Performance Evaluation Tool for Simulating Gas Engines – A GUI Package

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CORE THEME

Development of Support System to Explore Gaseous fuel Performance in Internal Combustion Engines

Background :	A variety of alternative fuels are being explored towards displacing conventional fuels in IC engines
Status :	Adaptation limited in light of performance characterization requirement due to differences in properties
Challenges :	Experimental investigation requires exhaustive and expensive test facilities, hence not always feasible
Solution :	Validated numerical simulation tools offer potential alternative to test bench investigations

Limitations of existing tools and improvisations in the current implementation

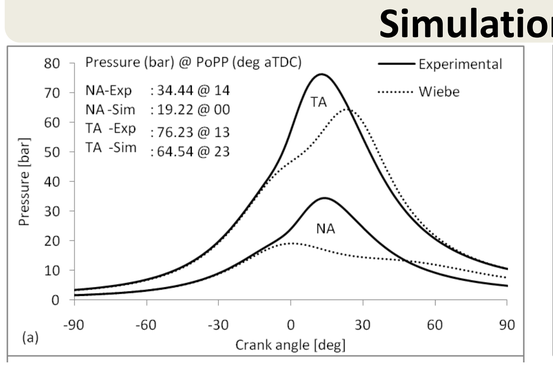
While a number of tools are available, they use coefficients and correlations derived from experience on conventional fuels.

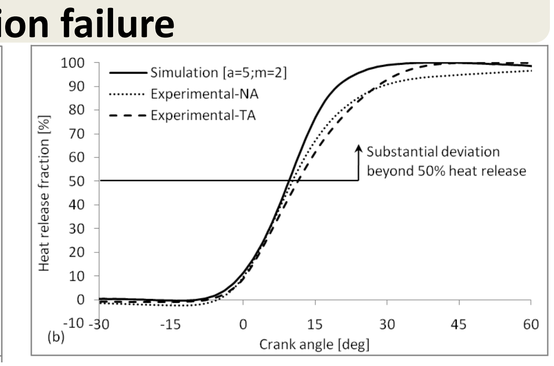
Differences in fuel/mixture thermo-physical properties renders monotonous adoption of such correlations infeasible.

Developed model addresses the mentioned concerns and is directed at handling engine simulation with bio-fuels

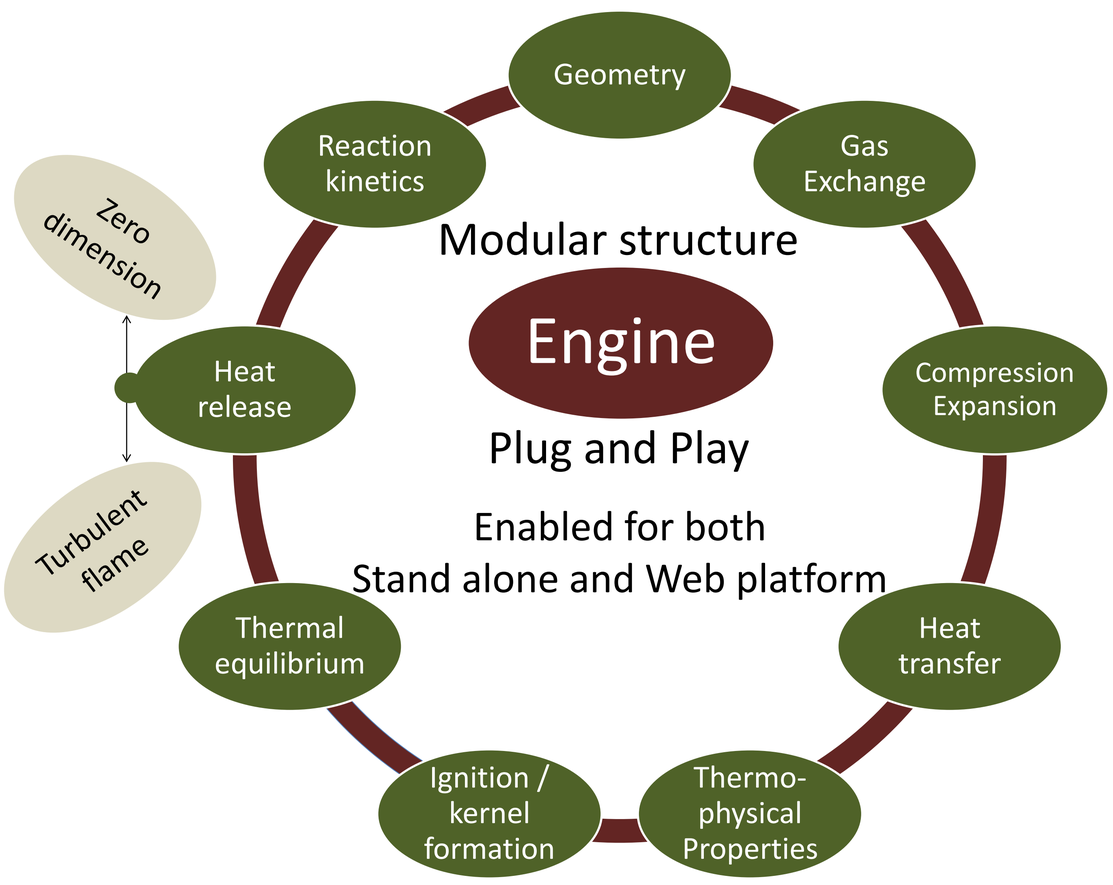
Consequences of using conventional simulation tools

