Predicting Oil Flow Distribution in a High Performance NASCAR Engine

GT-SUTE Conference
Birmingham-MI, November 7, 2011

Paul Bolton
Earnhardt-Childress Racing
Presentation Overview

- Introduction
- Why model the lubrication system?
- GT Lubrication Model
- Oil System Analysis Corroboration
- Results Comparison
- Summary
Introduction

- 7 NASCAR Nextel Cup engine programs
- 3 NASCAR Nationwide engine programs
- 9 NASCAR Truck Series engine programs
- 600+ Engines a year
- 5.8L, 90°, OHV V8
- 830+ hp
- 530+ ft-lbs
- 10,200 rpm redline
- 140+ hp/L
- Wide operating range
  - 5,400 to 10,200 rpm
Why model the R07 Lubrication System?

- Identify main consumers in the system
- Detailed main bearing analysis – effects of oil groove size and location, clearances
- Investigate causes of cavitation in connecting rods
- Oil pump sizing
- Squirters both piston and spring – sizing, effectivity etc.
- Targeted Oiling and Scavenge
ECR have been using the GT suite of tools for over 10 years.

Development of all rotating and reciprocating components driven by detailed cranktrain model, all camshaft profiles and valve train components developed through detailed valvetrain model.

Comprehensive mechanical/dynamic models for GM/ECR R07 engine architecture.

Decision made in 2010 to use base models to drive GT lubrication model.
GT Lubrication Model

- Model was discretized from a 3D CAD file in GEM3D
- Everything is based on actual geometry i.e., no pressure loss components used
• Pre-Existing detailed Cranktrain model
  – Dynamic (instantaneous) bearing loads
• Minimum calibration parameters
  – Main bearing clearance
  – Spring squirter orifice size
  – Distributor Feed orifice size
• Imposed Pressure Models:
  – Inlet pressure test data is used as the inlet boundary condition in the models
• The predicted flow rates going into the system are compared to test data
  – If each case’s prediction matches test data well, it means that the oil flow distribution is accurate
Oil System Analysis Corroboration

To help validate the model and continue the development process a thorough oil system test was planned with a dedicated race engine build.

Engine instrumented for high speed pressure, temperature and flow measurement.

Steady state, sweep and lap simulation testing performed.
Pressure was measured at various locations in the system using high-speed piezoresistant pressure sensors.

For the purpose of this presentation we will consider the main pressure feed to the engine and at an area in cylinder block used as measurement point for the drivers in-cockpit gauges.
Test Setup – Oil Flow

• Flow measured before and after the oil pump, only oil entering the engine considered for this test.
• Rear oil distribution plate allows the blocking of various passages so that the change in oil flow to the engine can be measured
• Six out of seven cases have some part of the flow circuit blocked
• Individual GT models created to allow for full validation.

1. Standard oil system (No passages blocked)
2. Left inboard piston squirters blocked
3. Right inboard piston squirters blocked
4. Left outboard piston squirters blocked
5. Right outboard piston squirters blocked
6. Right valve cover feed blocked
7. Left valve cover feeds blocked
Results Comparison

Setup 1 - Standard Model (No passages blocked)

- Flow rate prediction
  - Maximum % difference = 0.79 %
- Pressure @ boss prediction
  - Maximum % difference = 5.1 %
Set-Up 2
Left Inboard Piston Squirters Blocked

- Flow rate prediction
  - Maximum % difference = 3.9 %
- Pressure @ boss prediction
  - Maximum % difference = 4.7 %
Set-Up 3
Right Inboard Piston Squirters Blocked

- Flow rate prediction
  - Maximum % difference = 3.9 %
- Pressure @ boss prediction
  - Maximum % difference = 5.4 %
Set-Up 4
Left Outboard Piston Squirters Blocked

- Flow rate prediction
  - Maximum % difference = 2.6%
- Pressure @ boss prediction
  - Maximum % difference = 5.7%
Set-Up 5
Right Outboard Piston Squirters Blocked

- Flow rate prediction
  - Maximum % difference = 2.2%
- Pressure @ boss prediction
  - Maximum % difference = 5.4%
Set-Up 6
Right Valve Cover Feed Blocked

- Flow rate prediction
  - Maximum % difference = 5.4 %
- Pressure @ boss prediction
  - Maximum % difference = 8.0 %
Set-Up 7
Left Valve Cover Feeds Blocked

- Flow rate prediction
  - Maximum % difference = 7.2 %
- Pressure @ boss prediction
  - Maximum % difference = 2.1 %
Summary

Oil Pressure

• The pressure drop between main feed and gauge point is well predicted.
• Using test information to continue further analysis of main and connecting rod bearing pressure

Flow rate prediction

• Test results show excellent correlation between simulated flow consumers and measured results
• Largest deviation seen with flow to left hand valve covers (only 10%), could be due to multiple leak paths in system set-up
• Further development of oil pump sizing based on simulation and tests.
Thanks to the following people who did the majority of the work:
Rodrigo Aihara (Gamma Technologies)
Jon Harrison (Gamma Technologies)
“Slick” Bobby Gada (ECR Engines)
Jason “Turkish” Yackley (ECR Engines)