

The Implementation and Validation of a Data-based FGM Model for Turbulent Combustion Simulation

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The Flamelet generated manifolds (FGM) method enables accurate turbulent combustion simulations at low computational costs. The joint probability density function (PDF) of mixture fraction and progress variable captures the interaction between turbulence and combustion in FGM. Previous studies demonstrate that the proposed conditional β distribution aligns more closely with the probability distribution in real flames than the conventional double β distribution, and the unknown parameters in conditional β distribution can be effectively modeled by machine learning methods trained on experimental data[1]. However, the limited availability of experimental data and the challenges of machine learning in extrapolation hinder the application of conditional β distribution in computational fluid dynamics (CFD) solver. In this study, a hybrid tabulation method of conditional β distribution and double β distribution has been developed to mitigate the extrapolation issues of machine learning methods. The hybrid tabulation method has been implemented within the FGM solver of Ansys Fluent and validated against experimental data. A sensitivity analysis of the tables of different scalars was performed and the result shows that although the modifications to the PDF induce only marginal changes in tabulated values, the correction of the reaction rate of progress variable, $\tilde{\omega}_c$, significantly influences the flow field, eventually leading to a substantial improvement of the CFD predictions. Additionally, preliminary investigation into data-fusion has been carried out with different experimental datasets[2,3]. The results show that within the FGM-PDF framework constructed by conditional β distribution, the data-fusion of different flames does not introduce critical inconsistencies, thereby expanding the model's applicability domain, which is a crucial advancement for data-based models.

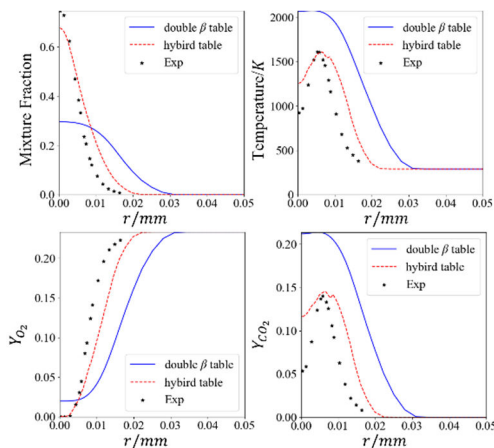


Fig.1 Validation of hybrid table in CFD

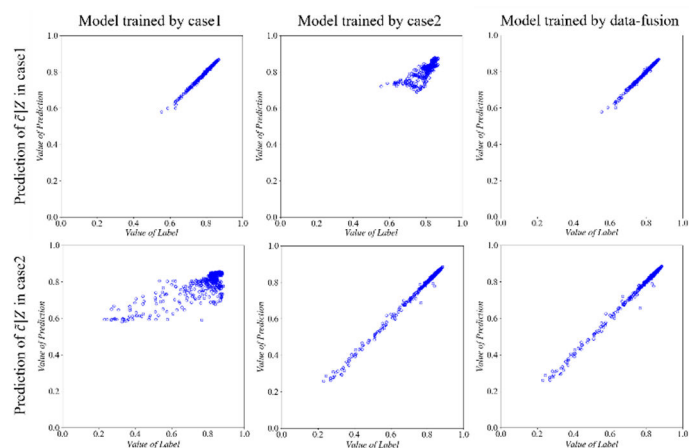


Fig.2 Validation of data-fusion

References

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