Application of SI Turbulent Combustion Model in a Chrysler Turbocharged Engine

North American GT-User Conference 2012
Nov. 05, 2012

Powertrain Virtual Analysis
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The model in this study is predictive by improving in following areas based on 1D GT-Power model in Chrysler:

- SI turbulent model
- Modified heat transfer model
- Chrysler developed new knock prediction model (Knock index model)
- Improved FMEP model
The model correlation procedure in Chrysler becomes a standard process, which includes the following levels:

- Level 1: Mass flow correlation at wide open throttle (WOT) by using empirical combustion model(s)
- Level 2: SI turbulent combustion model correlation by using Dyno spark timing
- Level 3: Chrysler developed new knock prediction model correlation by adding spark timing controller
- Level 4: Extend the model correlation to part throttle
- Repeat correlation from Level 2 to Level 4 if needed
- A predictive model is ready for application
1D GT-Power model structure

- 6.1L V8 Engine
- 1D GT-Power model structure
- Turbine
- Waste Gate
- Pb Controller
- HPEGR Valve
- Intercooler
- CBV OFF
- CBV ON
- TBV OFF
- TBV ON
- EGR Intercooler
A Predictive Combustion Model Correlation

- Cylinder Pressure Traces at WOT Running Condition (each grid is 10 bar/º CA)
- The model was well-correlated at WOT

![Diagram showing cylinder pressure traces at different speeds (1600, 4400, 3600, and 6400 rpm). Each grid is 10 bar/º CA.)]
Engine Model Validations at 2000rpm

- The model correlation was extended to part throttle conditions.
- The model then was validated by all available PT Dyno data, the error is < 3% except for two points in turbocharger speed.

![Graphs showing model validation results for BSFC, MAP, TC Speed, and PMEP with EGR percentage increase.](image-url)
How to Optimize Compression Ratio

- Compression ratio increases from A1 to A5
- Compression ratio A4 was selected

CR increases and BSFC drops.

CR increases and BSFC increases too but peak torque drops.

Engine Torque (N-m, 1200rpm)

BSFC (g/kWhr)
Turbine Size Study

- Turbine size increases from T5 to T1 while compressor is unchanged
- Turbine size has a significant influence on BSFC
- Turbines T2 and T3 are picked up for this study
Cycle-to-Cycle Variations in Dyno Tests

- NMEP and CA50 were calculated from 150 cycles x 8 cylinder pressure data
- The difference in NMEP variation is around 2.2 bar (each grid is 1 bar in NMEP and 2° CA in CA50)
- CA50 can be moved closer to MBT if lowest NMEP points could be removed
Cylinder-to-Cylinder Variations in Simulation

- Cylinder-to-Cylinder variations are found through modeling
- A new set of valve lift profiles are optimized through DOE run in GT-Power model
- With new valve lifts, cylinder-to-cylinder variations are reduced greatly

![Graph showing VE Variation (%)](image)

- Boost Pressure (bar, 1200rpm)
- Original Design
- New Design
- 5% increase
- 0.1 bar
With new valve lifts, engine brake power increases more than 45 kW, IMEP COV and fuel economy are improved.
Summary

- SI Turbulent combustion model in 1D GT-Power was developed, well correlated and applied in this engine development to save cost and development time.
- In this study the well-correlated model was used for compression ratio selection, turbocharger sizing and cycle-to-cycle variation reduction.
- A model-based new valve lift profiles were designed to reduce cylinder-to-cylinder variations in VE.
- With the new designed valve lifts, significant improvement in power, BSFC and IMEP COV were observed in Dyno tests with external CEGR.
Questions?