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# Application of data driven modeling for MARS-KS code to improve performance

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## Introduction

- In order to improve the physical model of safety analysis codes, various institutes are conducting separate effect test and integral effect test.
- In this study, a methodology for using IET experimental data and SET experimental data to improve the system code constitutive equation is proposed.
- Heat transfer regimes and flow regimes of MARS-KS code were further divided by using the self-organizing map clustering method.
- For each sub-regime divided by SOM clustering, multipliers were applied to the constitutive equation, and how similar the modified code results correspond to the experimental results were evaluated.

## Methods and Results

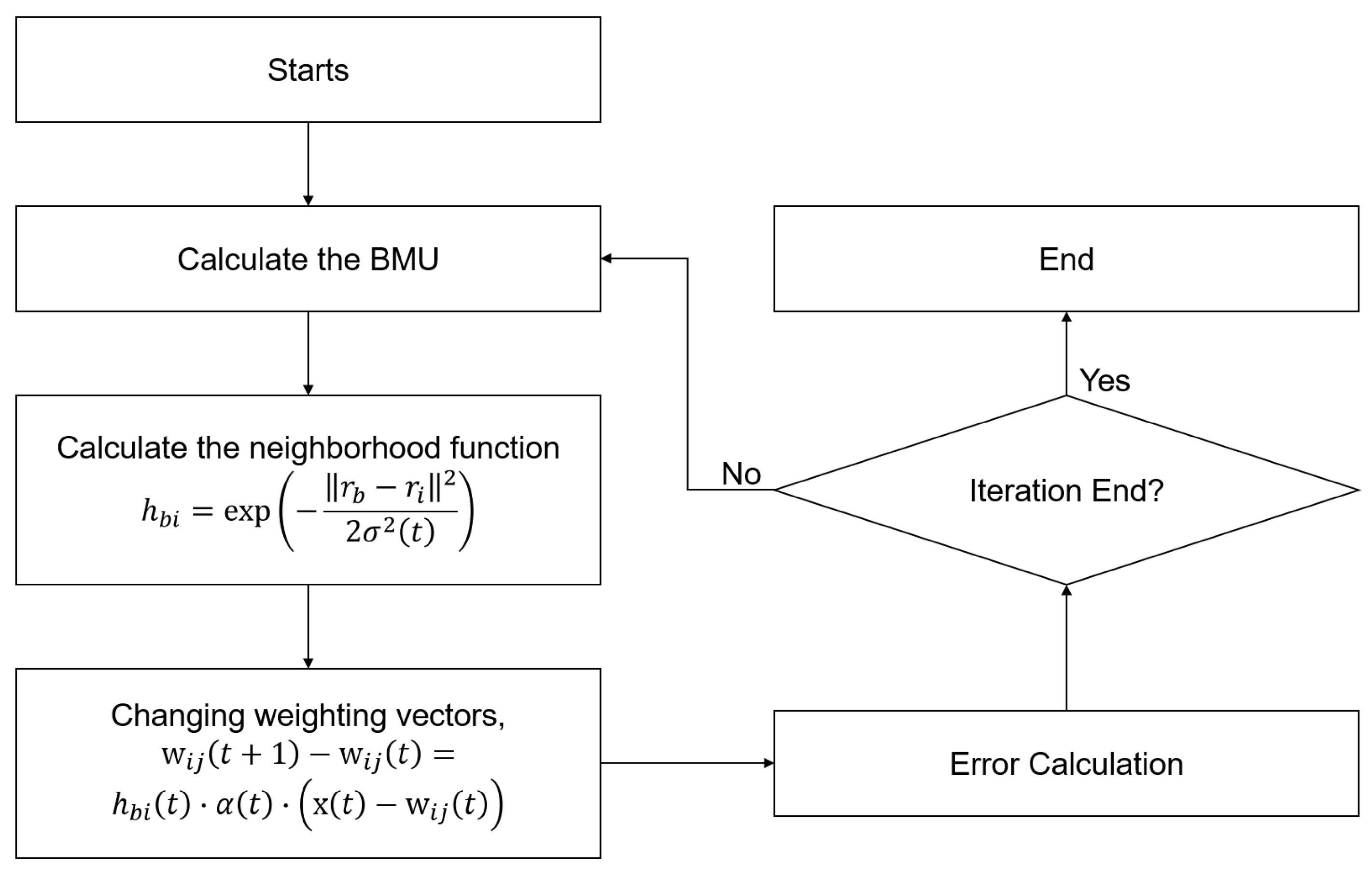



Fig.1. SOM calculation algorithm

- SOM clustering is a method of clustering by simulating original data using a self-organizing map, a type of artificial neural network.
- In this study, SOM clustering was used for each regime of wall heat transfer, interfacial heat transfer, wall friction, and interfacial friction used in MARS-KS code.
- The numbers 6,14,27,34 in the legend shown in Figure 2 represent the numbers corresponding to the regime number of mist area when the entire wall friction regime is divided by the new regime number.

