reaction DESIGN

ENERGICO

Predicting Combustion Efficiency from Burners and Boilers with ENERGICO

Combustion efficiency is a critical design parameter for burner-boiler designers. Excessive CO and Unburned Hydrocarbons (UHC) emissions represent unburned fuel and lost efficiency. Additionally, CO and UHC emissions are regulated and continually monitored for emissions compliance. Unfortunately, modern CFD codes provide limited chemistry information that renders them unreliable when predicting emissions of CO and UHC. ENERGICO represents the combustor with a series of idealized reactors and allows use of detailed chemistry with a reasonable amount of computational time to accurately predict CO and UHC emissions.

ENERGICO automatically converts a complex combustor geometry into an Equivalent Reactor Network (ERN). Once the ERN is created, a fully detailed chemical mechanism can be used to provide an understanding of combustion performance and emissions such as NO_x, CO and Unburned Hydrocarbons (UHC). This Solution Brief describes how to use ENERGICO to predict CO emissions and how to set up an automatic parameter study to predict the impact of fuel/air ratio changes on CO emissions.

Setting Up in ENERGICO

ENERGICO reads in the reacting flow CFD solution of a natural gas fired burner (Figure 1). A series of filters are applied to the variables in the CFD solution to divide the combustor into regions that have similar conditions that are important for the desired results (e.g., temperature, oxygen concentration, fuel concentration when looking at NO_x emissions). A set of these filters comprises an ERN algorithm. ENERGICO can also automatically apply previously developed ERN algorithms to help save time and eliminate errors.

ENERGICO allows each reactor zone to be defined as either a Perfectly Stirred Reactor (PSR) with the temperature fixed to the average temperature in the CFD, a PSR with the energy equation turned on, or a Plug Flow Reactor (PFR). ENERGICO then creates the reactor network automatically and solves it using the detailed chemistry mechanism.

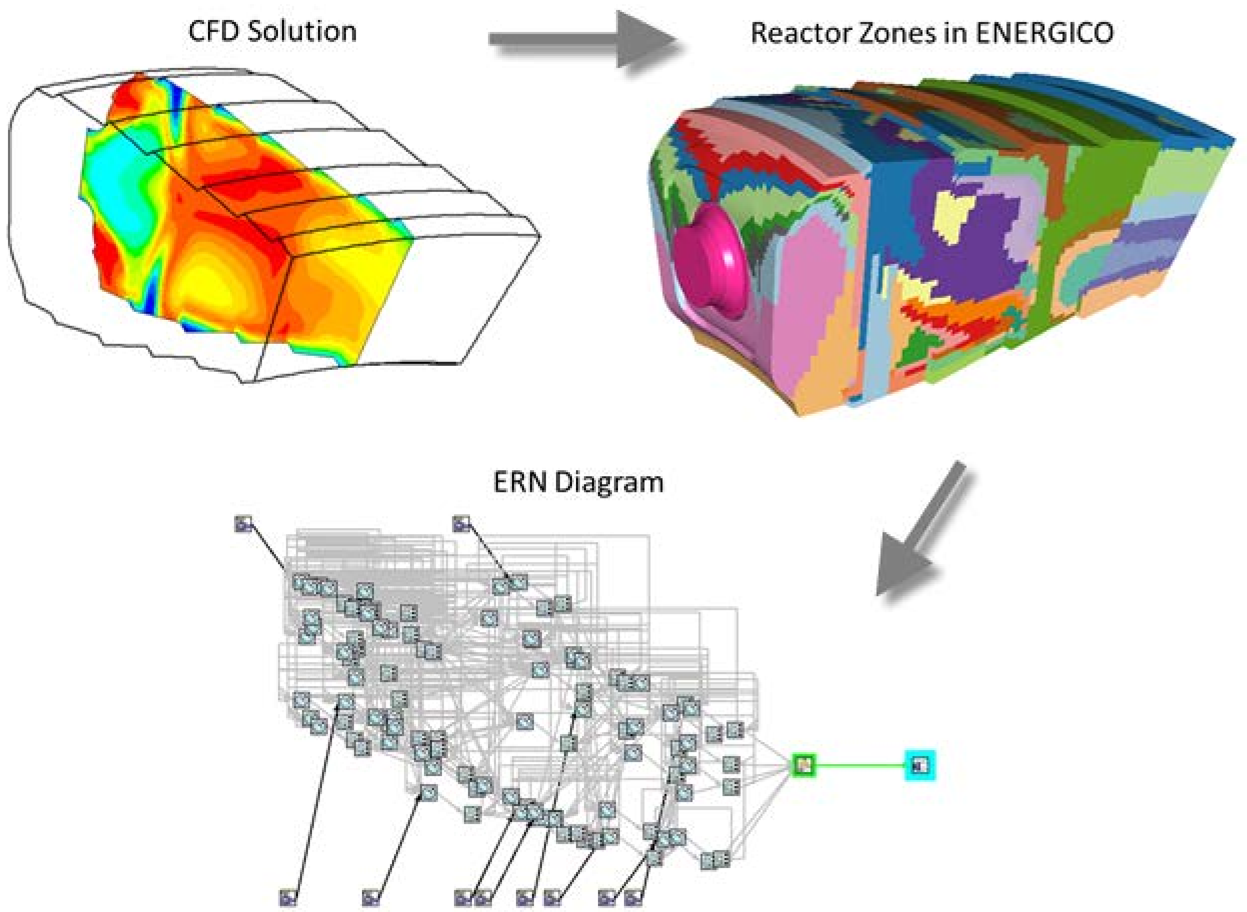

Figure 1. ENERGICO workflow starting from a CFD solution, dividing the combustor into Zones that become reactors in the ERN.

