Vehicle Propulsion Information Integration

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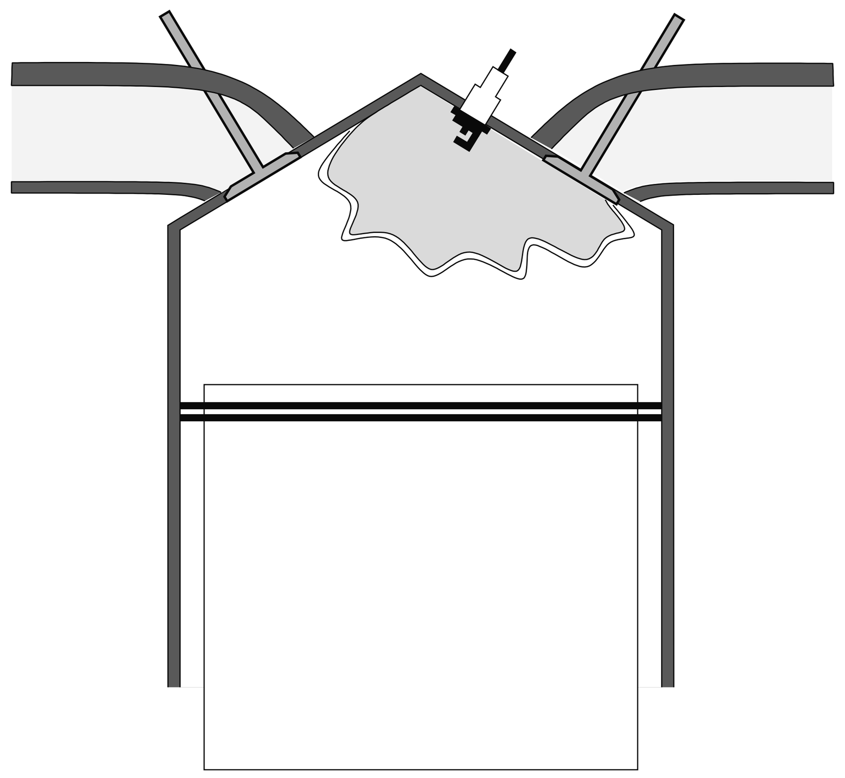
Problem Outline

There are situations where it is important keep track of the temperature distribution in a cylinder. This can be done by introducing multiple zones to a control volume. The zones can have a geometrical interpretation or they can be used for bookkeeping of the mass that have burned at a specific instance.



A Dae Formulation

A DAE formulation for multi-zone in-cylinder is extended with change of composition and the possibility to handle liquid components

$$\begin{pmatrix} \mathbb{A}(x,y) & \mathbf{0} \\ \mathbf{0} & I \end{pmatrix} \begin{pmatrix} \dot{x} \\ \dot{y} \end{pmatrix} = \begin{pmatrix} \mathbb{B}(x,y,z) \\ \mathbb{B}_y(x,y,z) \end{pmatrix}$$

The DAE formulation has nice properties w.r.t. scalability and adding/removing zones is as easy as updating $\mathbb{A}$ and $\mathbb{B}$ as well as giving the zone an initial state while traditional ODE formulations lack this possibility. It is shown that for all *Well Behaved Gases* the DAE formulation gives a unique solution for all pressures, temperature and compositions.

