Alfa-Bird: Alternative Fuels and Biofuels for Aircraft Development

Definition of the final alternative fuels matrix

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INTRODUCTION

Air traffic has been steadily increasing for the last years. Moreover, fuel availability at a reasonable cost seems more and more uncertain. Climate change implies that greenhouse gases emissions should be reduced. In this context, the search for new alternative fuels for aircraft seems to be a promising solution. Nevertheless, aeronautic represents a very specific transportation mode, due to its usage (short range, middle range, long range with the same fuel, worldwide distribution of the fuel...) and its compulsory security constraints.

In the first part of ALFA-BIRD project, a first matrix of 12 interesting alternative fuels has been defined. In this second part, IFP Energies nouvelles has worked with DLR (Germany) and Shell (UK) to select the 4 best candidates to become the fuels for the future of aircraft.

Evaluation of 12 interesting blends

1. Selection of 12 blends

- Blends of synthetic fuels with novel organic components and bio-derived components, currently outside Jet fuel specification compositional boundaries
- Fuel matrix built around three axes:
  - Paraffinic compounds → FRL 7-9
  - Naphthenic compounds → FRL 3
  - Oxygenated compounds → FRL 1

FRL = Fuel readiness level, a measure of the fuel's progress towards full commercialization

2. Analysis of 12 blends

Based on standard characterization (ASTM D7566, for finished Jet A-1 and 100% SPK)

This first phase of analysis was conducted by Shell.

FSJF
FT - SPK
FT-SPK + 50% Naphthenic cut
FT-SPK + 20% Hexanol
FT-SPK + 10% Furane
FT-SPK + 20% Furane
FT-SPK + 30% Furane
FT-SPK + 10% FAE
FT-SPK + 20% FAE
FT-SPK + 30% FAE
FT-SPK + 50% HVO
FT-SPK + 75% HVO

Reference fuel: FSJF from Sasol → FRL 7-9

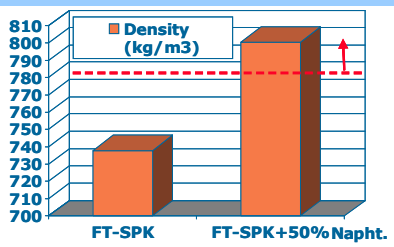
- 50% FT-SPK + 50% of severely hydrogenated coal tar kerosene → Well-defined composition
- Less variability compare to Jet A-1/JetA
- Study in a long-term view
- Coherence with projects (SWAFEA, CAAFI)
- Only one to pass JetA-1 requirements

Base fuel: FT-SPK, GtL from Shell → FRL 7-9

- Availability of this product
- Coherence with projects (SWAFEA, CAAFI)
- Tested neat to clearly identify the fuel impact
- Meets Table A-1 SPK requirements (ASTM D7566)

The naphthenic compounds → FRL 3

- Produced from direct liquefaction of coal (nowadays) or of biomass in the future.
- Some characteristics suitable for jet fuel use:
  - Good cold flow properties and energy content in volume
  - Some elements are still to be checked like the behavior in combustion, the pollutant emissions, and the material compatibility
- Effect of adding naphthenic cut to FT-SPK → bring the FT-SPK blend into the Jet A-1 specification limits (ASTM D7566) in terms of:
  - Minimum aromatics contain (8% in volume by IP 156)
  - Density (775 kg/m3 as a minimum by IP 365)



Important to explore the potential of this product in more detailed tests

The oxygenated compounds → FRL 1

1. FAE (Fatty Acids Esters)

- Used as blending components for diesel fuel → high availability, well-known process, large production investments
- Esters properties depend on starting material: different numbers of C atoms and varying degrees of unsaturation → choice for jet fuels use
- FAE had most deleterious effect on total acid number (TAN)
- Limiting areas for blends: high viscosity, freeze point, corrosion...

2. Furans

- Produced from carbohydrate found in lignocellulosic biomass, in sugar beet and in sugar beet pulp. Process in the early stages of development.
- In spite of a high density, the cold flow properties as well as the boiling and the flash point of this kind of molecule are in the range of a Jet fuel.
- TAN fundamental problem

3. Alcohols

- Production by fermentation → ethanol & butanol available
- To fit with specified jet fuel properties (such as energy density, flash point or water solubility)
  - Need to use other alcohol (meaning higher carbon number) instead of ethanol because some of these drawbacks can be overcome
  - Some properties are more or less proportional to the carbon chain length
- Need to find production pathways for alcohols like hexanol
- Hexanol passed all other SPK properties that were tested, except C and H minimum content and corrected measured heat combustion

Choice of Alfa-Bird : FT-SPK + 20% hexanol

Conclusion and prospects: Selection of 4 fuels for SP2 tests

- The four fuels proposed for the tests (ignition, combustion, evaporation...) in the 2nd part of the project are:
  - FSJF → FRL 7-9
  - FT-SPK → FRL 7-9
  - FT-SPK + naphthenic cut (50%) → FRL 3
  - FT-SPK + hexanol (20%) → FRL 1

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