Assessment of Dynamically Evaluated Mixing Time-Scales for MMC-LES

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The report contains the predictions of Sandia piloted flames D-F with the dynamically evaluated minor mixing time scale model. The objective of the study is to eliminate the need to specify any static constants to calculate the scalar mixing time scale. The effect of the variation is studied for a piloted Methane flame series with varying levels of local extinction. The time scales, evaluated in three different manner, do not show much sensitivity to the results for the relatively stable flame D, while significant variation is seen for flame F.

# Introduction

# Mathematical Modelling

## Numerical Details

#### Mesh

The domain is a cylinder with a length of $35D\_{jet}$ and diameter of $28D\_{jet}$. The LES mesh is discretised into $2.24$M cells approximately ($77(r)x64(θ)x480(z)$. The secondary mesh, used to control the particle resolution, has around $19.2$K cells.

#### Particle Resolution

Maximum of $0.43$M particles exist in the computational domain with $N\_{pc}=20$ and resolution $1L/6E$.

#### Chemical Mechanism

A $30$-species skeletal mechanism, based on GRI 3.0, developed by Lu and Law is used 1.

#### Inlet B.C.

The **jet** was imposed with an instantaneous velocity profile from precursor pipe flow simulation with the **mean and rms scaled** up with the centreline experimental measurements.
The **pilot** was provided top-hat velocity profile using measured bulk velocity with imposed artificial turbulent fluctuations using the Turbulent Spot method 2. The **co-flow** was laminar with experimental bulk velocities. All other scalars were provided uniform boundary values from the measurements.

#### Integration Schemes

A second order central differencing scheme is used for the convective terms in the finite volume momentum equation while the scalar equations use a second order accurate NVD schemes 3. The finite volume equations are marched in time using fully implicit Crank-Nicolson scheme. The particle ODE’s, on the other hand, are limited to first order Euler integration.

#### Mixing Time Scale

An anisotropic minor mixing time scale 4 is used for the all the simulations. The three variations of the mixing time scale are shown in Table ???. The mixing pairs were advanced with a harmonic mean of the time scales of the two particles.

llr
(r)1-2 Time Scale & Description
dyn-aISO & dynamic $ν\_{sgs}$, $˜$ and $χ\_{L}^{sgs}$
constCf & dynamic $ν\_{sgs}$, $χ\_{L}^{sgs}$, but static $˜$ ($C\_{f}=0.1$)
st-aISO & fixed coeff. for $ν\_{sgs}$ ($C\_{s}=0.16$), $˜$ ($C\_{f}=0.1$) and $χ\_{L}^{sgs}$ ($C\_{d}=0.4$)

# Result and Discussion

In this section, predictions only with the dynamically evaluated mixing model are shown in comparisons with the experiments. Note these flames with were studied previously 5,6 with a different mixing model which is known to suppress conditional fluctuations. In the next section, we compare three variations of the anisotropic mixing time scale model, which gives a better estimate of the dissipation of minor scalar fluctuations 4.

# Non-LaTeX Section

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