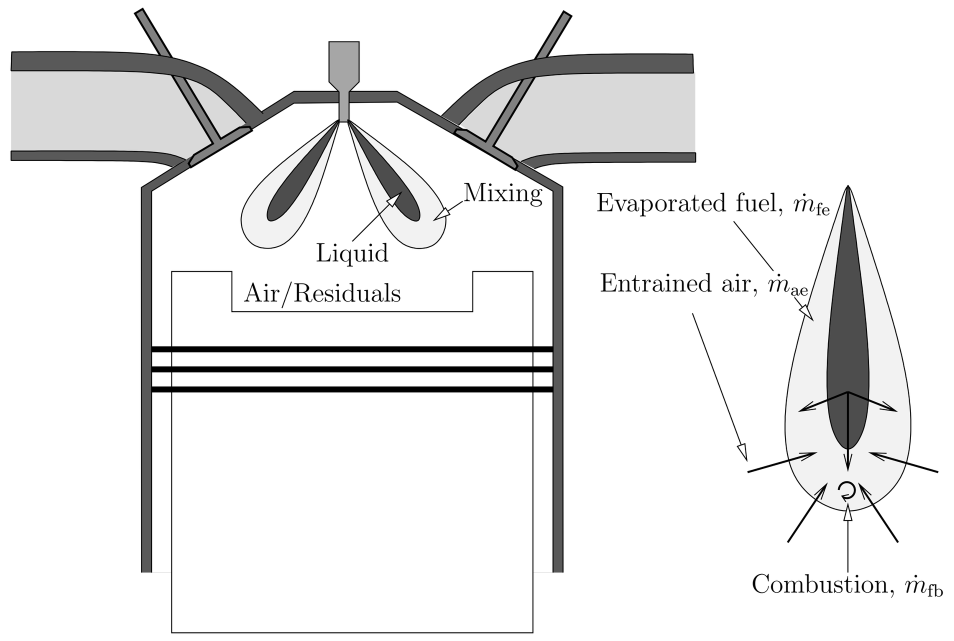
The concept of composition parameters is introduced and it is shown that the same set of equations can be used for both the *Mixer* and *Reactor* cases of the state equations regardless if the composition parameters represent atoms, molecules or collection of atoms or molecules. In this manner it is possible to make a distinction between the thermodynamic state equations and properties.

Project Overview

In the automotive area there are ever increasing demands from legislators and customers on low emissions and good fuel economy. In the process of developing and investigating new technologies, that can meet these demands, modeling and simulation have become important as standard engineering tools.

To improve the modeling process new concepts and tools are also being developed and a key point is the interplay between modeling and information fusion, using information from in-vehicle sensors, models of different complexity and time scales, and prior knowledge.

Example - Diesel Combustion



The complexity of Diesel engine combustion makes the control of a multi-injection system a non-trivial problem and understanding the effects that are involved can help in the design of such control systems.

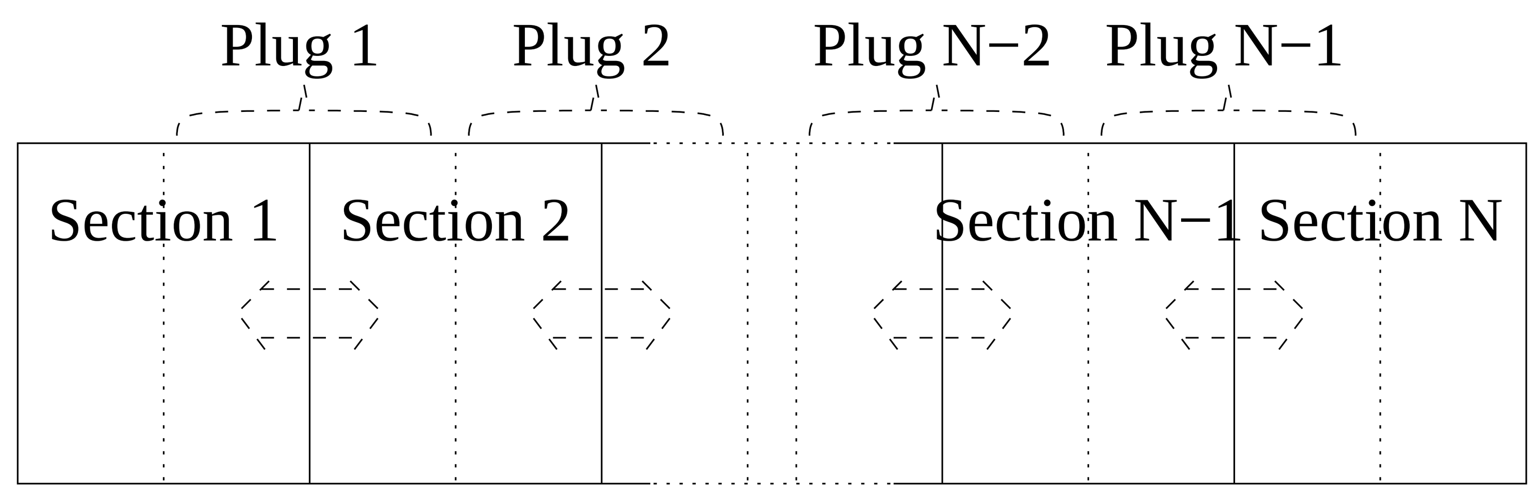
A four zone model that separates liquid fuel, evaporated fuel, air/residuals, and burned gases is used to evaluate the DAE formulation. The Diesel model is a good test application since it has zones with different fuel/air ratios. The main conclusion is that the framework is able to preserve the total mass, energy and volume as well as handle the incompressible zone for this diesel model setup