Results

Results for CO, NO, NO_2 and UHC emissions at the exit are presented in a table. They also can be plotted on top of the combustor geometry (Figure 2). The CO emissions show high concentrations in the dome regions as expected from the primary combustion of the fuel (Figure 3). It is helpful to plot the CO emissions at the exit of the combustor to see where peaks of CO are located. The peak in CO concentration can then be traced back upstream to see if it is occurring because the flame is too long or quenching along the walls from cooling flows.

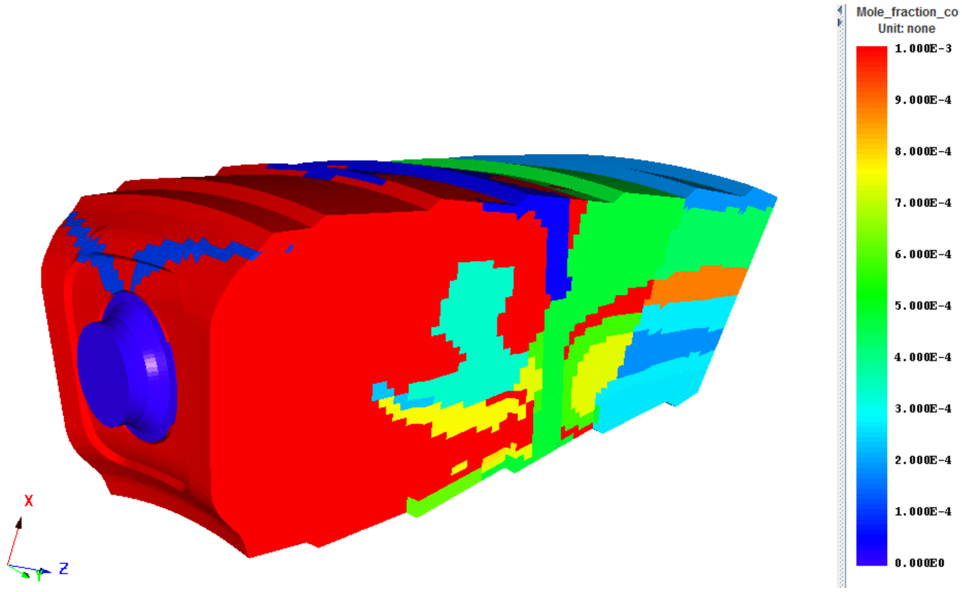

Figure 2. CO emissions on the combustor geometry.

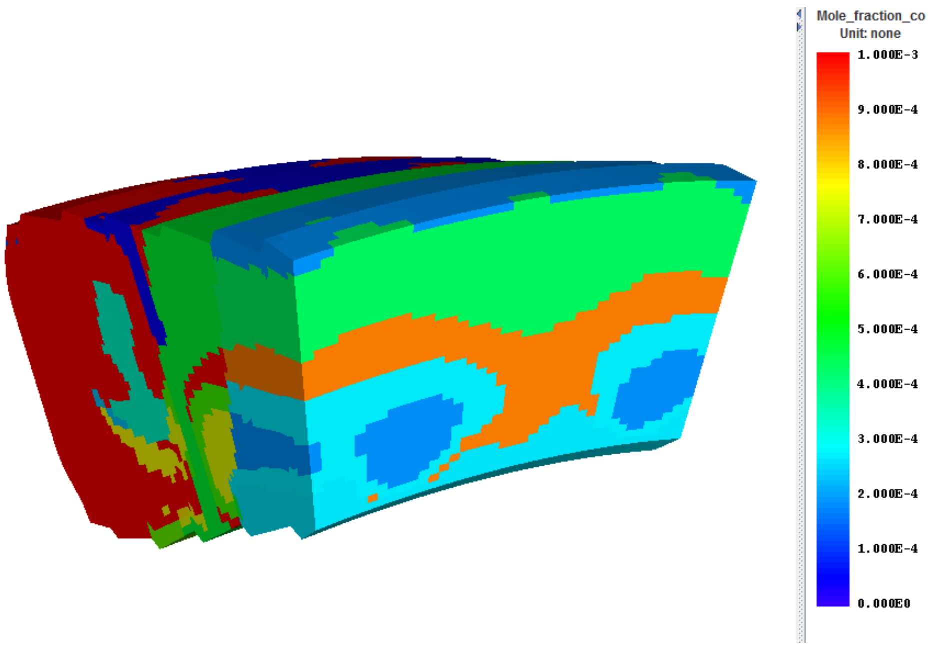

Figure 3. CO emissions at the combustor exit.