Introduction

Motivation
- Understanding the physical mechanisms through which the thermal-diffusive properties of the fuel/air mixture influence the overall turbulent burning rate [1].
- Laminar burning velocity is altered by flame strain $K_c$ and flame curvature $K_f$. The total flame stretch rate is given by $\kappa = K_c + \delta K_f$.
- The burning rate sensitivity to stretch exists because local species and radical concentrations, as well as temperature profiles, are altered by strain and curvature.
- Characterize the mechanisms through which the average reactant consumption rates increase with increasing turbulence intensity.
- Use an approach to understand how turbulence modifies global burning rates based upon so-called “leading points” [2], which are intrinsically local properties of the turbulent flame.

Methods

- Direct numerical simulations (DNS) of highly stretch-sensitive flames, described by Aspden et al. [3].
- Lean H$_2$/Air flames ($\phi = 0.31$) at moderate and high turbulent intensities.
- Flame is chosen as an isotherm of $T=1088K$ where the fuel consumption peaks as shown in Figure 1.

Figure 1. Prism shaped volume constructed using curves locally normal to the isotherm [4]

Objectives

WHAT?
To characterize the structure of a strongly stretch-sensitive flame brush.

HOW?
By comparing local statistics with those averaged over the entire brush.

Results

Table 1. Summary of cases[5]

<table>
<thead>
<tr>
<th>Case</th>
<th>Turbulence intensity</th>
<th>Turbulent straining rate,</th>
</tr>
</thead>
<tbody>
<tr>
<td>A31</td>
<td>26.5 $(\delta_{t0}/\delta_{t0})$</td>
<td>7.36</td>
</tr>
<tr>
<td>B31</td>
<td>17.1 $(\delta_{t0}/\delta_{t0})$</td>
<td>34.2</td>
</tr>
<tr>
<td>C31</td>
<td>12.5 $(\delta_{t0}/\delta_{t0})$</td>
<td>65.8</td>
</tr>
<tr>
<td>D31</td>
<td>10.7 $(\delta_{t0}/\delta_{t0})$</td>
<td>213.6</td>
</tr>
</tbody>
</table>

Figure 2. Fuel consumption weighted JDF’s of principal curvatures

Figure 3. JDF of curvature and strain on isotherm $T=1088K$.

Figure 4. JDF of curvature and strain at the leading edge.

Conclusions

1. Strongly positive stretch flamelet geometries dominate the topology of the flame front.
2. The local structure of the lowest turbulent correlate well with local flame front curvature. In the turbulent flame, curvature and strain rate are negatively correlated.

References