| | |
|---|---|
| MAP size | 30 x 30 |
| Initial topology | Hexagonal Layer |
| The number of iterations | 10000 |
| Learning restraint | 1-t/t(end) |

SOM hyper parameters

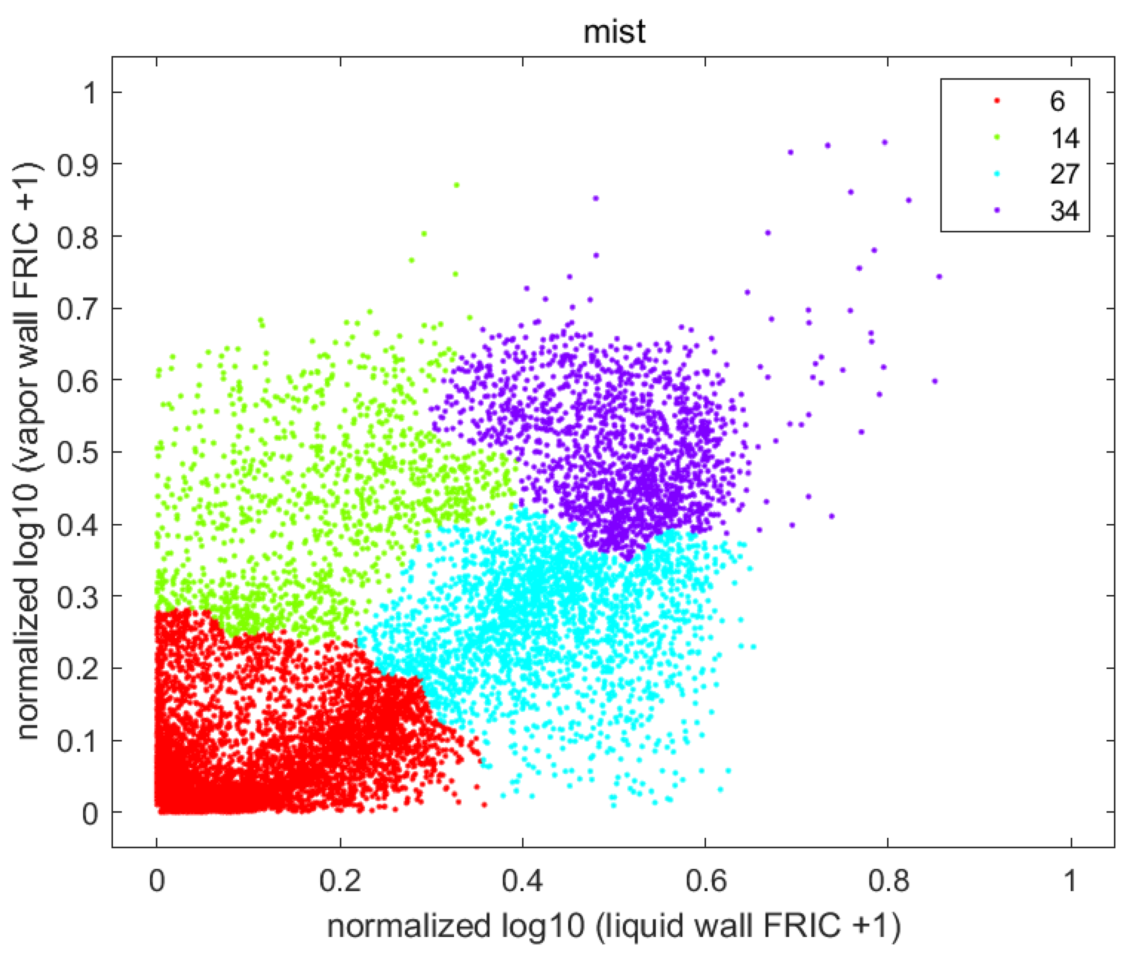



Fig.2. Wall friction SOM clustering result

- MARS-KS code has been modified to use SOM clustering inside the source code. During the MARS-KS code calculation process, each sub-regime was calculated, and then clustering related calculations were additionally performed to get newly defined regime number.

