Paving the way for GTL products in international markets

Paul Morgan  January 2013
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The Sasol Chevron name and the associated symbol are proprietary to Sasol Chevron Holdings Limited, and use herein does not necessarily imply any endorsement by Sasol Chevron.
The Sasol Slurry Phase Distillate™ process has three steps:

- reforming natural gas with oxygen and steam to produce syngas
- converting syngas into long-chain waxy hydrocarbons
- selectively cracking the waxy hydrocarbons to produce GTL diesel and related products
Gas to Liquids Diesel
GTL diesel properties:

- ultra low sulphur (<5 ppm)
- paraffinic diesel with near zero aromatics and poly-aromatics
- very high cetane (> 70)
- colourless
- lower tailpipe emissions, especially particulate matter
- low density (~0.77 kg/l)
- reduced injector fouling
GTL diesel has an emissions improvement effect relative to refinery diesel and this effect is also visible in blends of GTL with refinery diesel.
GTL diesel product application opportunities

1. Blend component to upgrade diesel
2. Premium fuel
3. Niche market fuel (fleets, mines, etc.)
4. The future: Optimized GTL diesel engine
Sasol was the first to bring commercial GTL diesel produced using low temperature hydrocarbon synthesis to market on a large scale and thus required:

- absolute confidence in performance and fit-for-purpose nature of the product (neat and blends)
- a large number of evaluations have been completed:
  - Laboratory chemical property evaluations
  - engine bench and vehicle evaluations – emissions and performance
  - engine bench durability tests
  - **ultimate test is on road application**
ORYX GTL diesel is fit for purpose in its neat form and in blends.
The ultimate test of neat GTL diesel is on the road.

2 SUV's
>350,000 km
~3,200 litres

10 buses
>295,000 km
>126,000 litres

14 busses
~173,000 km
~54,000 litres

2 cars
>35,000 km
~3,200 litres

1 car
>40,000 km
>2,400 litres

1 SUV
~11,000 km
~1,400 litres

Totals
30 vehicles
~905,000 km
~226,000 litres

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Passenger car trials – 75 000 km’s

- no fuel related issues during trials
- visible combustion chamber and injector deposits comparable between conventional diesel and GTL diesel
- oil condition monitoring indicated reduced wear with GTL diesel
- emissions tests at completion of trials show GTL diesel use results in emissions benefits
Bus fleet trials – 468 000 km’s

- no fuel related concerns
- significant oil condition and wear benefits
  - near zero levels of sulphur and aromatics result in:
    - reduced soot loading and possibly smaller particulate size
    - reduced acidic products entering lubricant
- no visible engine wear
- exhaust smoke benefit with GTL diesel maintained throughout trial
- injector tip deposits reduced with GTL diesel
- ~3% increase in volumetric fuel consumption
- slight measured power reduction – not perceptible to regular drivers
Three year long term SUV trial – 350 000 km’s

- no fuel related concerns
- oil condition monitoring showed:
  - lubricant soot loading very low
  - no indication of abnormal wear
  - oil condition remained well within limits for all drain intervals
Three year long term SUV trial (continued)

- no negative visible effect on exhaust aftertreatment devices
- post trial component evaluations:
  - high pressure fuel pumps and injectors successfully passed functional testing - no significant wear
  - fuel injectors flow rates within tolerance, and fouling as expected for mileage completed
Trans African expedition – 11,000 km’s

The GTL Challenge:
- SUV operated on GTL diesel
- GTL diesel ex pilot plant
- 46 days
- 11,000 km
- 1,400 litres GTL diesel

“a symbolic passage of the technology across Africa, from where it was developed, to Qatar, where it has been taken to the next stage of commercial development”
Trans African expedition (continued)

Conclusions

- no fuel related concerns
- noticeably less oil sooting relative to accompanying vehicles operated on conventional diesel fuel
GTL diesel has been thoroughly evaluated in actual on road applications as a neat fuel

- in 30 vehicles ranging from passenger cars to heavy duty buses
- > 900,000 km on neat GTL diesel and many more on blended fuels and comparative reference fuels
- > 225,000 litres of neat GTL diesel consumed
- thorough and detailed investigations have shown the superior properties of GTL diesel
Achieving the optimum from fuel and vehicle

Project demonstrated:

- The favourable exhaust emission characteristics of GTL diesel in neat and blended form
- That there is significant additional potential with a simple vehicle software recalibration
- That GTL diesel fuel can enable very cost-efficient compliance with future exhaust emissions specification requirements

