Enhancement of Development Process in Hydrogen Combustion Technologies

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Hydrogen combustion is considered as a key technology in the next-generation power generation system, which is carbon-free as well as sustainable. Although the current combustion technologies basically can be applied, the hydrogen combustion technologies still require large development efforts, mainly due to its properties, e.g. high flame speed, temperature, and invisibility, resulting in a high-cost experiment or higher simulation efforts. The usage of combustion simulation in the industry is not widely utilized than a CFD or structural simulation. Moreover, the combustion simulation requires very high computational capacity to be able to solve complex problems, resulting in high cost and long time for calculation. Therefore, a data-driven method is proposed, in which a simulation result is used to train a physics-informed neural network that will predict a combustion field out of a cold flow field.

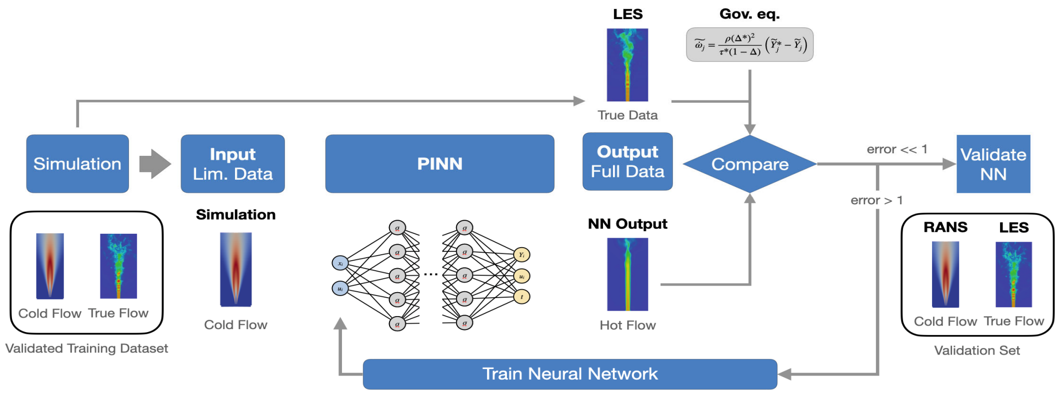
Emulating Combustion Simulation

The development of a combustion chamber requires an interactive optimization cycle starting from prototyping a combustion chamber, then a numerical investigation followed by experimental investigation, and finally a system validation. If this optimization process can be achieved model-based, as it is done in the automobile industry, the development cost could be reduced drastically.

The numerical simulation of hydrogen combustion consumes a lot of computational capacity than a conventional fuel like methane because of its higher flame speed. Therefore, the spatial, as well as the temporal resolution of the calculation domain, must be higher for a valid result.

To overcome the problem of limited computational resources, a coupling of a reaction-free flow field and reacting combustion flow field by a physics informed neural network is proposed.

First, a training and validation set is prepared by running multiple sets of unsteady (hot & cold) LES simulations. The cold flow field is fed into the neural network, and by comparing it with the true combustion field and the governing equation, the parameter of the network will be adjusted.



Expected Results and Future Prospects

This research aims to shorten the development process of the hydrogen combustion chamber. The number of optimization iterations will be decreased by emulating the combustion field by inputting a cold flow field. The emulation is performed by a neural network so that the result can be obtained very fast.

Besides the development process, it is expected to function as a digital twin too. By changing the input for the neural network to real-time data instead of simulation data, an actual combustion field can be emulated. This can be used for monitoring or failure prediction.