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

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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

1. ASTM 7566 requires maximum 0.5 mass % Aromatics for hydro processed Synthetic Paraffinic Kerosene
   - Why was this maximum set?
   - What can we learn about Aromatics in regard to thermal stability?

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

![ASTM Standard Color Code]

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

Well within range of noise expected
JFTOT Results @ 380°C with Increasing Aromatics

Repeatability?
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