NOx Emissions Performance and Correlation Equations for a Multipoint LDI Injector

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Research Background and Purposes

Background

- ERA project goal
  - LTO NOx 75% reduction wrt CAEP/6
- Five contracts
  - Two companies produce sector combustors.
  - Three companies produce single cup combustors.
- Parker Hannifin has two single cup configurations

Purposes

- This study presents NO\textsubscript{x} emissions result of Parker’s first configuration
- Develop NO\textsubscript{x} correlation equations to predict its LTO NO\textsubscript{x} emissions.
Experiment setup and hardware

- CE-5
  - Air, max(1720 kPa, 810 K)
  - Jet-A aviation fuel

- Parker’s 3-zone multipoint LDI concept

- Fuel staging (3 fuel circuits)
  - Pilot (one fuel circuit)
  - Low power (Two F-stages)
  - High power (Three F-stages)
Correlation Methodology

\[ EINOx = K \times P_3^{N1} \times e^{\frac{T_3}{N2}} \times \Phi^{N3} \]

- Plot Plotting EINOx vs. \( \Phi \), EINOx vs. P3, EINOx vs. T3, to estimate N1, N2, N3.

- With estimated N1, N2, N3 as initial guesses, Multiple regression method is used to determine the final values for K, N1, N2, N3.
Test Results

Low Engine Power

![Graph showing EINOx vs T4 for Two Fuel Stages.](image1)

High Engine Power

![Graph showing EINOx vs T4 at T3 = 828 K.](image2)

![Graph showing EINOx vs T4 at T3 = 735 K.](image3)
Three NOx Correlation Equations

(1) Two F-Stages

\[ EINOx = 0.364 \cdot P_3^{0.60} \cdot \frac{T_3}{200} \cdot \Phi^{3.03} \]

(2) Three F-Stages (T4 < 1810 K)

\[ EINOx = 0.0052 \cdot P_3^{0.46} \cdot \frac{T_3}{170} \cdot \Phi^{0.97} \]

(3) Three F-Stages (T4 > 1810 K)

\[ EINOx = 0.0058 \cdot P_3^{0.516} \cdot \frac{T_3}{132} \cdot \Phi^{3.32} \]
55:1 pressure-ratio engine cycle.

37.6 g/kN, 66 % blow ICAO CAEP-6.

<table>
<thead>
<tr>
<th>Power condition</th>
<th>Cyclic Time (min)</th>
<th>NOx, EI (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7%</td>
<td>26</td>
<td>1.68</td>
</tr>
<tr>
<td>30%</td>
<td>4</td>
<td>3.57</td>
</tr>
<tr>
<td>85%</td>
<td>2.2</td>
<td>24.7</td>
</tr>
<tr>
<td>100%</td>
<td>0.7</td>
<td>52.4</td>
</tr>
<tr>
<td><strong>Total LTO NOx</strong></td>
<td></td>
<td><strong>37.6 g/kN</strong></td>
</tr>
</tbody>
</table>
Conclusion

- Three NOx correlation equations
- NOx is a strong function of $\Phi$ and T3, weak function of P3.
- N1,N2,N3 change with fuel staging, flame temperature.
- NOx emission for this LDI injection concepts is 66% blow ICAO CAEP-6.
- P3 tested was less than 50% of full power engine inlet air pressure, future experiment at higher inlet air pressure condition is needed.
Acknowledgements

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