Project emission targets were achieved without compromising maximum power or energy efficiency.
**Blending of GTL diesel with biodiesel (FAME)**

- Density increased linearly with FAME addition
- FAME/GTL diesel blends were more stable than FAME/EN590 blends in the Rancimat test
- FAME addition had a small negative effect on the cold flow properties of the blend (1 deg C increase in CFPP at 10% FAME addition)
- Addition of as little as 0.5% FAME resulted in SL-BOCLE performance of >3500g
- Properties of the GTL diesel blends like the sulphur content, copper corrosion and ash content were unaffected by the addition of FAME
- Injector fouling test results: cleanliness improvement when neat GTL diesel is compared to EN590 diesel. Further improvement was found with FAME/GTL diesel blends (not seen for FAME/EN590 diesel blends).
- FAME/GTL diesel blends were shown to result in less fuel (oil) dilution than the corresponding FAME/EN590 blends

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Gas to Liquids Jet Fuel
Sasol’s synthetic fuel technologies

Gasification

Coal or Biomass → Syngas gas (CO + H₂) → High Temperature Hydrocarbon synthesis (340°C, 25 bar) → LPG (5%) → Gasoline (30-40%) → Kerosene (15-20%) → Diesel (15-20%) → Chemicals (20-50%)

Reforming

Natural gas → Syngas gas (CO + H₂) → Low Temperature Hydrocarbon Synthesis (220°C, 20 bar) → LPG (0-5%) → Naphtha (15-25%) → Kerosene (25-40%) → Diesel (30-50%) → Lubricants, Waxes (0-30%)
The synthetic jet fuel journey led by Sasol

- Crude oil based Jet-A1 (Since 1944)
- Semi-synthetic coal based jet fuel approved (February 1999)
- Fully synthetic coal based jet fuel approved (April 2008)
- Generic GTL semi-synthetic jet fuel (September 2009)
- Blends of Bio derived and GTL jet fuel (future)
- Generic GTL fully synthetic jet fuel (future?)
Approval is understandably a very slow process

Sasol pioneered this protocol (now ASTM D4054) with CTL derived jet fuel
Engine Tests with Commercial Turbines

- **US Navy: T700 engine test**
- **SAA Technical: JT-9D engine endurance test**
GTL jet fuel blends now part of the specifications

Ministry of Defence
Defence Standard 91-91

D.3 Generic Synthetic Paraffinic Kerosine


D.3.1.1 Synthetic Paraffinic Kerosine certified as meeting the requirements of ASTM D7566 Annex A-1 may be used as a blending component in Aviation Turbine Fuels meeting the requirements of this standard at up to 50% by volume. The originator’s Certificate of Quality must be available and be quoted as part of the reporting requirements in Table 1 of this specification.

D.3.1.2 From the point of manufacture to the point of blending to meet this specification, the synthetic blend component shall be handled and transported in the same manner as finished jet fuel in order to maintain product integrity. In particular the restrictions of Clause 5.5 and Annex G, paragraphs G3 and G4 must be observed.

D.3.1.3 The aromatic content of the semi-synthetic Aviation Turbine Fuel shall not be less than 8.0% nor greater than 25.0% by volume when using method IP156, or not less than 8.4% nor greater than 26.5% by volume when using method IP436.
Sasol’s jet fuel story in summary...

- 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 13 years’ experience of commercially producing and marketing semi-synthetic jet fuel.
- Sasol’s fully synthetic jet fuel was approved in April 2008 with the publication of DEFSTAN 91-91, Issue 6.
- First passenger flights on Sasol’s fully synthetic jet fuel in September 2010.
- Generic GTL approval 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 a neat form.
Further research
Sasol has paved the way for the introduction of GTL fuels in international markets

- GTL diesel has been thoroughly tested in neat form and in blends.
- It has been tested in the chemistry laboratory, in a variety of engines in test cells and extensively in vehicles on the road.
- These thorough and detailed investigations have shown the superior properties of GTL diesel to the world in over 100 research publications and presentations.
- Sasol has led the way in gaining international approval for fully synthetic jet fuel – the only fully synthetic alternative jet fuel.
- Approval for semi synthetic GTL jet fuel is now contained in ASTM D7566.
- Extensive research and testing has shown GTL jet fuel and diesel to be superior products.
Questions