NOx Emissions Performance and Correlation Equations for a Multipoint LDI Injector

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Research Background and Purposes

Background

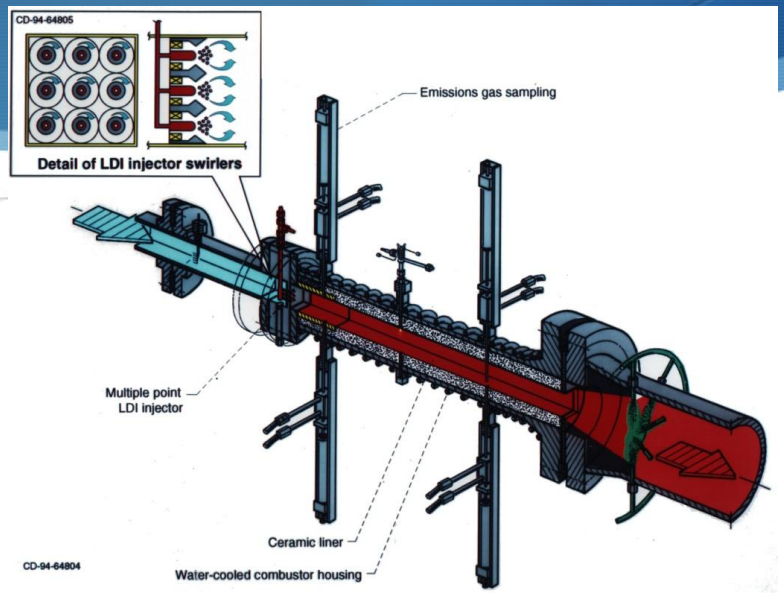
- ERA project goal
  - LTO NOx 75% reduction wrt CAEP/6
- Five contracts
  - Two companies produce sector combustors.
  - Three companies produce single cup combustors.
- Parker Hannifin has two single cup configurations

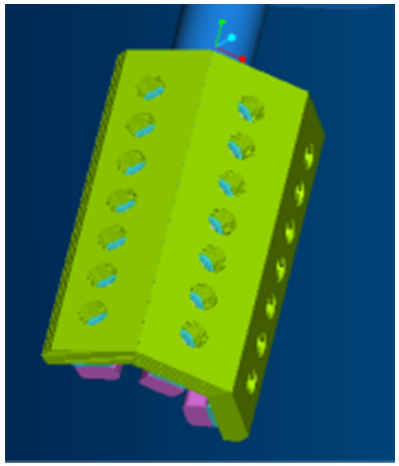
Purposes

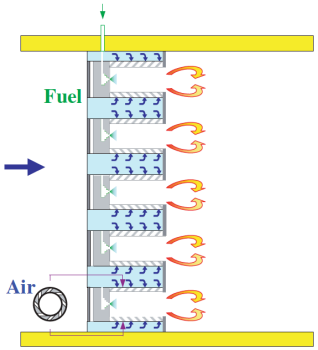
- This study presents NO_x emissions result of Parker's first configuration
- Develop NO_x correlation equations to predict its LTO NO_x emissions.

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)





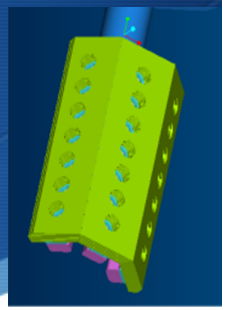


Correlation Methodology

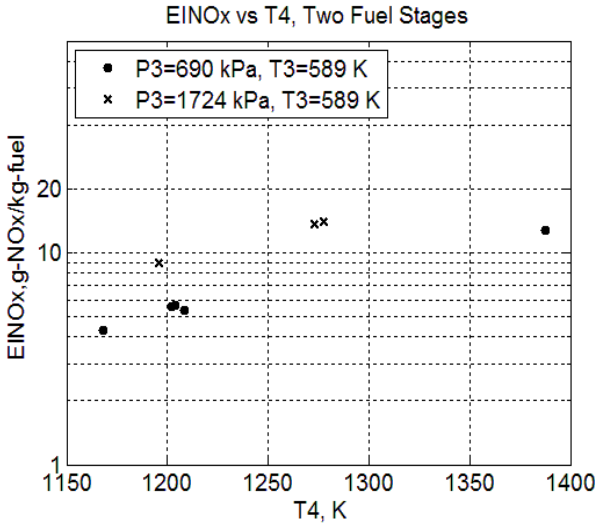
$$EINOx = K * P_3^{N1} * e^{\frac{T_3}{N2}} * \Phi^{N3}$$

- Plot Plotting EINOx vs. Φ, 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.

