Co-Flow, Non-Premixed Methane/Air Flame

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Summary

This application note describes the analysis of a co-flow, non-premixed methane/air flame, using the Cylindrical Shear-Flow Reactor and a user-routine option to establish the inlet co-flow conditions.

Introduction

In this example, we establish a co-annular flow inlet condition by employing the user routine option to override the default inlet profiles. By default, the cylindrical shear-flow reactor model uses a uniform inlet and initial profile for all variables except axial velocity. The default inlet velocity profile is considered to be fully developed. The user-routine option, however, allows us to specify an arbitrary inlet condition, as long as it obeys the radial symmetry condition of the Cylindrical Shear-flow Reactor. In this case, properties of both jets are assumed to be uniform when they enter the reactor so there is a jump in the inlet profiles at the jet interface. A non-premixed flame will be established downstream as fuel and air are mixed due to diffusion. The co-flow annular jet configuration is shown in Figure 1 and properties of the inner (fuel) and the outer (air) jets are given in Table 1. For this example, we assume that the outer wall is adiabatic.

Figure 1. Confined Co-flowing Annular Jet Configuration.

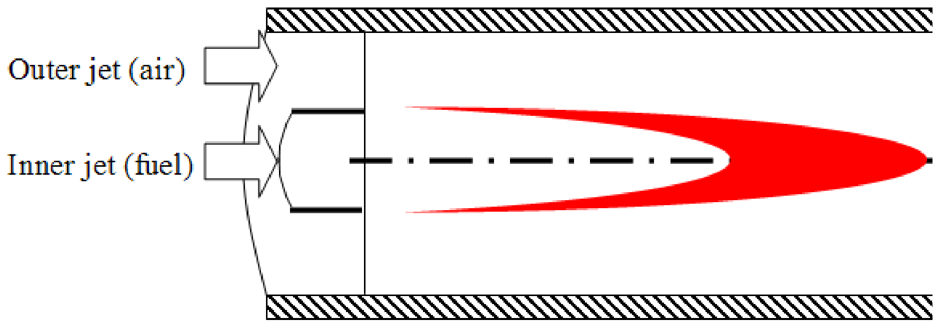


Table 1. Properties of the Co-flowing Jets

	Inner Jet (Fuel)	Outer Jet (Air)
Radius (cm)	0.8	4.0
Velocity (cm/sec)	10	25

	Inner Jet (Fuel)	Outer Jet (Air)
Temperature (K)	600	1000
H_2 Mass Fraction	0.05	0
CH_4 Mass Fraction	0.45	0
O_2 Mass Fraction	0	0.2329
N_2 Mass Fraction	0.5	0.7671

Application Setup

The GRI-Mech 3.0 reaction mechanism is used for the gas-phase combustion chemistry for methane. No surface-chemistry mechanism is needed because the outer wall is assumed to be chemically inert.

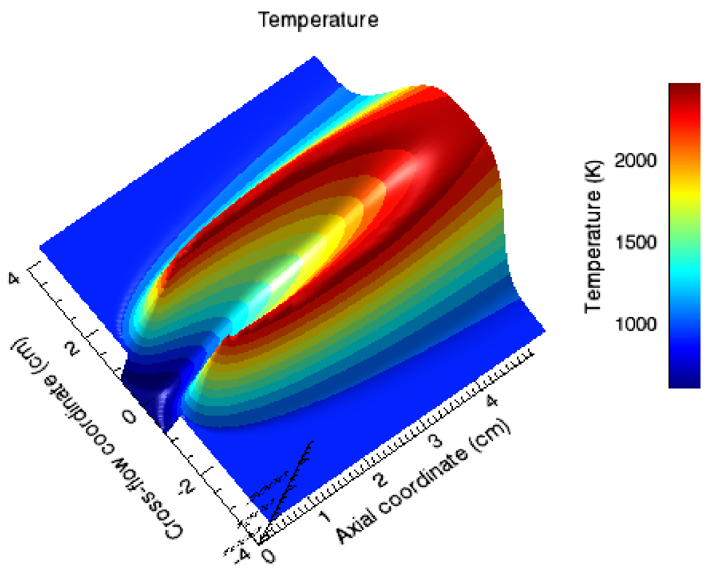
The user routine options are not shown in the graphical User Interface by default. To make these options available from the User Interface, the Display User Routine Options box in the Preferences panel must be checked. Once **Display User Routine Options** is enabled, the **Get Solution Profile from User Routine** option will become available when the Reactor Physical Property panel is opened. Once this option is selected, the reactor model will use the initial profiles defined by the CRUPROF subroutine, which must be compiled and linked to the Shear-Flow Reactor model, following the instructions in the CHEMKIN-PRO API manual. In addition to the user routine option, also specify other reactor parameters such as the number of grid points in the radial direction, reactor pressure, reactor radius (radius of the outer pipe wall), and ending axial position.

The cylindrical shear flow reactor model will set the outer wall temperature to the inlet stream temperature when the wall is not chemically active (no surface chemistry). If the inlet temperature given in the Stream Property Data panel is different from that of the outer jet (as defined in the user profile routine), a thermal boundary layer will be developed next to the outer wall.

Summary

After the simulation has completed successfully, we can visualize contour plots of solution variables in the CHEMKIN-PRO Post-Processor. Since this is an axisymmetric problem, the reactor model only solves the top half of the flow domain. To visualize the solutions of the entire physical domain, we have the CHEMKIN-PRO Post-Processor reconstruct contours in the bottom half of the physical domain by “mirroring” the contours with respect to the x-axis. The results are shown for Temperature in Figure 2, showing a classic diffusion jet flame profile. The main assumption that is made in employing the Shear-flow Reactor for this type of simulation is that axial diffusion is negligible, relative to convection and radial diffusion. For high-speed jets, this can be a reasonable assumption.

Figure 2. Final 3-D Temperature Contours of the Entire Physical Domain with Vertical Contour Legend (Colorbar).



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