ESEngSim

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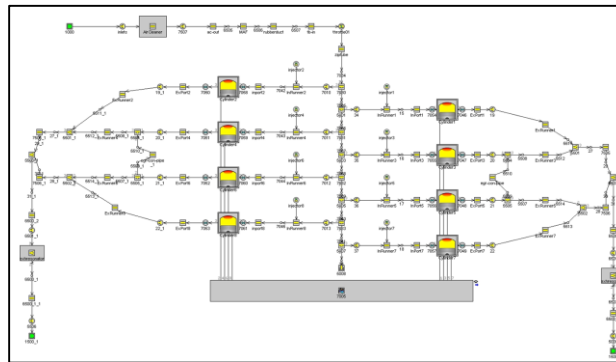
Engine Concepts
- Novel valve strategies
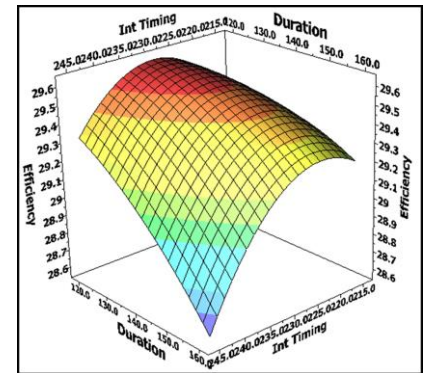- Varying piston motion/cycle

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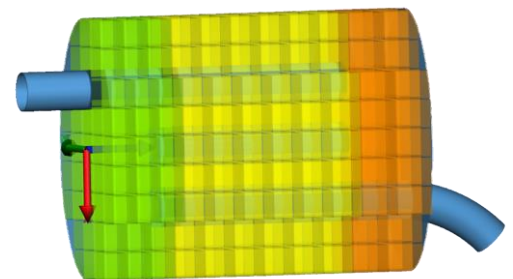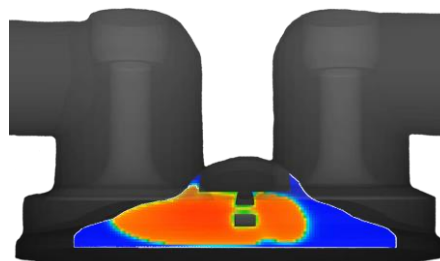- Controls
- Timing Drive

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.
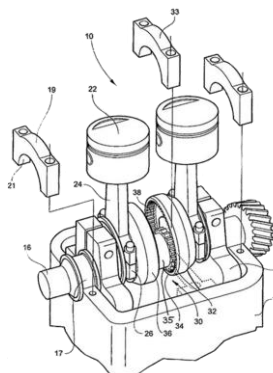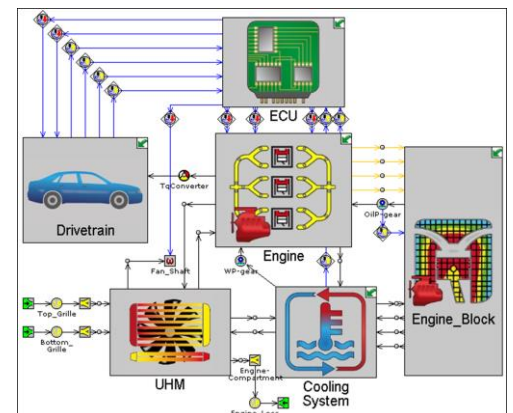
Detailed combustion using CONVERGE CFD

Finely discretized muffler for acoustic studies

Concept Lugo crank mechanism

Modeling of multiple integrated vehicle systems

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Performance Vehicle and Powertrain Modeling

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.
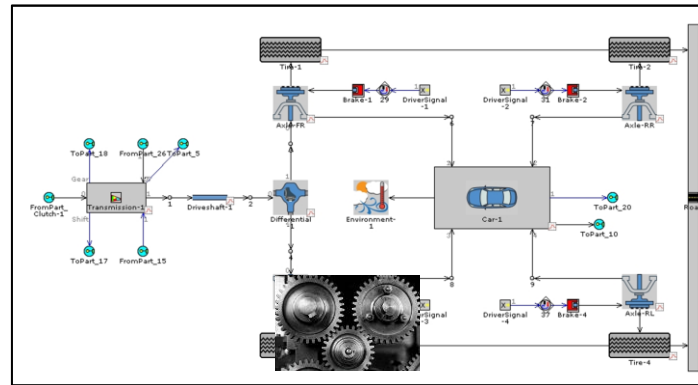
Simulation Capabilities

