An Overview of Sasol’s Jet Fuel Journey

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Forum 12: New Refinery Technologies to Meet Feedstock Flexibility, Transportation Fuel Demand and Quality
Presentation Overview

- Background to the introduction of synthetic jet fuel
- Qualification of a semi-synthetic jet fuel as Jet A-1 for use as commercial aviation turbine fuel
- Qualification of fully synthetic jet fuel for commercial use
- Qualification of GTL kerosene as semi-synthetic jet fuel component for commercial use
- Alternative jet fuels in the future
- Further research
- Conclusions
Background to the introduction of synthetic jet fuel

Air traffic to South Africa had increased by ~10% per year since 1994. Only two sources of jet fuel for O.R. Tambo International Airport (ORTIA) in Johannesburg:

- Sasol / Total Natref refinery (Volume constrained)
- Coastal refineries (BP, Shell, Engen) in Durban (Logistics constrained)

Projections indicated that, by 1999, market demand for jet fuel would have exceeded available supply (without interventions). An alternative inland source of jet fuel was required.

The original driving force: Security of supply in South Africa.
Current drivers for alternative jet fuels

New Jet Fuels required that will:

- Reduce emissions that impact global climate change
- Expand and diversify energy supplies
- Be produced in large volumes without adverse impacts on land and water resources
- Act as drop-in replacement fuels for conventional Jet fuel
- Be cheap enough to burn!

Synthesized Paraffinic Kerosene from FT process
Jet Fuel – a conservative industry

- For Safety reasons the quality of Jet Fuel is internationally governed by the Joint Checklist
- The Joint Checklist is a combination of the most stringent Jet Fuel specifications:
  - British Ministry of Defence Standard DEF STAN 91-91
  - ASTM Standard Specification D1655 for Aviation Turbine Fuel
Sasol’s synthetic fuel technologies

Coal or Biomass → Gasification

Natural gas → Reforming

CO + H₂ → Synthesis gas → LTFT (220°C, 20 bar) → Diesel (15-20%), Kerosene (15-20%), Chemicals (20-50%), Polymers/Plastics

HTFT (340°C, 25 bar) → LPG (5%), Gasoline (30-40%), Kerosene (15-20%), Diesel (15-20%), Chemicals (20-50%), Polymers/Plastics
Sasol’s Synthetic Jet Fuel Journey

- **Crude oil based Jet-A1 (Natref)** (1976)
- **Semi-synthetic coal based jet fuel** (February 1999)
- **Fully synthetic coal based jet fuel, HT-FT** (April 2008)
- **Generic semi-synthetic jet fuel** (September 2009)
- **Generic fully synthetic jet fuel (future)**
Semi-Synthetic Jet Fuel

1991  First visit to the ASTM by Sasol
1996  Discussions started with ASTM and other parties
       Independent technical experts contracted: SwRI and Cliff Moses
       Extensive test work in SA and the USA
1997  Final Report (SwRI 8531) submitted
1998  Aviation Fuels Committee approval
1999  First batch of 50% synthetic blend certified at Natref
       Semi-synthetic jet fuel included in UK Defence Standard 91-91, Issue 3
1999 - 2009 Only alternative Jet A-1 in commercial use
2010  Approval of Heavy Naphtha as SSJF component
2011  Approval of SPK with aromatics as SSJF component
Fully Synthetic Jet Fuel (FSJF)

2001  Qualification test work started

2003  Final Report submitted to AFC requesting acceptance of fully synthetic jet fuel as Jet A-1 under DEF STAN 91-91

2006  Final series of Engine Tests (endurance) and Combustor rig tests (emissions, cold start)

2007  Further high-altitude re-light tests and tests on APU

2008  Qualification process completed with final qualification obtained with publication of DEFSTAN 91-91, Issue 6, on 8 April 2008

2009  Production and certification of 173 000 liters of FSJF for PR & marketing purposes

2010  First commercial flights in the world on 100% FSJF, 21 September 2010
Approval is a very slow process

Sasol pioneered this protocol
Engine Tests with Commercial Turbines

- US Navy: T700 engine test
- SAA Technical: JT-9D engine endurance test
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Additional fully synthetic jet fuel specifications:

- 8% minimum aromatics specification
- High altitude relight tests by Rolls-Royce caused concern from OEM’s
- Believed to be due to flat distillation curve of FSJF
- Thus T50 – T10 ≥ 20°C and T90 – T10 ≥ 40°C specification requirements introduced for FSJF in DEFSTAN 91-91 (Issue 6)

Turbine Fuel, Aviation Kerosine Type, Jet A-1
NATO Code: F-35
Joint Service Designation: AVTUR

IMPLEMENTATION DATE: 8 July 2008
GTL Kerosene as a Synthetic Jet Fuel

2007
Oryx-GTL in Qatar: Joint venture between Sasol and Qatar Petroleum producing LPG, Diesel and Naphtha

2009
Qualification of generic GTL kerosene as semi-synthetic jet fuel component

Future
Gas to Liquids derived fully synthetic jet fuel (GTL) - aromatics, or not?
Alternative jet fuels in the future

Not much scope for special fuels in the global aviation industry.

- Long lifetime and high capital cost of aircraft - kerosene will be the jet fuel for next 30 years.

- Focus on safety means lead times for fuel or additive development are long (~10 years).

- Airlines don’t like aircraft that need special fuel.

- Little incentive for OEMs to develop aircraft/engines running on a special high performance or alternative fuel.

- Local alternative fuel solutions (e.g. biofuels) common in ground transportation fuels are not applicable to general aviation.

- Hydrogen would need completely new aircraft and infrastructure.

- FT Jet fuel is the first demonstrated drop-in fuel.
Further research

T63 research engine at Sasol’s Research Facility at UCT

Laminar Flame Speed Measurement Rig
Further research
Combustor test rig
Conclusions

- Over a period of 20 years Sasol followed an extensive and comprehensive route for the qualification of firstly semi-synthetic and later fully synthetic jet fuel – engaging all international stakeholders and pioneering the process protocol.

- Sasol has more than 10 years’ experience of commercially producing and marketing semi-synthetic jet fuel.

- The qualification process for fully synthetic jet fuel was finalized with the approval obtained in April 2008 with publication of DEFSTAN 91-91, Issue 6.

- First successful flights were undertaken in September 2010.

- Generic GTL approval (valid around the globe) contained in ASTM D7566 (September 2009).

- The responsible route that Sasol followed was seen as the benchmark for newcomers (e.g. the Bio Industry – HEFA approval on 5 July 2011).

- Sasol’s synthetic Jet Fuel is the only alternative fuel that has been approved for commercial use in neat form.
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Paul Morgan is the Manager of the Fuels Technology Function in Sasol Technology. He has a Bachelor of Science (Honours) degree in chemistry, a Master of Science degree in chemical engineering and a MBA. He started his career as a scientist in 1989 at Sasol Technology Research and Development in the Coal and Gasification Research department. He then moved to Sasol Oil’s Fuels Research team in 1992 where he was involved in lubricants and fuels R&D. He was appointed in 2000 as Manager of Coal Research and then later became Manager, Applied Research. He returned to Fuels Research in 2006 as Manager of the department and was appointed as Manager of Fuels Technology in 2008. He is currently accountable for the quality and performance of all Sasol’s fuels, lubricants, fuel oils and road binding materials in the market and for research and development on these products.