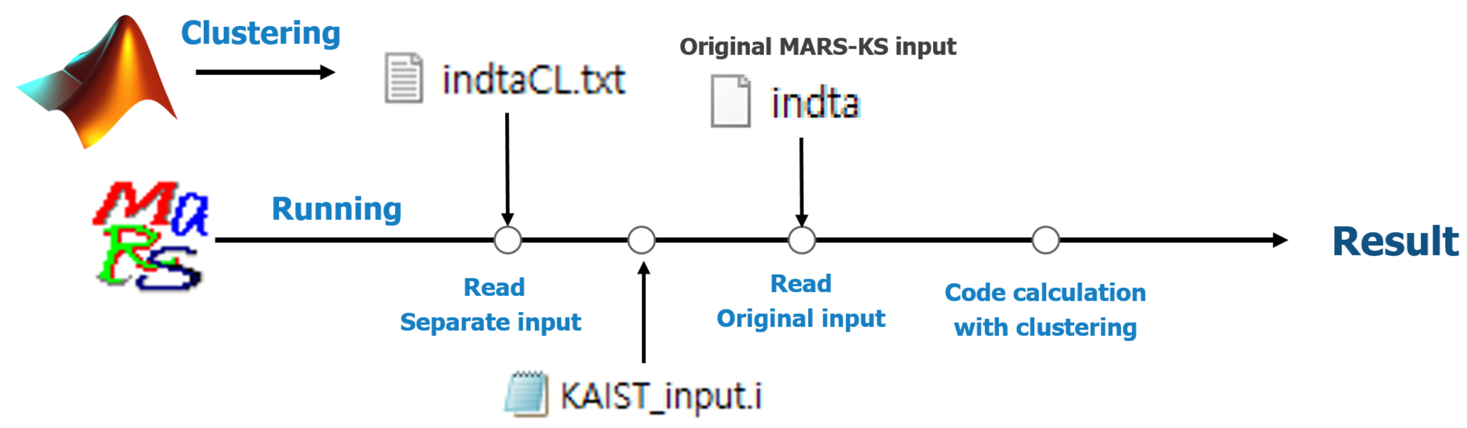
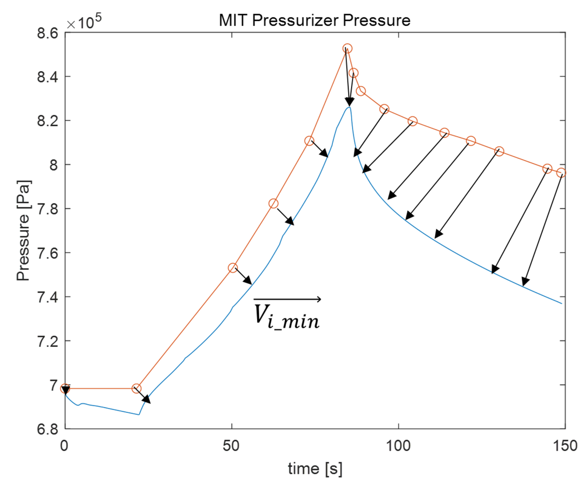



Fig.3. Code progress of Modified MARS-KS code

- In the process of calculating MARS-KS every step, the newly defined regime number is calculated, and the constitutive equation is multiplied by a coefficient for the corresponding regime number which is prescribed to the code via input.
- In the case of most IET and SET, it is impossible to compare them at the same time because the nature of the experiment is time dependent. Therefore, the error measruemtn method for comparing time series data is defined through the following equation.




$$\text{Error} = \frac{\sum_{i=1}^{n} \overrightarrow{V_{i,min}}}{n * (X\_max - X\_min) * (Y\_max - Y\_min)}$$

Fig.4. Newly defined error measurement method

- Using the modified MARS-KS code, the multiplier coefficient is optimized so that the constitutive equation of the MARS-KS code predicts close to the experimental value. Through the Latin Hypercube sampling method, the distribution of the multiplier coefficient is determined within the range of 0.8-1.2, which is the uncertainty of the correlation.