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

Vehicle system model can be comprised of many simple or complex sub-models

Speed

Acceleration

Gear

RPM
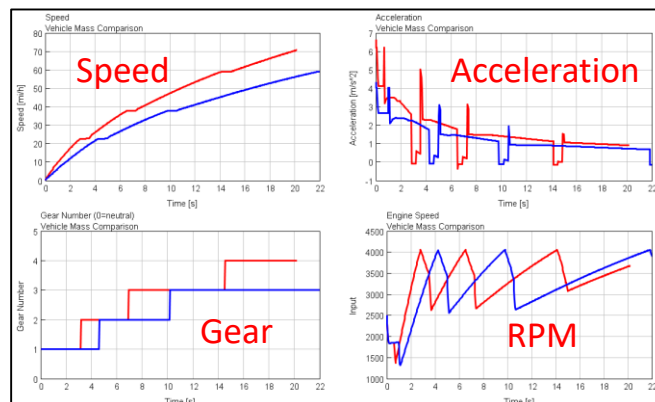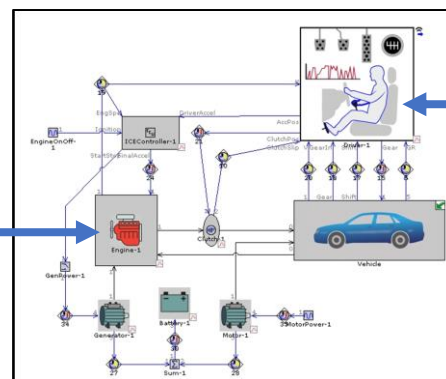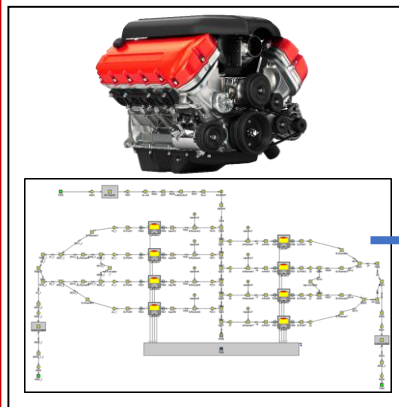
Many output parameters can be optimized

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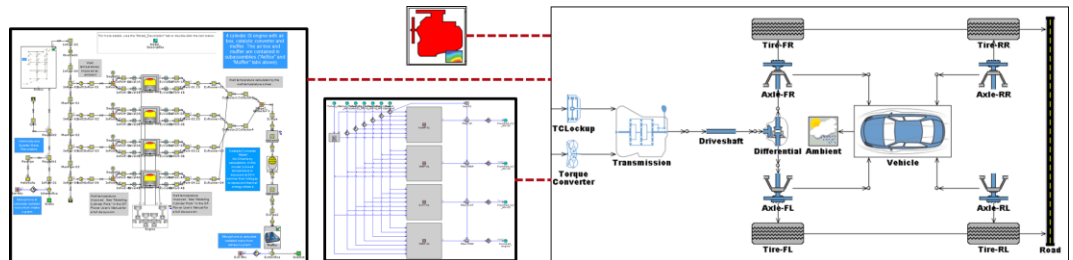
Hybrid Vehicle
- Battery and motor sizing
- Architecture analysis
- Building GT and Simulink based first phase controls to maximize FE potential

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.
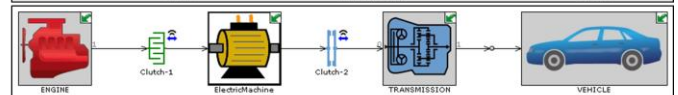

