reaction DESIGN

FORTÉ
Diesel Emissions Predictions

Focus on improving diesel-engine performance is critical to addressing regulatory objectives of reducing fuel consumption and global warming gases. Low-temperature combustion regimes are characteristic of the advanced combustion strategies being considered to improve performance. Such regimes promise improved efficiency and fuel consumption with lower emissions. Low-temperature combustion regimes, however, rely more critically on the kinetics of the fuel combustion than do more conventional operating conditions. Accurate simulation therefore requires a detailed kinetics description of the fuel combustion.

FORTÉ can be used to simulate 3-D diesel-engine combustion simulations with advanced spray models and accurate detailed chemistry, while keeping the simulation time to a minimum through the use of a sector-mesh approximation of the engine geometry. This simulation uses advanced chemistry solution algorithms that include dynamic adaptive chemistry (DAC) and dynamic cell clustering (DCC). The FORTÉ Simulation Package uses an advanced KH-RT spray model that simulates liquid breakup, secondary droplet breakup, distribution and evaporation. The FORTÉ spray model has been shown to produce consistent results independent of mesh size.

Setting Up in FORTÉ

In this case, the model represents a single-cylinder, direct-injection (DI), 4-stroke diesel engine based on a Cummins N-series production engine. The engine is equipped with a non-production, high-pressure, electronically-controlled, common-rail fuel injector (Figure 1). The eight fuel orifices are equally spaced allowing simulation in a 45-degree sector.

To set up the problem in FORTÉ, we begin generating the sector mesh, using the Sector Mesh Generator option. The simulation employs a multi-component diesel-fuel surrogate mechanism (included with FORTÉ) with 437 species that was reduced for the conditions of interest from a comprehensive and well-validated master mechanism.[1]

[1]Singh, S., Reitz, R., and Musculus, M., "Comparison of the Characteristic Time (CTC), Representative Interactive Flamelet (RIF), and Direct Integration with Detailed Chemistry Combustion Models against Optical Diagnostic Data for Multi-Mode Combustion in a Heavy-Duty DI Diesel Engine," SAE Paper No. 2006-01-055, Detroit, Michigan, April 2006.

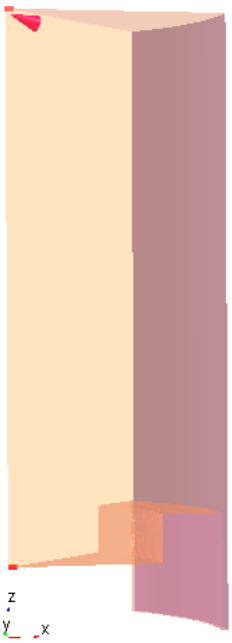

Figure 1. Diesel sector simulation showing injector location.

A vaporization model for the fuel surrogate has a composition of 51% *n*-tetradecane, 35.5% *n*-decane, and 15.5% 1-methylnaphthalene.essing techniques that mimic experimental setups during solution visualization (Figure 1).

Results

The results show prediction of ignition behavior for low-temperature combustion conditions, which provides good agreement with measured pressure and heat-release profiles (Figure 2). The results for the 3-component, 437 species surrogate mechanism are compared against experimental data of Singh et al.[1] in Figure 2. The pressure curve shows excellent agreement with the experimental data. The heat release also shows good agreement with experimental data, particularly for the timing of the initial heat release and the peak heat-release-rate value. FORTÉ allows prediction of the NO and CO Emission throughout the cycle (Figures 3 and 4).

