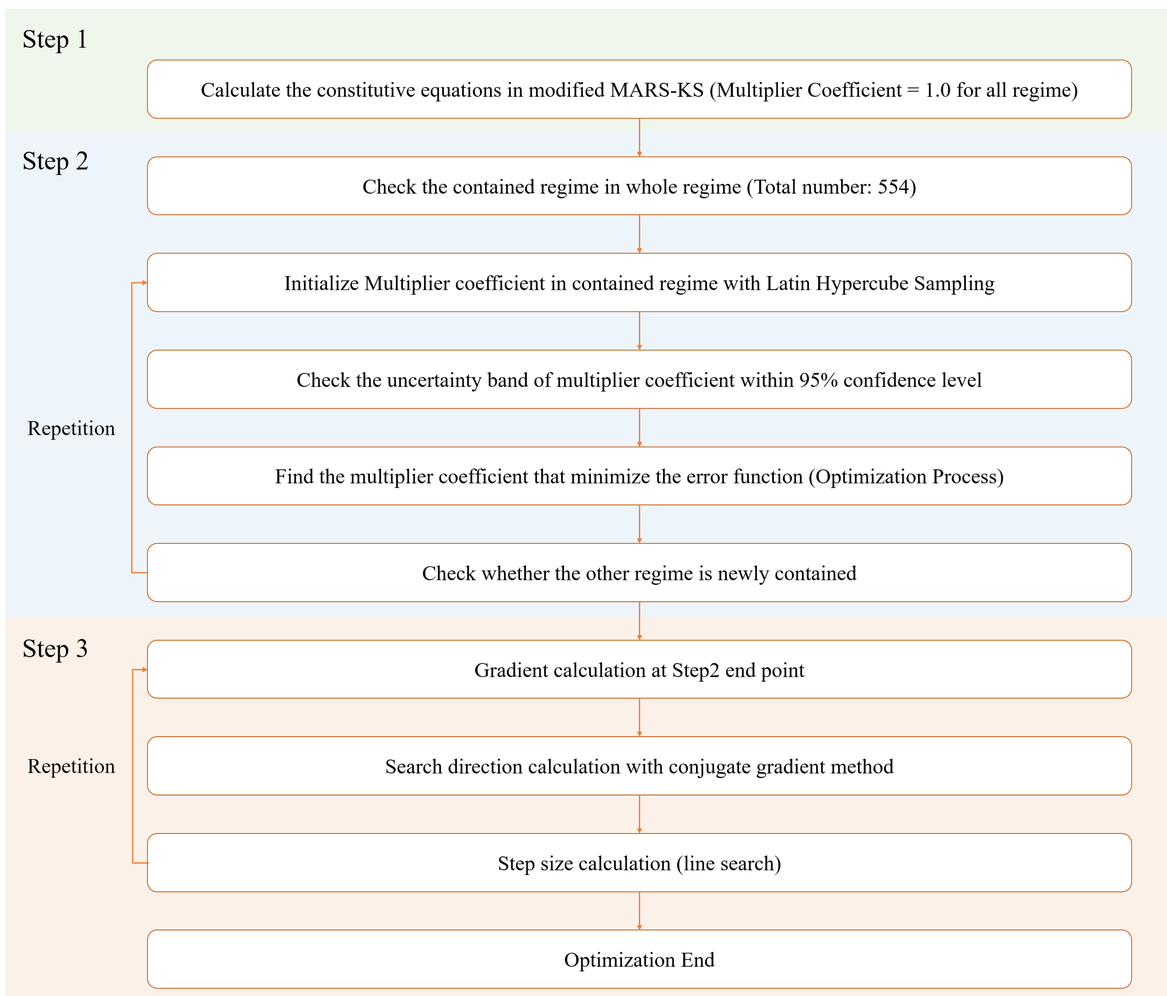
Optimal cluster number and results

	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



- Step 1: Original MARS-KS
- Step 2: MARS-KS modification with KREM method
- Step 3: MARS-KS modification with conjugate gradient method

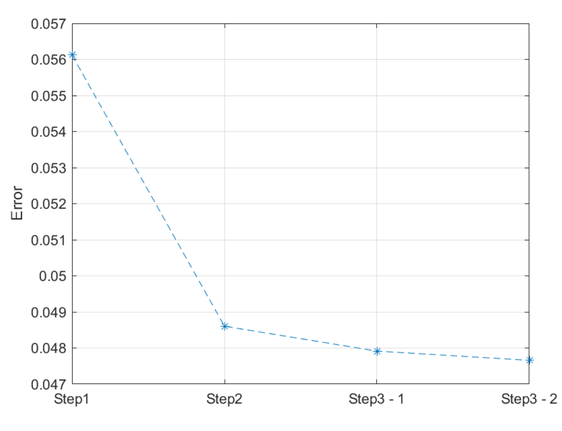
- KREM method

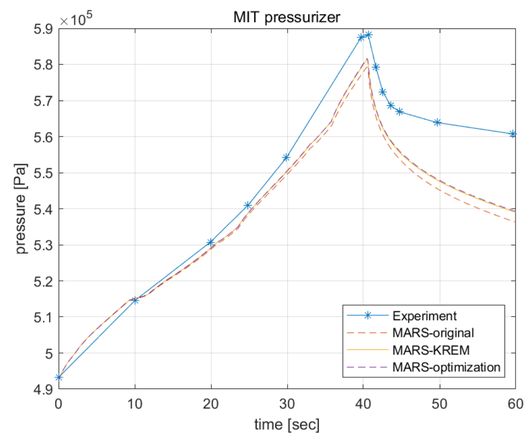
$$1 - (p/100)^n \geq (q/100)$$

- Error Calculation

$$\text{Error} = \sum_{i=1}^{n} |\overrightarrow{V_{i,min}}| / [n(X_{max} - X_{min})(Y_{max} - Y_{min})]$$

MIT experiment optimization





	Original MARS-KS	MARS-KS – KREM	MARS-KS – optimization
Error	0.0561	0.0486	0.0477

Summary and Further Works

▣ An artificial neural network based clustering method is used to categorize constitutive equations in finer sub-regimes.

▣ Multiplier coefficients are then applied to each sub-regime so that the safety analysis code can self-improve its accuracy from the accumulation of the data.

▣ The MIT pressurizer experiment is used for testing.

▣ For further exploration of the suggested method IET experiments will be next selected and tested.

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