Different types of hybrid architecture come with advantages and disadvantages. Mild hybrid architecture was studied with a client and published at the 2018 SAE World Congress.
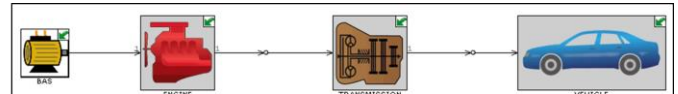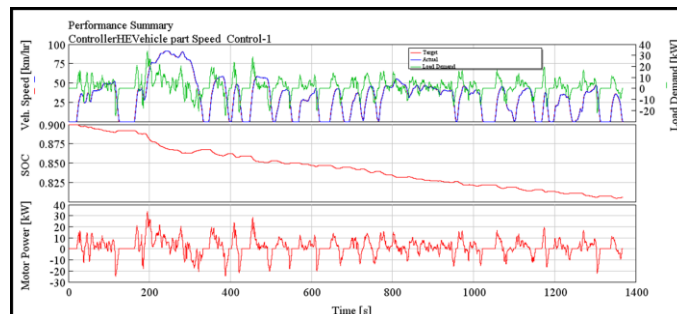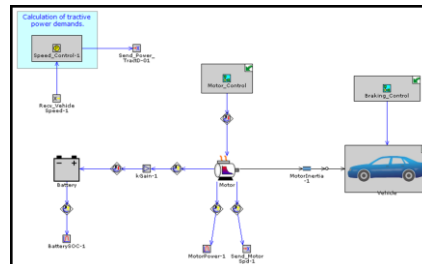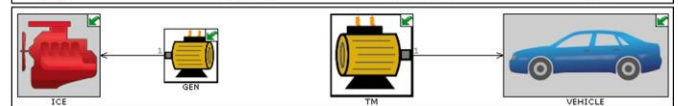

Electric vehicles can be designed to achieve the target load demand. The battery and motor can be sized according to the FE target and performance. Energy regeneration can be quantified.

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Valvetrain Modeling

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

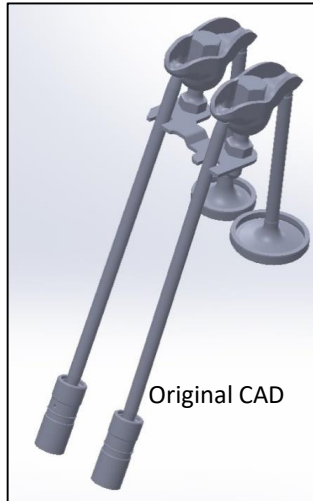*Hydraulic Elements for HLA, Phasers, Actuators*

Single Branch, Single or Multi-Cylinder Systems
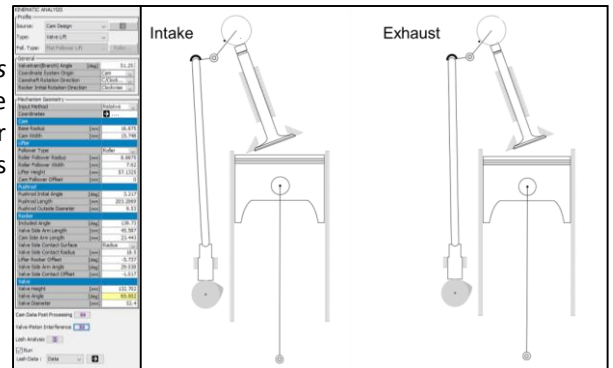
Camshaft Torsional and Bending Analysis

Easy Visualization of Results

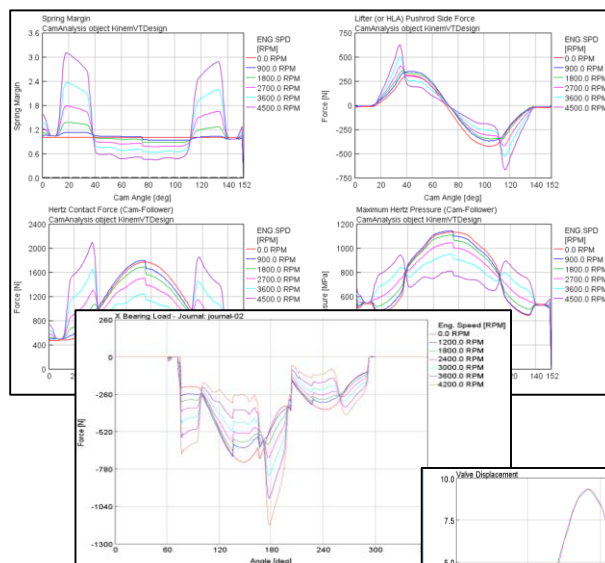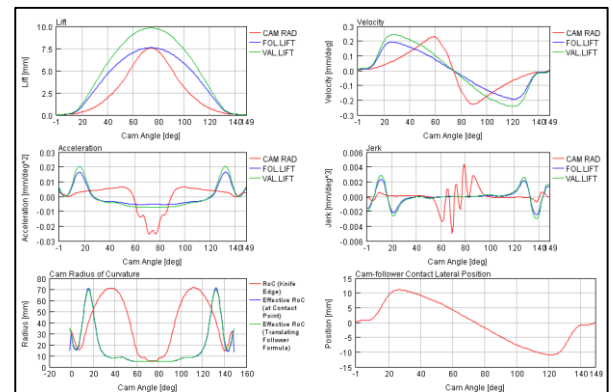*Can Be Integrated with Other GT-SUITE Modules*
- Engine performance
- Lubrication
- Timing drive