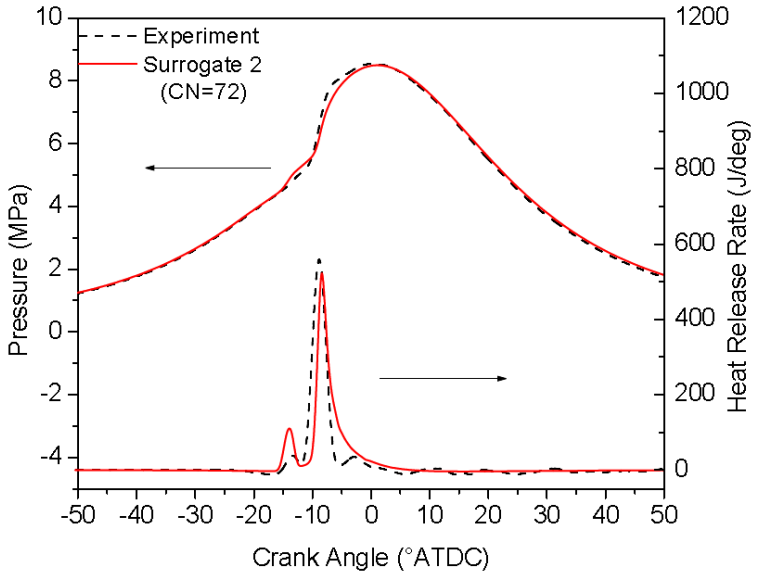

Figure 2. Pressure and heat release compare well with experimental data.

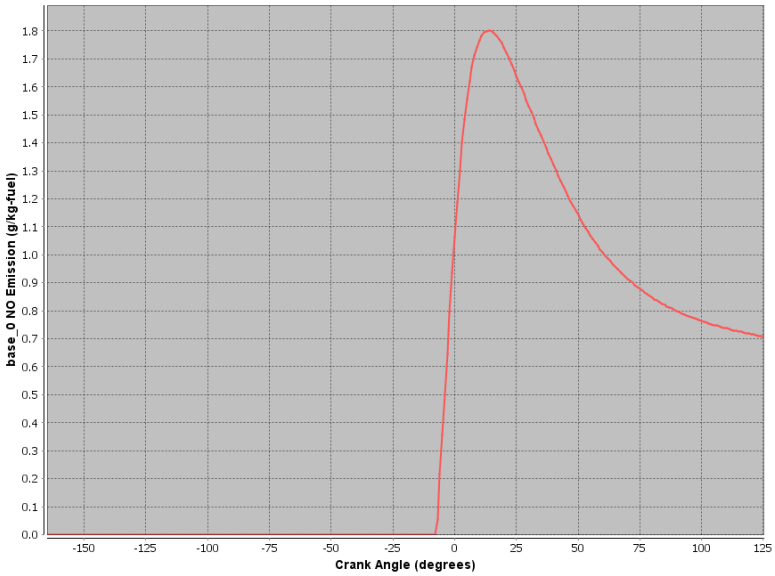

Figure 3. NO emissions.

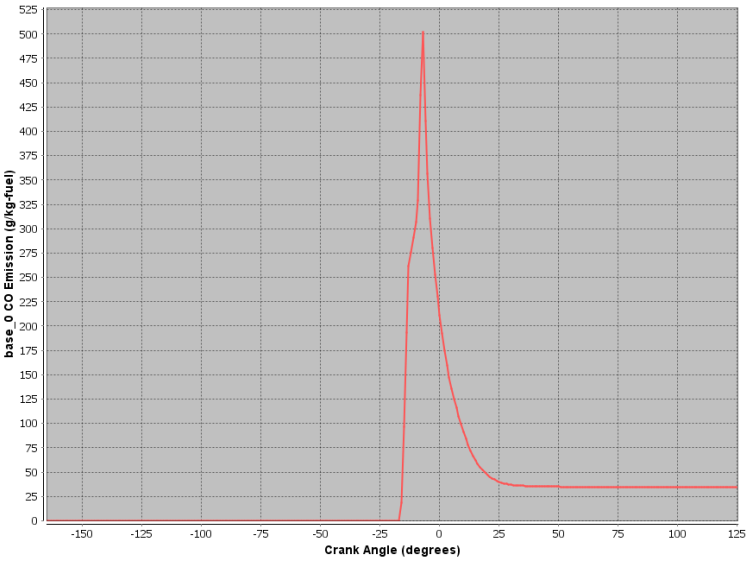

Figure 4. CO emissions.