Emissions Characteristics Study of Conventional and Alternative Aviation Fuels

Intern: Cameron Underwood, University of Maryland, Baltimore County

Co-Participant: Christopher Taylor, Morgan State University

Mentor: Dr. Seong Lee, Morgan State University
Conventional Jet Fuels vs Renewable Biofuels

Purpose: Explore whether biofuels are a suitable replacement to conventional jet fuels while mitigating negative impacts of fuel combustion on environment

Areas of Interest:

- The Combustion Process and Reactions
- Comparing Fuel Properties of Various Fuels
- Emissions Output of Conventional Jet Fuels vs Renewable Biofuels
Research Process

- Read Articles on Fuel Properties, Emissions, Effects of Mixing on Performance
- Collection and Comparison of Fuel Properties

Preparation

- C491 Machine Calibration
- Collection of Fuel Samples

Experimentation

- Testing of Fuels and Analysis of Experiment Results
Combustion Process

Ideal Reaction: \( C_xH_x + O_2 \Rightarrow H_2O + CO_2 \)

Other Significant Reactants:
- \( N_2 \)
- \( H_2S \)
- \( NO \)
- \( C \)

Other Significant Reactions:
- \( N_2(g) + O_2(g) \Rightarrow 2NO(g) \)
- \( 2H_2S(g) + 3O_2(g) \Rightarrow 2SO_2(g) + 2H_2O(l) \)
- \( CH_4(g) + O_2(g) \Rightarrow C(s) + 2H_2O(g) \)
- \( 2C(s) + O_2(g) \Rightarrow 2CO(g) \)
## Comparison of Fuel Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Jet A Fuel</th>
<th>Biofuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>$(\text{@15}^\circ\text{C})$ 775/840 kg/m³</td>
<td>Higher</td>
</tr>
<tr>
<td>Viscosity</td>
<td>$(\text{@-20}^\circ\text{C})$ 8.0 mm/s</td>
<td>Higher</td>
</tr>
<tr>
<td>Freezing Point</td>
<td>-40°C</td>
<td>Lower</td>
</tr>
<tr>
<td>Flash Point</td>
<td>38°C</td>
<td>Varies</td>
</tr>
<tr>
<td>Specific Enthalpy</td>
<td>42.8 MJ/kg</td>
<td>Varies</td>
</tr>
</tbody>
</table>
Experimental Setup

Fig. 4 Enerac 500 Micro Emissions Analyzer

Fig. 5 C491 Combustion Laboratory Unit
Comparison of Emissions: Carbon Monoxide

Jet A requires more oxygen

Focus is on carbon output

Biodiesel produces less carbon monoxide

Biofuels are carbon neutral
Net carbon output is zero
Comparison of Emissions: Nitric Oxide

Average NO emissions are relatively similar.

Neither fuel proves better for environment in terms of NO emissions

Neither fuel produced a measurable amount of NO2

Air is the source of nitrogen. More air more nitric oxide
Impurities in fuel contain traces of sulfur resulting in SO2 emissions during combustion.

Despite restrictions on sulfur content, Jet A still releases significant SO2 emissions.

In contrast biofuels emit less SO2 and don’t incur further refinement costs.
Ignition and Burn Demonstration

B80 (right container) burns visibly cleaner than Jet A (left container)
Biofuels successfully tested and proved to be a suitable replacement for conventional jet fuels while simultaneously producing less harmful emissions. Still, there are some tradeoffs.

Benefits:
- Lower impact on the environment
- Good lubricant for engine parts

Potential Future Work:
- Research on the tradeoffs between emissions and power output
- Fuel efficiency of conventional jet fuels vs biofuels

Problems:
- Poor low temperature fuel flow properties
- Thick biofuels can clog fuel filters and put extra strain on fuel pumps
References and Acknowledgements


MDSGC Program Office Staff (Dr. Henry, Dr. Collinge, Ms. Dillard-Ewing)

Dr. Chen, Morgan State University

Morgan State University CAESECT Lab Staff: Dr. Seong Lee

Xuejun Qian

Moses Chendi

Raghul Kumar

Yulai Yang

Christropher Taylor

Marcial Tienteu
Thanks and Q&A!!!

Research Lab Team Members at Morgan State University