Original CAD

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 can include metrics such as spring margin, component force, hertz force and pressure, and dynamic valve lift
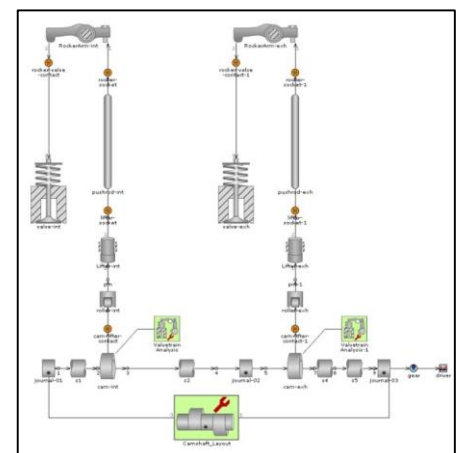
GT-SUITE dynamic single-cylinder system model

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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
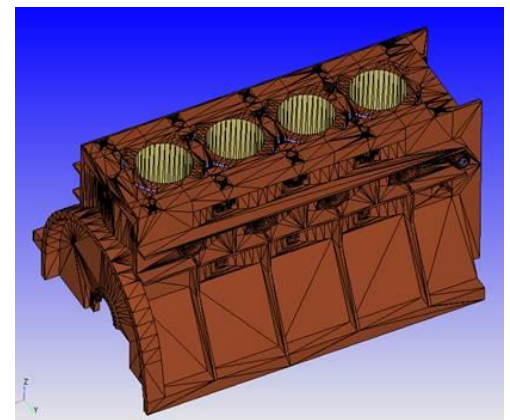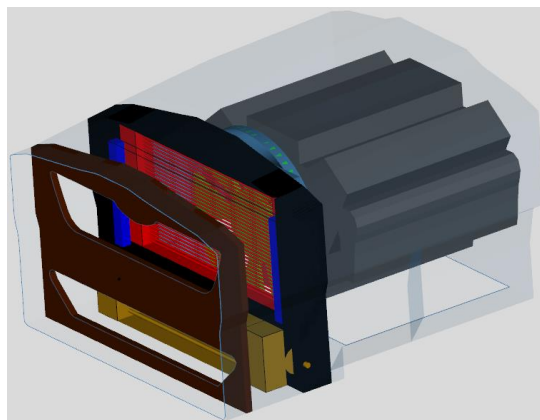- Conjugate heat transfer
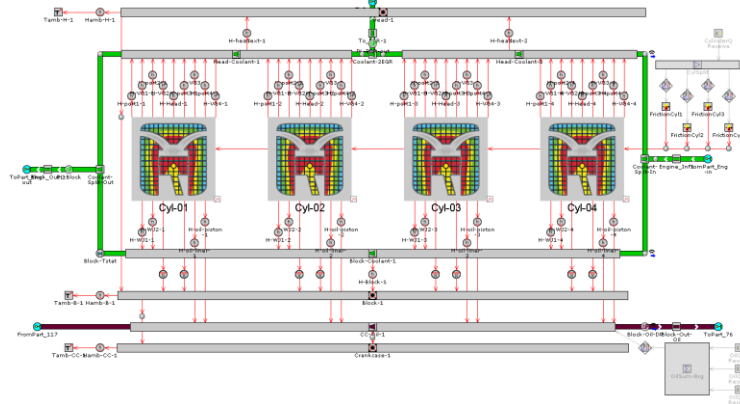
Detailed cooling system development with component level heat transfer calculation for the engine