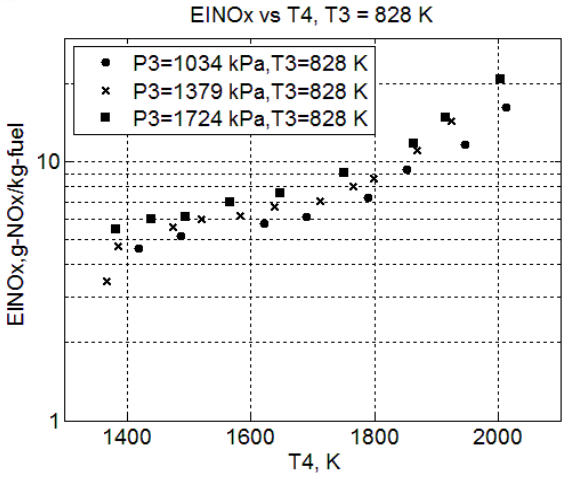
Test Results

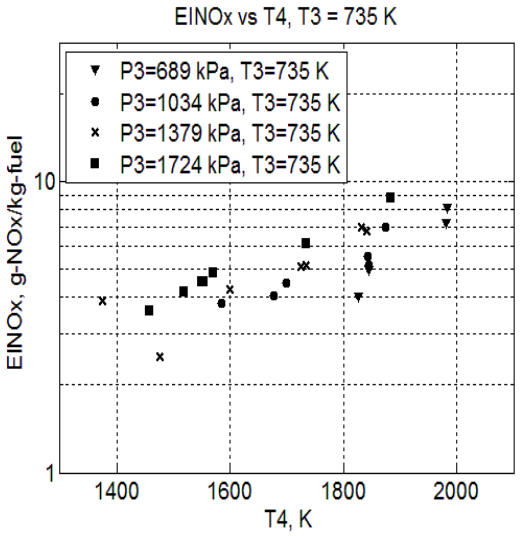


Low Engine Power

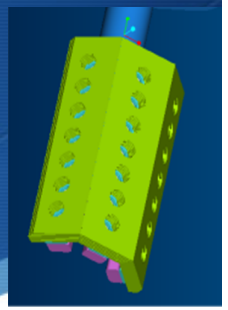


High Engine Power

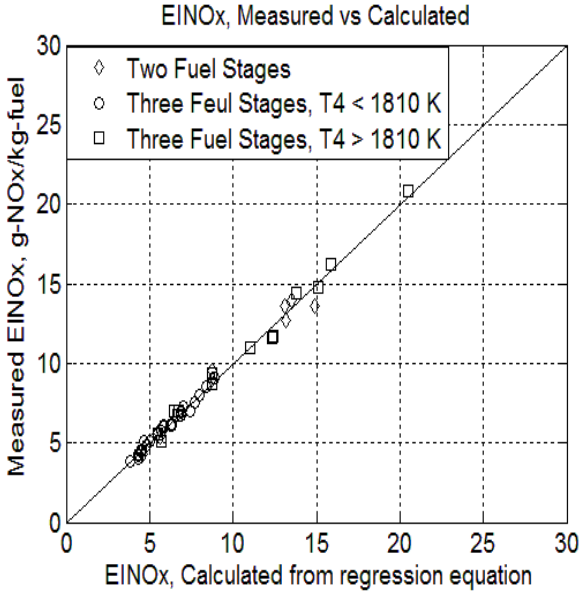


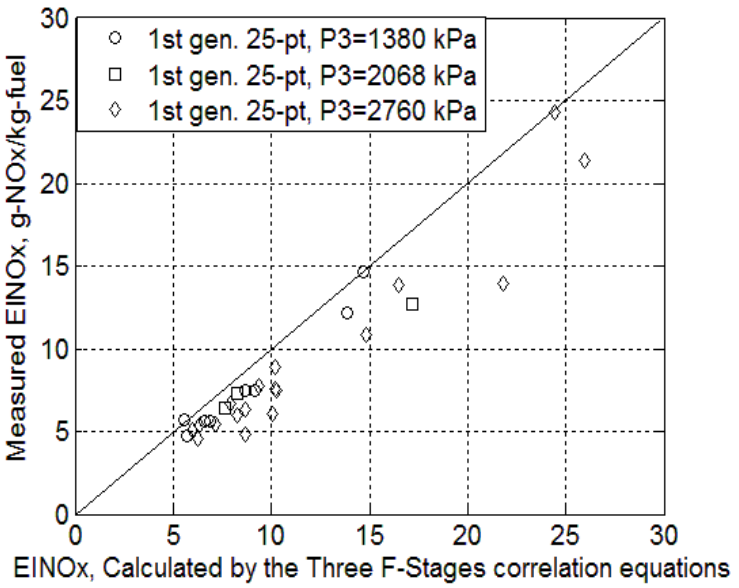


Three NOx Correlation Equations



(1) Two F-Stages	$EINOx = 0.364 * P_3^{0.60} * e^{\frac{T_3}{200}} * \Phi^{3.03}$
(2) Three F-Stages (T4 < 1810 K)	$EINOx = 0.0052 * P_3^{0.46} * e^{\frac{T_3}{170}} * \Phi^{0.97}$
(3) Three F-Stages (T4 > 1810 K)	$EINOx = 0.0058 * P_3^{0.516} * e^{\frac{T_3}{132}} * \Phi^{3.32}$





ICAO LTO NOx Emissions

- 55:1 pressure-ratio engine cycle.
- 37.6 g/kN, 66 % blow ICAO CAEP-6.

Power condition	Cyclic Time (min)	NOx, EI (g/kg)
7%	26	1.68
30%	4	3.57
85%	2.2	24.7
100%	0.7	52.4
Total LTO NOx		37.6 g/kN

Conclusion

- Three NOx correlation equations
- NOx is a strong function of Φ 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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