National Aeronautics and Space Administration

Effect of Aromatic Concentration of a Fischer-Tropsch Fuel on Thermal Stability

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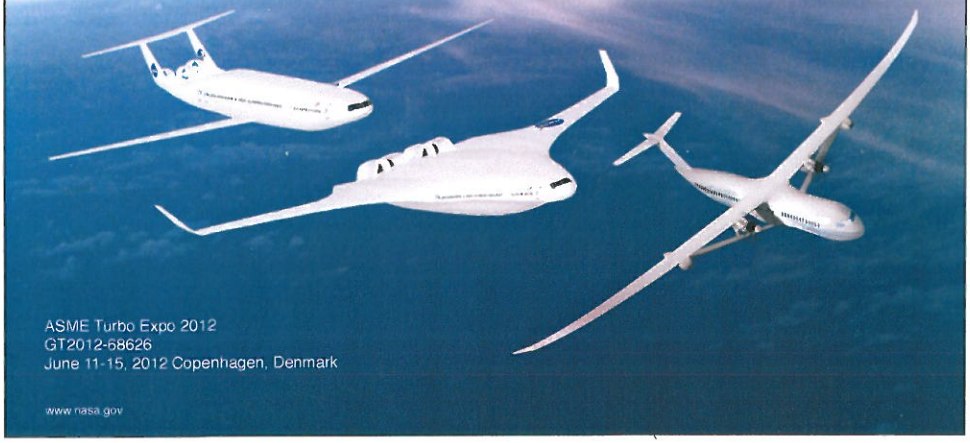

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Background

- ASTM D 7566 (2009)
  - Fischer-Tropsch approved for commercial use as a blend, up to 50% (by volume)
  - Minimum 8% aromatics (by volume)
  - Minimum JFTOT of 325C
- FT fuel is known to have significantly lower particulate matter combustion emissions
- Previous research showed that Fischer-Tropsch fuel has a significantly higher break point temperature than conventional fuel

Motivation for Project

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   - Why was this maximum set?
   - What can we learn about Aromatics in regard to thermal stability?

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2. Aromatics known to improve seal-swell characteristics [1]

Alternative Aviation Fuel Experiment - AAFEX

Location: *NASA Dryden Aircraft Operation Facility*

Dates: *January 20 – February 3, 2009*

Sponsors: *NASA, Air Force, EPA, FAA*

Aircraft: *DC-8 with CFM56-2 engines*

Fuels:
1--Standard JP-8
2-- Fischer-Tropsch Fuel from Natural Gas (FT1)
3--50/50 JP-8/FT1 blend
4-- Fischer-Tropsch fuel from Coal (FT2)
5--50/50 JP-8/FT2 blend

Runtime: *~35 hours total*

Leaks vanished as soon as aromatic-containing fuel introduced

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   - How to increase aromatic content in F-T to solve seal swell problems:
     - Blend F-T fuel with conventional fuel
     - Add synthesized aromatic solution
   - If aromatics are added, will this affect thermal stability?

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3. Aromatics increase engine particulate emissions [1]
   - AFRL -particulate emissions increased with molecular weight and concentration
   - Attributed to increased soot precursors in aromatics
   - Does this mean the presence of aromatics will affect thermal stability?