Coupling thermal systems and vehicle using GT-SUITE. Includes engine HT, motor HT, battery HT, oil circuit, coolant circuit, and HXs
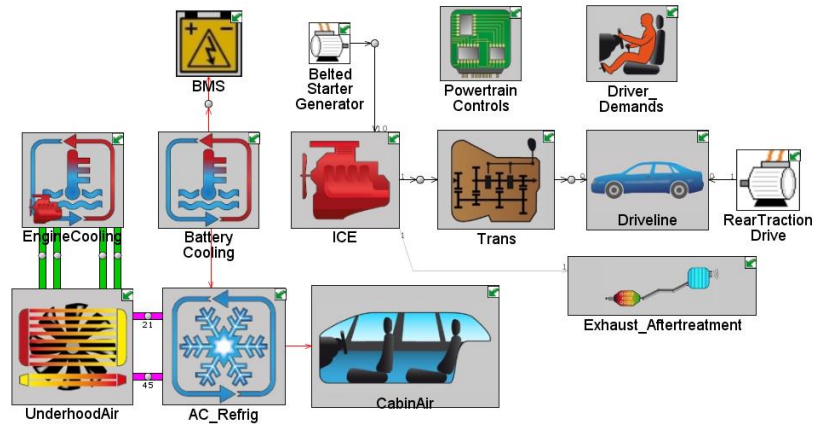
3D Underhood, 3D CFD coolant/oil flow and CHT analysis

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Computational Fluid Dynamics
Fluid Flow, Combustion, Heat Transfer, Gas Mixing

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
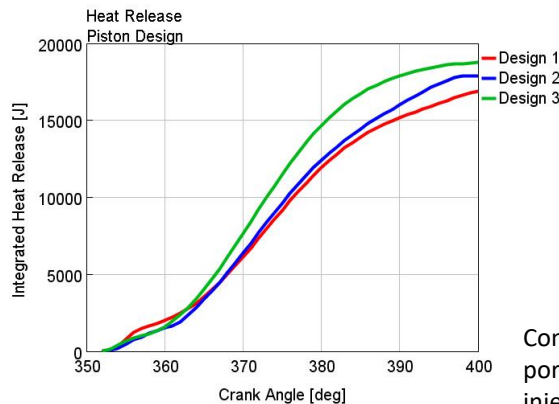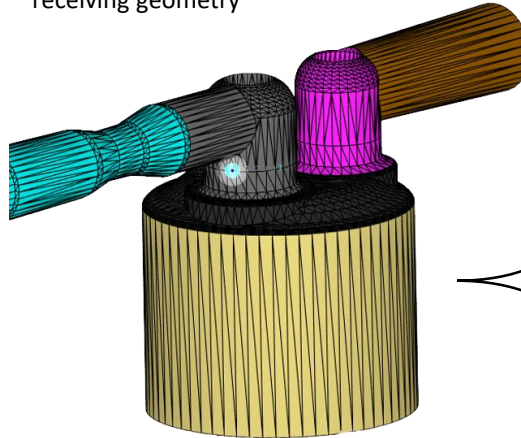- EGR distribution

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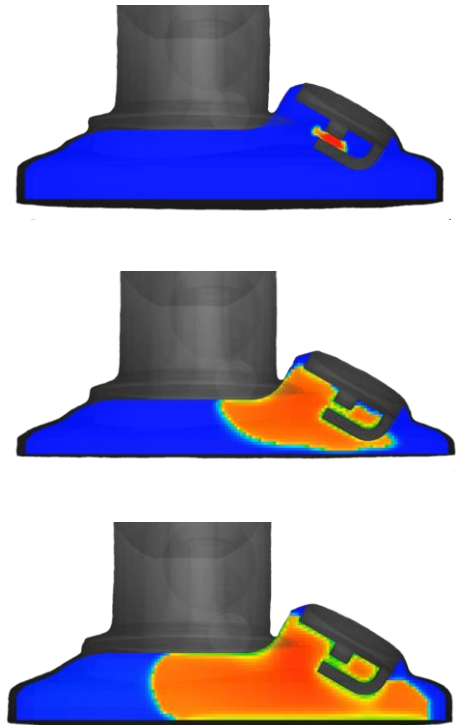- Convection coefficient predictions

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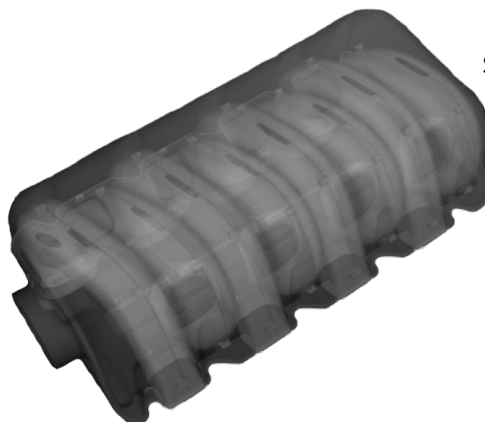- Exchange of boundary conditions w/1D code

Models can be run within a few days of receiving geometry

Heat Release Piston Design

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

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