Publications

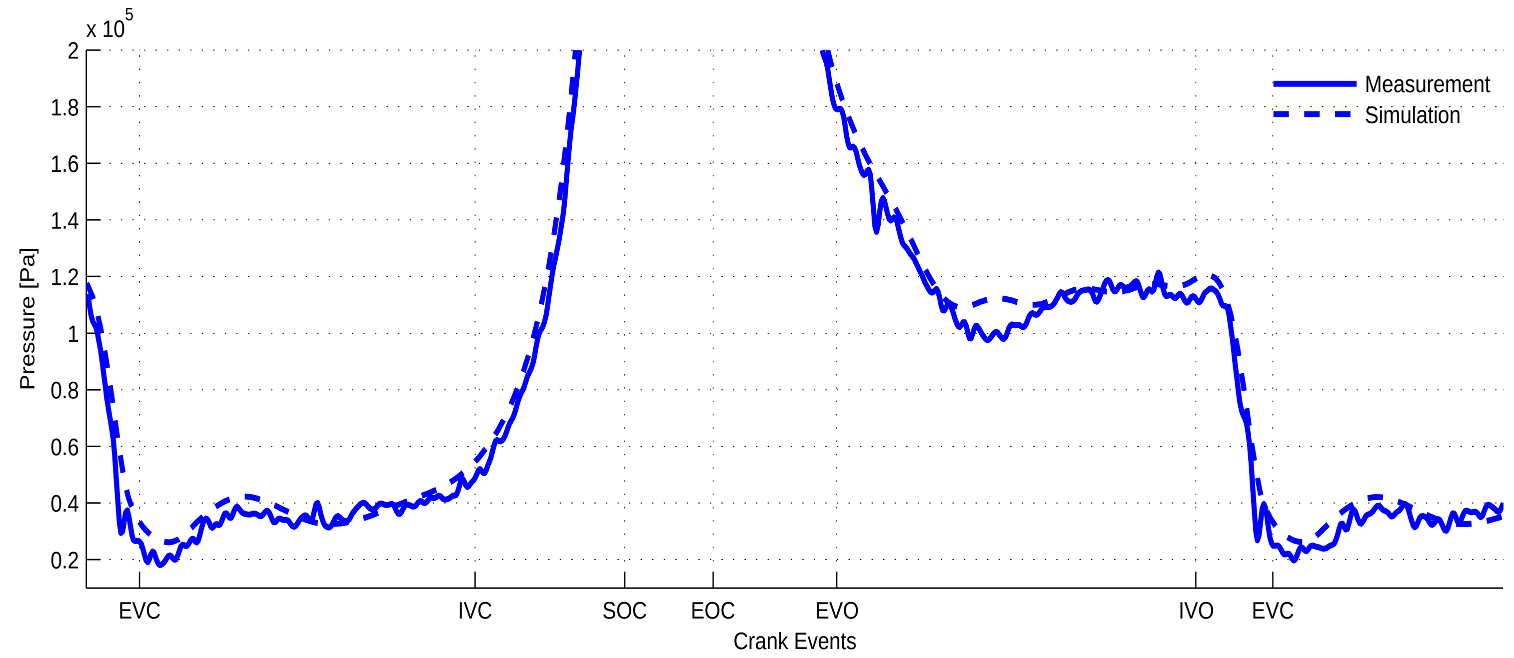
[1] Per Öberg. *A DAE Formulation for Multi-Zone Thermodynamic Models and its Application to CVCP Engines*. PhD thesis, Linköpings universitet, May 2009.

Example - Cvcp Engine Modeling

The traditional way of modeling pipes is to use an energy, momentum, and mass preservation equation and solve them using the method of characteristics or a finite difference method. In the DAE framework, mass and energy are already taken care of. Therefore the pipes are divided into configurable number of sections that all have their own pressure, temperature and composition.



The velocity of the plugs that are overlapping the sections is modeled using Newtonian physics and the energy from the moving plugs are thus not linked to the internal energy of the gas. The plugs simply act as flow governors.



When the parameters of the intake pipe are tuned to measured data the pressure trace gives a quite good fit.

The conclusion is that the DAE formulation is a flexible and robust tool, and that it is well suited for multi-zone in-cylinder models as well as models for manifolds and pipes outside the cylinder.