A Near Real-Time GT-POWER Engine Model in Dyno Testing for Residual Gas and Dilution Tolerance Response Modeling

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Contents

• Introduction
  – Using a Near Real-Time GT-POWER Model to Supplement Test Cell Measurement for Residual and Dilution Tolerance

• Motivation
  – Combustion system development
  – Calibration process
  – Advanced models and simulation

• Process
  – Test engine measurement
  – Model preparation
  – Implementation

• Results
  – Engine load sweeps
  – Residual mapping

• Conclusions
Motivation

- Combustion Performance
  - High specific output balanced with good light load run quality
  - Strong inner-cycle tuning dynamics
  - Residual concentration measurement
Motivation

- Calibration Support
  - Identify engine out emission sources
  - Immediate insight to fuel control
  - Base calibration table population

- Mapping and FRM development
  - Model output data immediately available with complete data set
    - Combustion quality (COV of IMEP, misfire, ΔSpeed) = f(residual concentration)
    - RSMs (CA50, EGTs, Res) - Optimization routines, FRMs
    - Mean Value Models (cylinder IMEP) - FRMs, plant models (HiL)
Process Overview

- **Engine Test**
  - Crank Angle resolved intake, exhaust, and cylinder pressure
  - System temperatures and pressure
- **1-D gas dynamic model**
  - Detailed gas dynamics
  - Apparent combustion calculation
  - Correlate to previously measured data
  - Prepare “Three Pressure Analysis” – TPA model
- **Data management**
  - Share test cell data to model
  - Execute model
  - Retrieve data
  - Push test cell and model data to database
Process Detail

- Engine Test
  - High speed pressure measurement
    - Manifold pressure measured downstream of throttle
    - Cylinder pressure measured with best practices
    - Exhaust pressure measured downstream of port
  - Low speed test condition measurement
    - Engine speed, load, head temperatures, EGTs, spark timing, lambda, etc.
    - Single values for model inputs
Process Detail

- Test Data Handling, Availability, and Real-Time
  - Cycle count from few to many
  - Buffer fills then creates statistical data and file
  - Model execution immediately after – near real-time
  - Sampling to running file while executing – real-time (N-1?)
  - Without combustion, real-time is easily achieved
Process Detail

- 1-D Model Preparation
  - Detailed / correlated or best practices base model
Process Detail

- 1-D Model Preparation
  - Strip the model beyond the intake and exhaust pressure measurement location
  - Add TPA end environments - iFiles and boundary conditions
  - Ensure robust burn rate calculations through correlated thermal boundaries and heat transfer coefficients
  - Balance gas dynamic detail with execution speed
Process Detail

- 1-D Model Preparation
  - Prepare Model Input
    - External file corresponding to input parameters
    - External file points to iFile name and location
    - Cell to model data manipulation for units and corrections
  - Prepare model output
    - Complete model output is available but time consuming
    - Prepare export template with output of interest
Process Detail

- **Data Handling – Script and Upload**
  - Creates statistical calculation from low speed data
  - Link statistical calculation of low speed data to iFile
  - Starts GT from a command line passing model, parameter file, statistical calculation of low speed data, and path to iFile
  - Starts GT export from a command line passing parameter file, and output file
  - Append GT data to test data file
  - Upload to database
Results
Dilution Tolerance

Residual Concentration
1600 RPM, Load Sweep

- Engine 1 - production cam - combustion OK
- Engine 2 - initial cam - poor combustion
- Engine 2 - intermediate cam - better combustion
- Engine 2 - final cam - good combustion
Results

Residual Concentration Response Surface Modelling

Engine Configuration A

Engine Configuration B
Conclusions

• A process for quick and robust evaluation, optimization, and calibration of a performance combustion system was developed

• Fast running GT-POWER model was prepared for and run in the test cell with each test

• The test conditions, along with steady-state results and crank angle resolved system pressures, are passed directly to the model

• A script within the test cell handles the data transfer, model execution, and completes data upload to a database

• Otherwise difficult to measure data is available at the test cell per run and at the engineers desk for correlation development, optimization and engine calibration
Discussion and Questions

Thank You!