Effect of EGR on Ignition Delay in Truck DI Diesel Engine

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Contents

• A brief Description of the DI Jet Combustion Model
• Operating Conditions
• Discussion on Experimental Data
• Comparison with Baseline Data with no EGR
• Comparison with EGR data without the Ignition Delay Model Enhancement
• Comparison with Ignition Delay Model Enhancement
DI Jet Combustion Model

- Injection
- Droplet Formation
- Evaporation, Entrainment and Mixture Formation
- Ignition
- Combustion: Mixing Limited and Kinetics Limited
Jet Model (Cont.)
### Engine Cylinder Geometry and Operating Conditions

#### Cylinder Geometry

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cylinder</td>
<td>6</td>
</tr>
<tr>
<td>Total volume</td>
<td>~2.00 liter</td>
</tr>
<tr>
<td>Bore</td>
<td>~130 mm</td>
</tr>
<tr>
<td>Stroke</td>
<td>~150 mm</td>
</tr>
<tr>
<td>Compression ratio</td>
<td>14.5</td>
</tr>
<tr>
<td>Intake valves</td>
<td>2</td>
</tr>
<tr>
<td>Valve lash</td>
<td>0.45 mm</td>
</tr>
<tr>
<td>Exhaust valves</td>
<td>1.0 mm</td>
</tr>
<tr>
<td>Valve lash</td>
<td>0.8 mm</td>
</tr>
</tbody>
</table>

#### Operating Conditions

<table>
<thead>
<tr>
<th>Temperature (Celsius)</th>
<th>Speed (RPM)</th>
<th>EGR level (%)</th>
<th>SOI (degrees CA)</th>
<th>Load (mg/stroke)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>1200</td>
<td>0</td>
<td>-10</td>
<td>50</td>
</tr>
<tr>
<td>80</td>
<td>1500</td>
<td>10</td>
<td>-5</td>
<td>100</td>
</tr>
<tr>
<td>1900</td>
<td>20</td>
<td>20</td>
<td>0</td>
<td>150</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Experimental Data

• Over 200 Operating Conditions with in-cylinder pressure, manifold pressure, emissions were provided

• Pressure Data were Carefully Inspected for Suitability of Heat Release Calculation
  - Straightness of LogP-LogV Compression line
  - Comparison with Simulation Results
  - Pegging and Phasing
Pressure Data Processing

Phasing
Heat Release --- 103% IMEP --- 7.52bar

Pegging
Heat Release --- 102% IMEP --- 7.28bar

Compression Ratio
Heat Release --- 88% IMEP --- 7.28

Graphs showing pressure data over volume for different scenarios.
Ignition Delay Model

- Default Model is a Function of Pressure, Temperature and Equivalence Ratio
- Thermodynamic State is Affected by EGR
- Specific Heat is Increased by the Presence of EGR resulting in a Lower Peak Temperature
- Equivalence Ratio is unaffected by EGR
- Dilution Effect is Missing
Comparison w/o Dilution Effect In Delay Model
Comparison with Dilution Effect In Delay Model
NOx Prediction: Effect of SOI
NOx Prediction: EGR effect
NOx Prediction: Speed effect
Performance Prediction
Conclusions

• Measured Pressure Data must be Carefully Examined and Processed Before being used for Combustion and Emissions Model Validation

• Default Ignition Delay Model Predicted Baseline Heat Release Satisfactorily (No EGR). However, Ignition Delay is Under-predicted at High EGR Levels

• The Dilution Correction in Ignition Delay Model Improved DI Jet Combustion Model Accuracy to up to 50% EGR Fraction