Vehicle Propulsion Information Integration

Per Öberg (`oberg@isy.liu.se`), Lars Eriksson (`larer@isy.liu.se`)
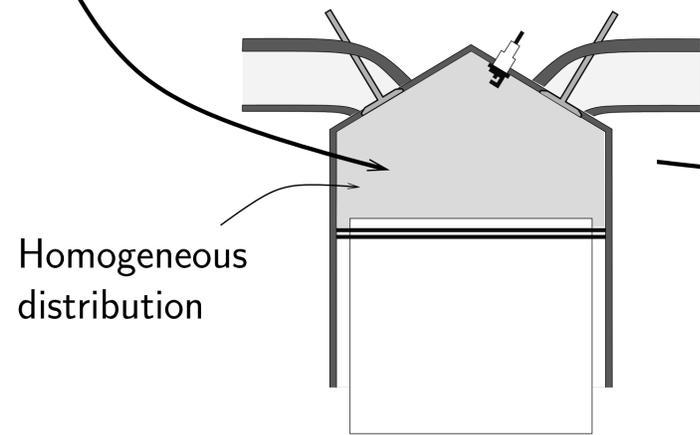
Control Volume (Theoretic model)

State variables

Composition

p, T
$V, \mathbf{x}$
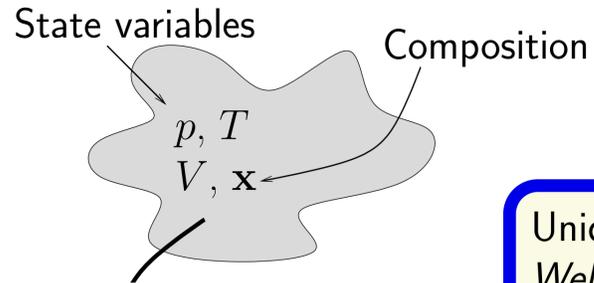
Unique solution $\Rightarrow$
Well Behaved Gas

Simulation model:

$a, \ldots f$ functions of state

$$\left.\begin{array}{l} a\,dp + b\,dT = e \\ c\,dp + d\,dT = dQ + f \end{array}\right\}$$

Single Zone (Traditional)

Homogeneous
distribution

Theorem:

If the gas is *Well Behaved*, then the Multi Zone DAE formulation has a unique solution as long as all zones have non zero size.

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. Here a new formulation for multi-zone in cylinder models is depicted.

Publications

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

N Single Zones +
$$\sum dV_i = dV$$

$\Downarrow$

Multi Zone DAE (New)

$$\begin{pmatrix} 0 & 1 & 0 & \cdots & 1 & 0 \\ a_1 & p & b_1 & \cdots & 0 & 0 \\ c_1 & p & d_1 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ a_N & 0 & 0 & \cdots & p & b_N \\ c_N & 0 & 0 & \cdots & p & d_N \end{pmatrix} \begin{pmatrix} dp \\ dV_1 \\ dT_1 \\ \vdots \\ dV_N \\ dT_N \end{pmatrix} = \begin{pmatrix} dV \\ e_1 \\ f_1 \\ \vdots \\ e_N \\ f_N \end{pmatrix}$$
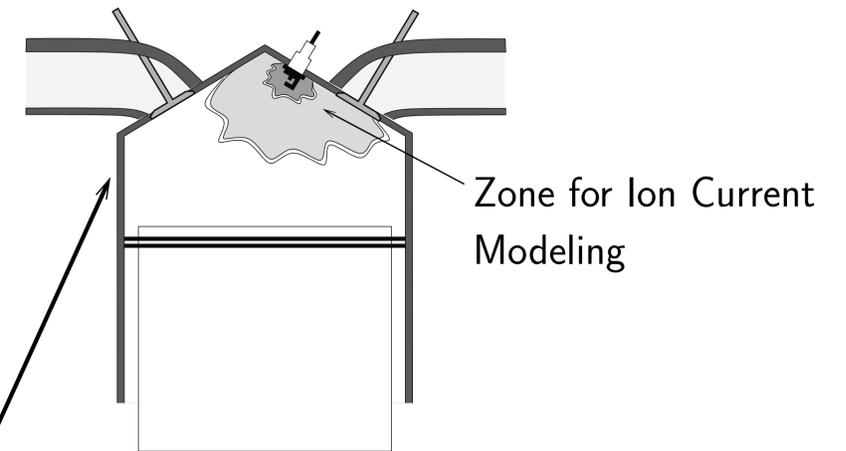
Diesel and SI Modeling

In Diesel and Sɪ engine models it is often advantageous to have multiple zones. In the Sɪ engine it can for example be used to track the temperature distribution which is important for e.g. models of ion currents. Because the combustion is rate controlled it is also essential for combustion models that the temperature is correctly modeled and therefore multi-zone models are used. The Dᴀᴇ formulation depicted here gives a new, flexible way to set up multi-zone models.

SI Engine

Zone for Ion Current
Modeling

Diesel Engine

Mixing

Liquid

Air/Residuals

Evaporated fuel, $\dot{m}_{fe}$

Entrained air, $\dot{m}_{ae}$

Combustion, $\dot{m}_{fb}$