Computer Simulated Engine Performance
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Abstract:
This model is a computer simulation which determines the performance of a four stroke internal combustion (IC) engine. The modeling of this process begins with the simulation of one cylinder of the four stroke IC engine which is assumed to have an ideal pressure-volume (p-V) relationship allowing for computation of peak performance. Once the ideal cylinder is modeled, factors which compensate for less than ideal p-V relationships are injected into the simulation to allow for computation of the performance figures across the entire operating range. The single cylinder model is then expanded to simulate the interaction of multiple cylinders at once and compute their combined effect giving total output numbers for the engine as a whole.

Performance figures computed include torque and horsepower curves for an engine’s entire operating range. Additionally, statistics are also available regarding the pressure and torque within a single cylinder as a function of the crank angle at a particular RPM. Finally, the combined efforts of cylinders functioning together and their effect on torque at a particular RPM are presented. This model has been used to simulate the performance of the Audi 1.8 liter I-4, the Subaru 3.0 liter H-6/Boxer, the Ford 347 Stroker, and a theoretical Chevy 350 buildup.

The Ideal Four-Stroke Otto Cycle:

The Real Otto Cycle:
Point a is where combustion begins.
Point b is where combustion ends.
Point c is where the exhaust valve(s) open(s).

How the simulation captures the distorted Otto Cycle:
Blue curve is ideal p-V relationship.
Red curve is maximally distorted p-V relationship.
Green curves represent the 4 intermediate levels of distortion.

Performance Data:
Constant RPM (Audi 1.8 Liter I-4)
Pressure vs. Crank angle for a single cylinder at constant RPM
Black curve is total moment, blue curve is inertial moment, red curve is moment due to pressure.

Full torque and HP curves over entire RPM range
Dark blue curves are torque curves generated by the simulation, dark red curves are HP curves generated by the simulation. Light blue and red curves in the Ford 347 graph are real world torque and HP curves generated by a dynamometer.