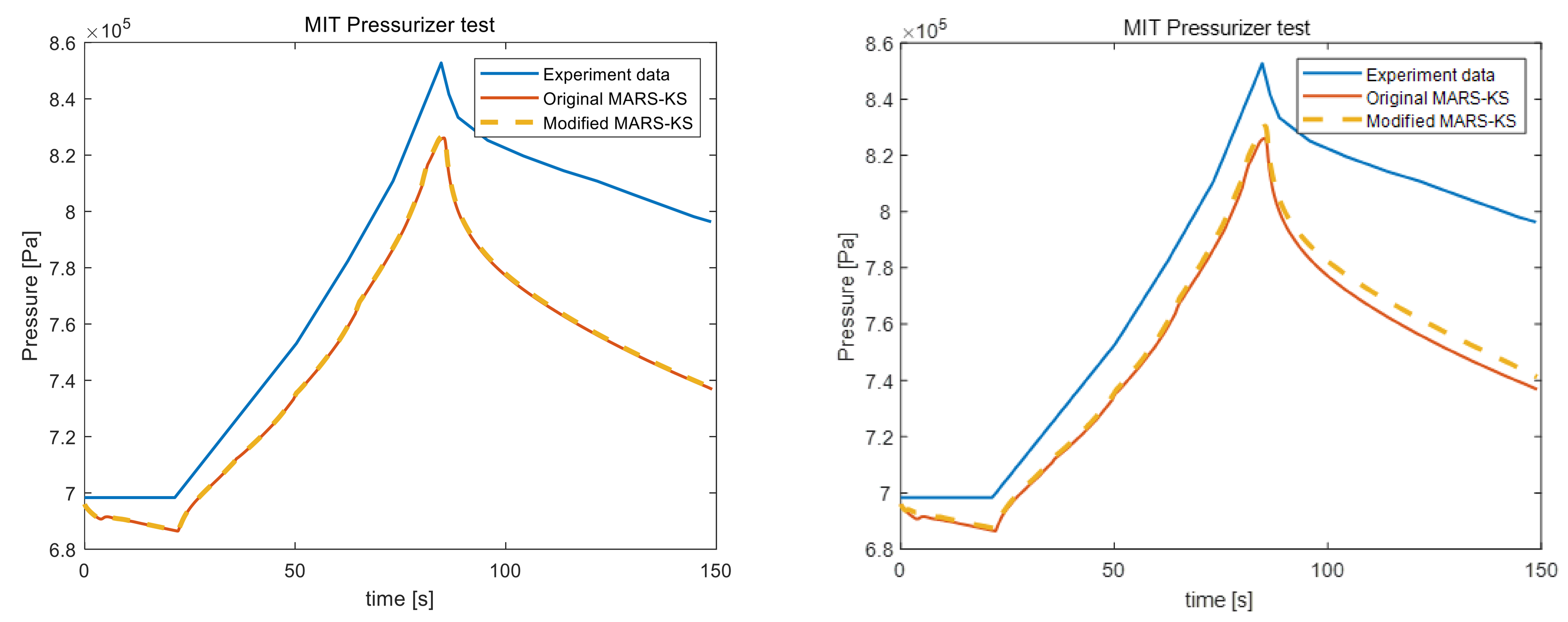



Fig.5. Pressure calculation result by multiplier coefficient 0.8-1.2 (Left), 0.1-10.0 (Right)

- Original MARS-KS error: 0.1318
- Modified MARS-KS error: 0.1300 (0.8-1.2)
- Modified MARS-KS error: 0.1193 (0.1-10.0)

- The MIT Pressurizer test is selected as Target experiment. The pressurizer pressure of experimental measurement value is selected as the time series value for calculating the defined error function.
- It was confirmed that the result of multiplier coefficient optimization within the constitutive equation uncertainty range (0.8-1.2) was not significantly different between the original MARS-KS and the modified MARS-KS.

## Conclusions

- As a result of applying the developed methodology to the MIT pressurizer experiment, it was confirmed that the calculation result did not improve significantly within the range of the correlation uncertainty, but the code calculation results improved when the range for searching optimal coefficient value was widened.
- Through this study, a sub-regime of the constitutive equation was newly defined, the code calculation result was marginally improved, and the regime mainly used in the experiment could be found by the developed methodology.