Simulation failure



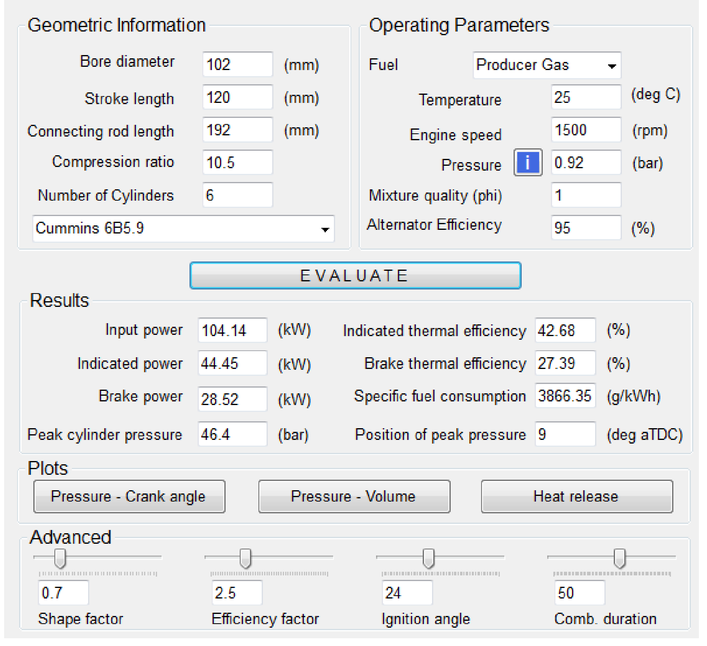


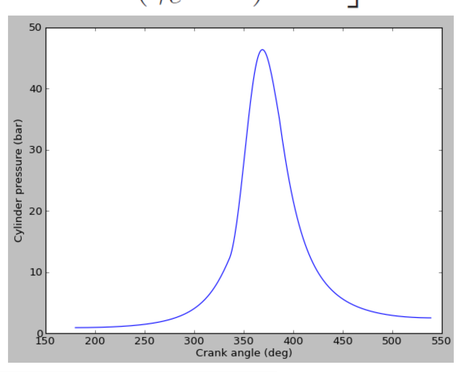
Numerical simulation model : Governing Physics, features and functionalities

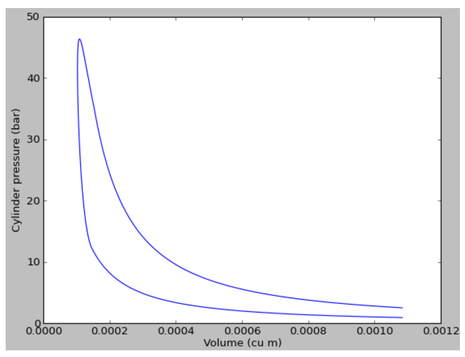


Fundamental governing equation

$$\frac{dP}{d\theta} = \frac{(\gamma-1)}{V}\frac{dQ}{d\theta} - \gamma\frac{P}{V}\frac{dV}{d\theta} + \frac{(\gamma-1)}{V}\left[\frac{c_i^2}{(\gamma_i-1)}\frac{dm_i}{d\theta} - \frac{c_e^2}{(\gamma_e-1)}\frac{dm_e}{d\theta}\right]$$







Key Feature – 1 : Spark sweep module for maximum brake torque estimation

Key Feature – 2 : Turbocharger module for estimation of optimal compressor pressure ratio

Key Feature – 3 : Reaction kinetics based knock estimation module

Engine turbocharger optimization – Case study

- Turbocharged PG fuelled operation of NG engine suggested ~ 65% de-rating

Base NG engine operation with PG

Model based power recovery analysis

- Peak manifold pressure of 2.4 bar suggested
- Knock limited peak load of 75 kWe

- Turbocharger optimization supported knock limited peak load of 72.8 kWe

Turbo-optimized engine operation

Producer gas fuelled power rating estimation

Engine			Baseline data			PG Operation		
Make	Model	cc	Fuel	CR	Rating kWe	CR	Obs kWe	Sim kWe
Honda	GX620	615	Gasoline	8.3	7	8.3	4.3	4.2
Kohler	CH740	725	NG	9.1	9	9.1	6.0	5.2
Cummins	CS 15 D5	1669	Diesel	18.5	12	11.6	7.9	8.8
Kirloskar	RB33	3308	Diesel	17.0	24	11.5	17.6	19.0
Cummins	6B 5.9-NA	5900	NG	10.5	40	10.5	27.3	28.5
Cummins	6B 5.9-TA		NG	10.5	72	10.5	72.8	67.0

A GUI based engine simulation tool has been developed and validated which can used for preliminary engine performance analysis with both conventional and bio-fuels.

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