Internal Combustion Engine Modeling

With GT-SUITE’s and CONVERGE CFD’s engine modeling tools, EngSim efficiently models and analyzes many designs, configurations, and operating conditions to quickly understand and optimize an engine system.

**Simulation Capabilities**

**Engine Performance and Efficiency**
- Evaluation of base engine specs and architecture
- Valve timing and profile optimization
- Turbocharger matching
- Engine and exhaust system warm-up
- HP and LP EGR studies
- Cooler analysis/sizing

**3D CFD**
- Full cycle, moving mesh CFD of engine cylinders for mixture motion, mixing, and combustion

**Engine Acoustics**
- Intake and exhaust noise analysis
- Intake resonators
- Replication of bench tests
- Internal muffler design

**Engine Concepts**
- Novel valve strategies
- Varying piston motion/cycle

**Integrated Systems**
- Vehicle
- Thermal/Cooling
- Valvetrain
- Controls
- Timing Drive

Full engine models can be built with GT-Suite and correlated in 1-3 weeks, depending on model complexity. These models can then be used for design analysis or full multi-variable optimization.

www.EngSim.com
With GT-SUITE’s vehicle modeling tools, EngSim can model any variety of vehicle configurations and drive cycles to predict performance and fuel economy solutions.

**Simulation Capabilities**

*Any Type of Vehicle*
- Conventional automotive
- Electric hybrid
- Off-Road
- Motorcycle
- Racing/Performance

*Include Simple or Complex Sub-Models*
- Engine
- Transmission
- Clutches
- Torque converter
- Axles
- Shift strategies
- Engine calibration & controls
- Cooling/Thermal
- Tires and brakes
- Driver inputs

**Available Results**
- Optimized vehicle configurations
- Active monitors to observe during runs
- Engine Torque/BMEP/Power
- Elapsed time
- Gear shifts and strategies
- Acceleration
- Fuel consumption
- Tractive forces
- Aero drag forces

www.EngSim.com
Electrified Powertrain and Vehicle Modeling

With GT-SUITE’s vehicle modeling tools, EngSim can model conventional, hybrid, or full-electric vehicles to optimize strategies for best performance and fuel economy over any drive cycle.

**Simulation Capabilities**

**Fuel Economy Prediction**
- Drive-cycle fuel predictions
- Development of control strategies to maximize FE potential of advanced components
- Four types of engine coupling: detailed, FRM, mean value, and map based

**Conventional Vehicle**
- Integrating stand-alone engine and vehicle models
- Using GT-Drive+ to build standard vehicle models
- Validation of vehicle using benchmark data
- Shift strategy generation and optimization

**48v Mild Hybrid Vehicle**
- Evaluating 48v technologies such as BAS and eBooster
- Building GT and Simulink based first phase controls to maximize FE potential

**Hybrid Vehicle**
- Battery and motor sizing
- Architecture analysis
- Building GT and Simulink based first phase controls to maximize FE potential

**Full Electric Vehicle**
- Evaluating energy regen options
- Running battery range tests

Four types of engine models can be used to build a system level vehicle analysis – detailed engine, Fast Running Model (FRM), mean value engine, and engine map.

Different types of hybrid architecture come with advantages and disadvantages. Mild hybrid architecture was studied with a client and published at the 2018 SAE World Congress.

Electric vehicles can be designed to achieve the target load demand. The battery and motor can be sized according to the FE target and performance. Energy regeneration can be quantified.
With GT-SUITE’s valvetrain engineering tools, EngSim can model complete solutions to optimize a valvetrain design for best engine performance while addressing stability, durability, and noise.

### Simulation Capabilities

- **Standard or Non-Conventional Mechanisms**
- **Many Profile Synthesis Options**
- **Kinematic and Dynamic Modeling**
- **Spring Dynamic Analysis**
  - Margin
  - Surge
  - Coil clash
  - Stress
- **Hydraulic Elements for HLA, Phasers, Actuators**
- **Single Branch, Single or Multi-Cylinder Systems**
- **Camshaft Torsional and Bending Analysis**
- **Easy Visualization of Results**
- **Can Be Integrated with Other GT-SUITE Modules**
  - Engine performance
  - Lubrication
  - Timing drive

### VT-DESIGN’s Interactive Modeling for Fast Iterations

Many kinematic valvetrain design metrics such as lift, velocity, acceleration, jerk, radius of curvature, or follower run-off can be generated to determine the optimum profile.

### Dynamic Valvetrain Output

Dynamic valvetrain output can include metrics such as spring margin, component force, hertz force and pressure, and dynamic valve lift.
Thermal Systems Modeling

With GT-SUITE’s vehicle modeling tools, EngSim can perform system level thermal analysis of the engine, transmission, and the vehicle. We can also use CONVERGE CFD to evaluate flow and conjugate heat transfer.

Simulation Capabilities

Published Work with Clients
- Active Thermal Mgmt with a Dual Mode Coolant Pump
- Modeling Engine Friction with Temperature Dependence for Vehicle Thermal Mgt

Detailed Thermal Systems
- Full cooling system model with engine oil, transmission oil and coolant circuit
- Modeling engine block, cylinder line, and engine components thermal mass
- 3D under-hood modeling

HEV, EV, and Conventional Vehicle Thermal Modeling
- Drive cycle analysis, fuel economy prediction, and engine warmup
- Development of advanced pump, fan, and thermostats
- Hybrid vehicle and battery thermal management

Thermoelectric Systems
- Exhaust gas recovery system effect on coolant energy
- Evaluating thermo-electric generators

3D CFD Analysis
- Coolant/oil side 3D CFD flow and temperature analysis
- Conjugate heat transfer

www.EngSim.com
EngSim uses CONVERGE CFD for fluid flow analysis and optimization of complex and wide-ranging engine and vehicle systems.

### Simulation Capabilities

**Port and Combustion Chamber Optimization**
- Steady port flow
- Gas exchange
- Combustion
- Emissions

**Manifolds and General Flow**
- Steady or transient
- Cyl-to-Cyl variation
- Flow distribution on CAT

**Spray Modeling**
- Port or direct injection
- Injector design
- Injector location, timing and spray targeting

**Mixing**
- Gaseous fuel mixing in ports and cylinder
- EGR distribution

**Coolant Flow Analysis**
- Water flow distribution in heads and blocks
- Convection coefficient predictions

**Coupling with GT-SUITE**
- Transient flow
- Exchange of boundary conditions w/1D code

Models can be run within a few days of receiving geometry

Full cycle, moving mesh simulation of internal combustion engines

Combustion optimization studies looking into port shape, chamber design, piston shape, injector design, injector targeting, injection timing, spark location, etc.

Steady-flow optimization and development

[EngSim website](www.EngSim.com)