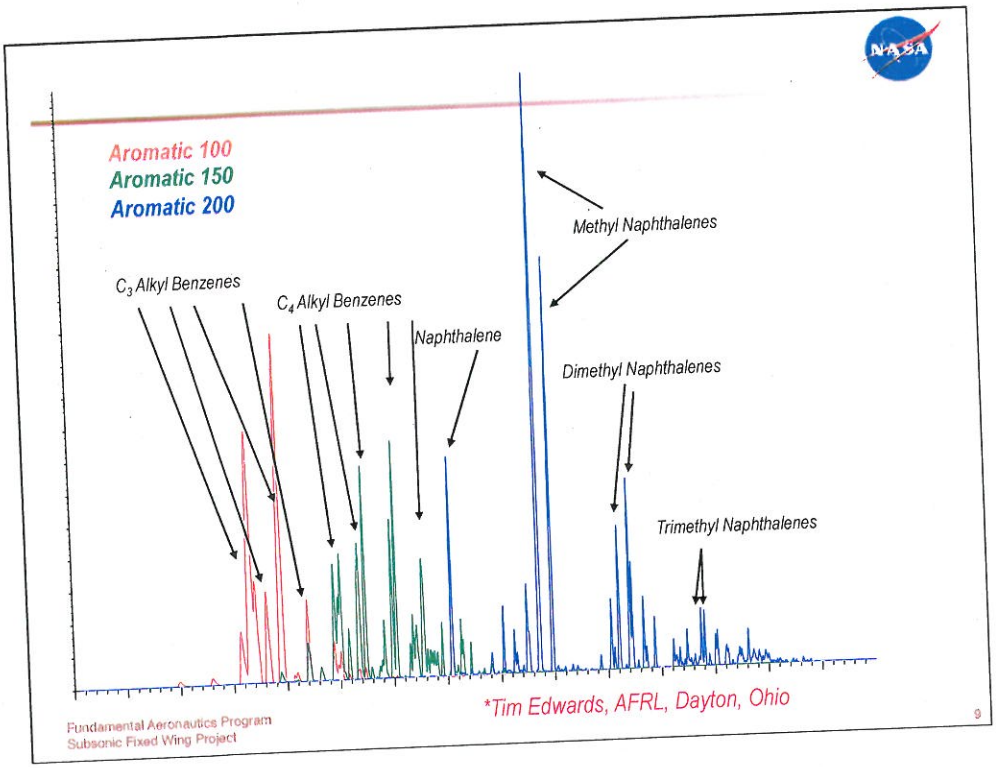
Aromatic Blend Solution & Fuel Blending

- Blend ratios determined to be best representation of jet fuel's aromatic composition
  - 30% Aromatic 100 (POSF 6867)
  - 60% Aromatic 150 (5.2 gallons - 4776, 18.8 gallons 6870)
  - 10% Aromatic 200 (POSF 4777)

Blended by volume at Air Force Research Laboratory

- ***All Aromatic Solutions are available commercially***

- Fuel chosen was manufactured by Rentech
  - Gas to Liquid F-T fuel
  - Colorado pilot plant
  - Natural gas feedstock
- ***All fuel was blended with solution by volume***


Aromatic 100
Aromatic 150
Aromatic 200
Methyl Naphthalenes
C_3 Alkyl Benzenes
C_4 Alkyl Benzenes
Naphthalene
Dimethyl Naphthalenes
Trimethyl Naphthalenes
*Tim Edwards, AFRL, Dayton, Ohio
Fundamental Aeronautics Program
Subsonic Fixed Wing Project
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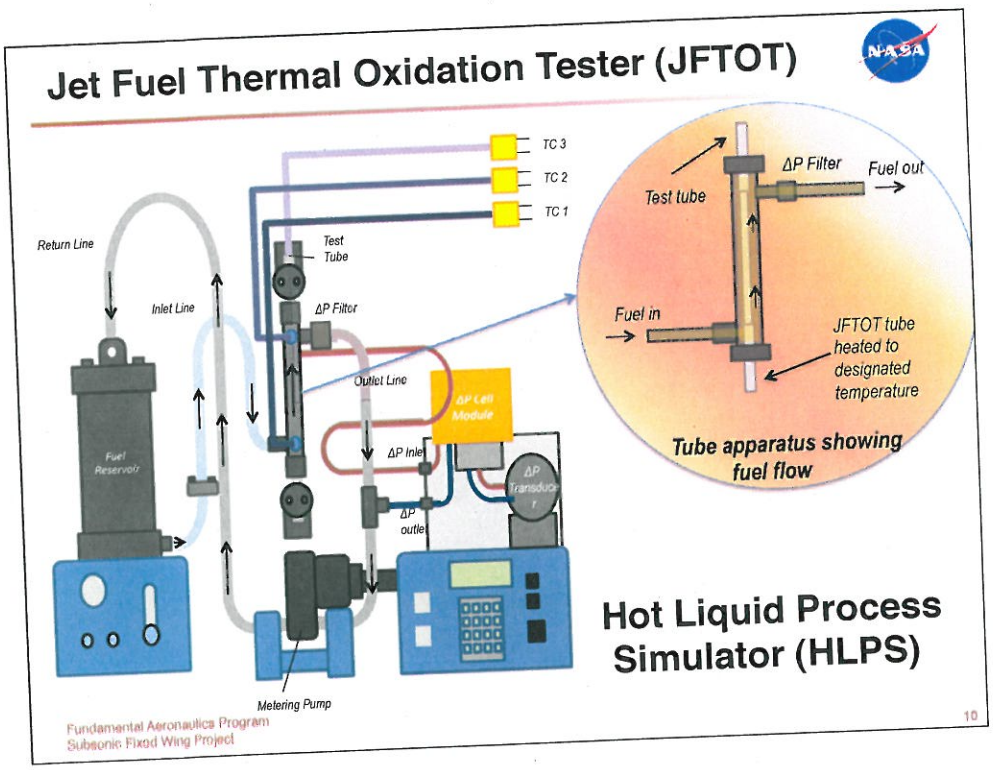
Jet Fuel Thermal Oxidation Tester (JFTOT)
TC 3
TC 2
TC 1
Return Line
Test Tube
Inlet Line
ΔP Filter
Outlet Line
ΔP Cell Module
ΔP Inlet
ΔP outlet
ΔP Transducer
Fuel Reservoir
Metering Pump
Test tube
ΔP Filter
Fuel out
Fuel in
JFTOT tube heated to designated temperature
Tube apparatus showing fuel flow
Hot Liquid Process Simulator (HLPS)
Fundamental Aeronautics Program
Subsonic Fixed Wing Project
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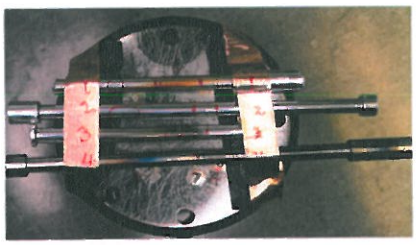
Data Collection & Analysis

