Hybrid RANS/PDF calculations of a swirling bluff body flame (SM1)

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HYBRID RANS/PDF CALCULATIONS OF SWIRLING BLUFF-BODY FLAME SM1

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The objective is to study the capability of hybrid RANS/PDF calculations in combination with tabulated chemistry techniques to capture finite rate chemistry effects such as local extinction and partial premixing with combustion products. This study is done for the specific case of the swirling bluff-body flame SM1 [1]. A transported PDF is used in order to study turbulence-chemistry interaction. Reasonable results are obtained.

All calculations are steady 2D axisymmetric and are performed with the same code PDFD [2], originally developed at TU Delft. A non-linear k-ε turbulence model [3] is used, which takes into account the effect of streamline curvature and rotation on turbulence. Two pre-tabulated combustion models are compared: a single steady laminar flamelet with strain rate of $100s^{-1}$ with mixture fraction as the only independent parameter and a REDIM [4] with mixture fraction and $Y(CO_2)$ as independent parameters. Equal diffusivities and unity Lewis number are assumed. A turbulent Schmidt number Sc_T=1.5 is used. Turbulence-chemistry interaction is modeled with a transported scalar PDF. Two micro-mixing models are compared: the Modified Curl's CD model and the EMST model.

The flow field of SM1 (not shown) contains two recirculation zones: one close to the bluff body and one further downstream near the central axis. Both recirculation zones are partially captured with both combustion models. A substantial difference in flow fields is seen between the flamelet and the REDIM, due to the difference in density field (not shown).

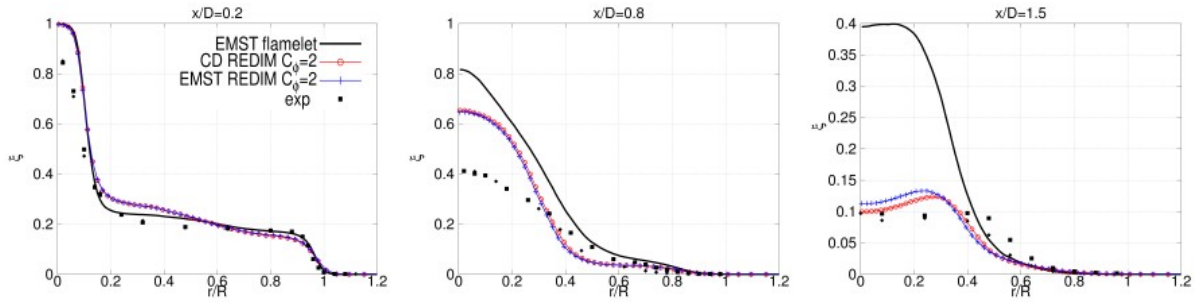

Figure 1: *Profiles of mean mixture fraction*

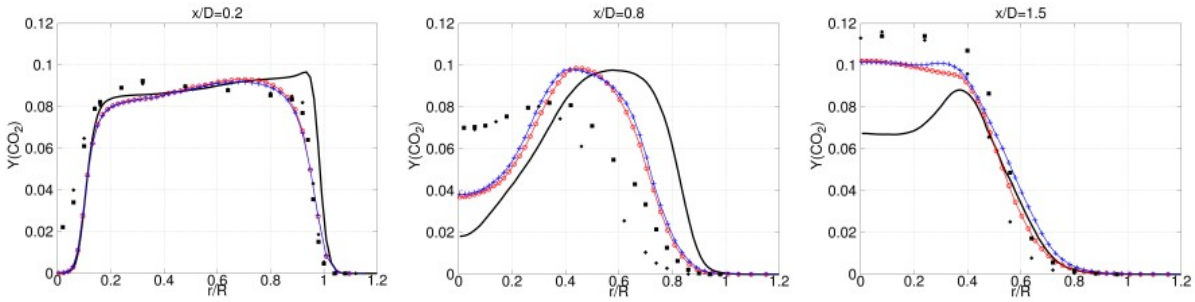

Figure 2: *Profiles of mean YCO_2*

The difference between the flamelet and REDIM calculations is more pronounced for the mean mixture fraction (Fig. 1) and $Y(CO_2)$ (Fig. 2). The predictions of the REDIM calculations are satisfactory, except for the region in between the two recirculation zones (x/D=0.8). The REDIM seems to benefit from the second independent parameter describing reaction progress. For the REDIM calculations, there are only minor differences between the two mixing models in physical space (Fig. 2). However, in composition space, there is more scatter with the CD model leading to better predictions of the conditional means and fluctuations (not shown).

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