OOKAMI PROJECT APPLICATION

Date: **September 6, 2021**

Project Title: **Combustion Acoustics of Residential Water Heaters**

Usage:

☒ Testbed

☐ Production

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Usage Description:

Computational Combustion Acoustics (**CCA**) is a challenging field, and it combines many tools from the computational aeroacoustics and computational fluid dynamics for flame dynamics fields. This is particularly challenging when studying practical furnaces geometries. Oklahoma State University and Rheem Manufacturing Company are currently collaborating to study the combustion acoustics of furnaces of residential water heaters with the goal of developing residential furnaces with ultra-low NOx emission (California Rule 1111 and Rule 4905) that can operate quietly.

There are two categories of problems in the CCA:

1) Determining the source of noise, which requires modeling small scale structures.
2) Simulating sound propagation into the far-field, of which the dimensions are generally an order of magnitude larger than the combustion region.

With different computational domain sizes, solving the above mentioned two problems in the same model is very challenging. Indirect or hybrid schemes generally use high fidelity simulation to calculate the fluctuations then in the second step the sound radiation is calculated using perturbed Euler Equations. The far-field noise can a be determined by extrapolation of the nearfield values. One such hybrid method uses Large Eddy Simulation (**LES**) to calculate the flow field then an acoustic analogy is used to determine the sound radiation. Lighthill's acoustic analogy is commonly used. Compressible LES is the most accurate method, but it requires large CPU resources compared to what is currently available on our campus.

We propose to use LES in combination with acoustic models to achieve higher fidelity and non-linear coupling of residential furnaces CCA simulations. LES has been successfully used to resolve noise sources in turbulent flames in the past. Hybrid and two-step methods have also been developed, which use the difference in the length scale of the mean flow field and the acoustic propagation. In low Mach flow, the turbulent flow can be modeled to resolve the acoustic sources and an aeroacoustics technique will be used to predict the noise.

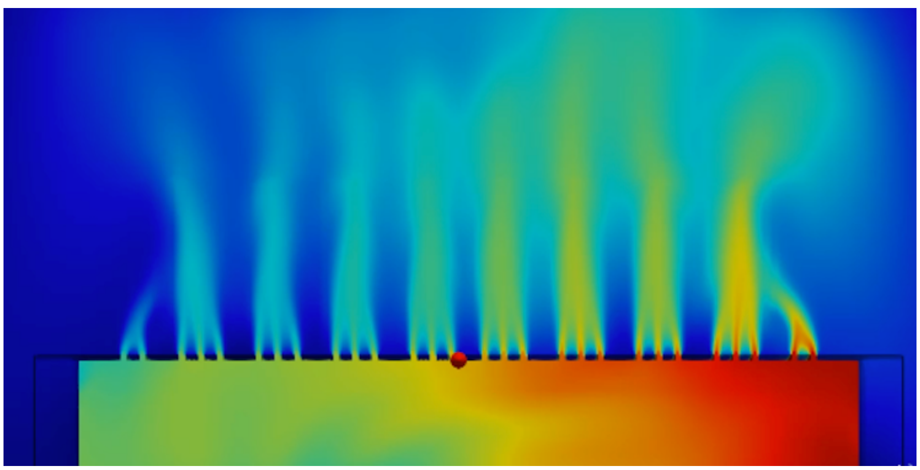

Fig. 1 CH_4 distribution in the residential furnace of the proposed study.

Computational Resources:

Total node hours per year: 2000

Size (nodes) and duration (hours) for a typical batch job: 4 nodes, 72 hours

Disk space (home, project, scratch): home - 30 Gb

Personnel Resources:
May need assistance compiling OpenFoam software on the system

Required software: OpenFoam v2012