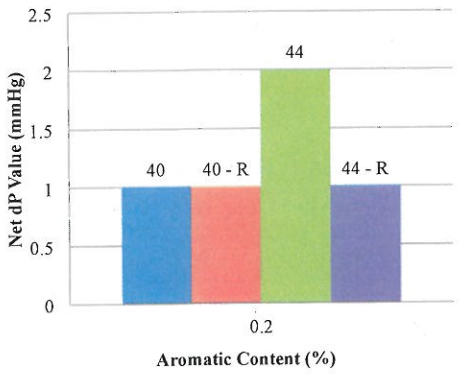
- Evaluation of fuel:
  - Visual tube rating: Fail >3 on ASTM Color Standard
  - Differential pressure fails >25 mmHg
- Fuel breakpoint determined 5°C increments

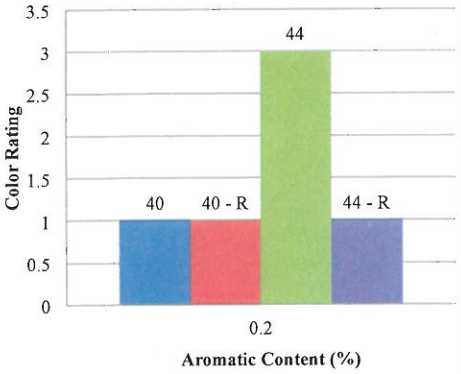


Test Matrix

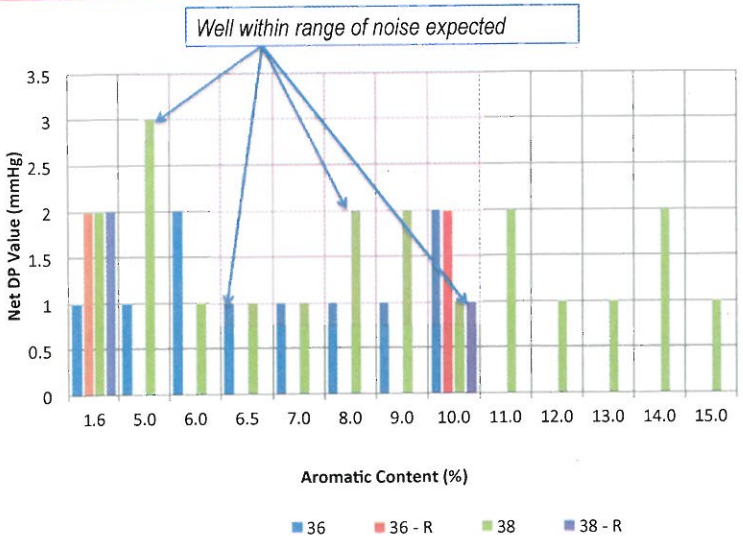
- Neat Rentech Fuel (0.2% Aromatics by volume)
- Neat Rentech Fuel (1.6% Aromatics by volume)
- Rentech Fuel with added aromatic solution
- Rentech with 10% total aromatics break point temperature determination

JFTOT Results @ 380°C for 0.2% Aromatics





JFTOT Results @ 380°C with Increasing Aromatics



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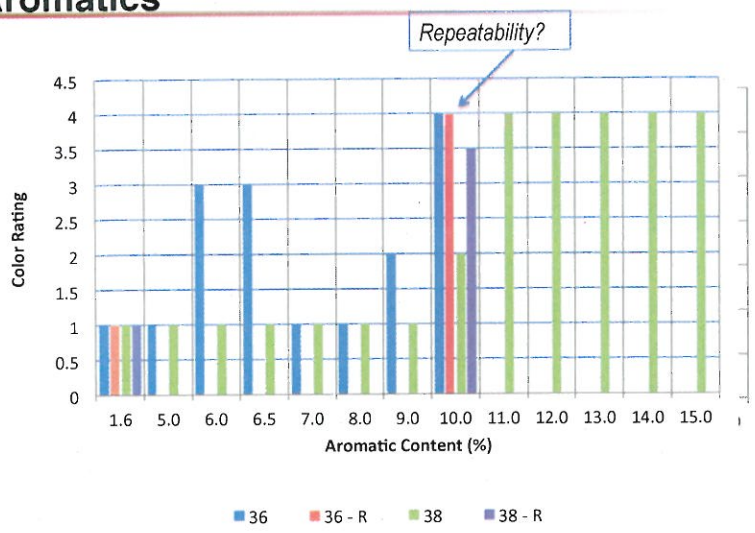

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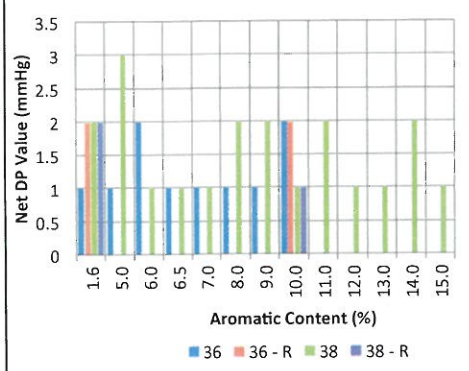
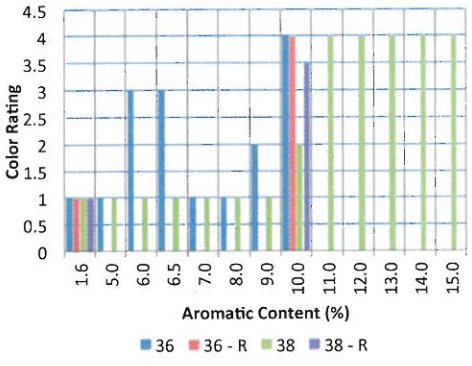
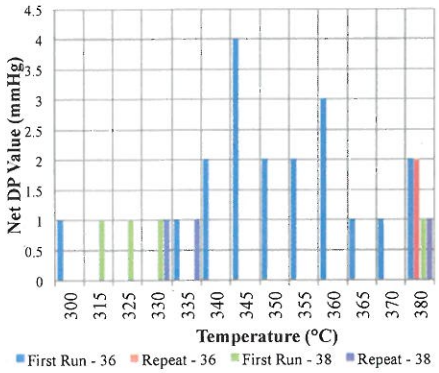
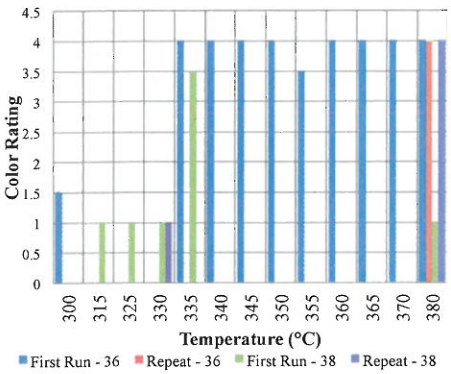




Breakpoint Results for 10% Aromatics





Conclusions & Future Work

- Aromatics affect only the tube color result in JFTOT analysis
- Initial results indicate no affect on thermal stability at up to 10% aromatics (by volume)
- Further research needs to be completed to determine if tube color correlates to more deposition on tube surface
- Run JFTOT @ 380°C on pure Aromatic Solution
- Collect data to determine repeatability
- Validate deposition through use of ellipsometer

Ellipsometer

- Optical method to determine thin film thicknesses
- Polarized light reflects off of surfaces
- Changes in polarization allow calculation to determine material properties (refractive index)
- Very accurate <1 nm resolution
- Standard instrumentation utilized in semiconductor industry with application flexibility