**Notes on Lecture to Loughborough RAeS Branch 24th January 2012**

**Bio Jet Fuel in the Aerospace Industry**
By Chris Lewis, Fuel Specialist, Rolls-Royce plc

Notes by Frank Chambers

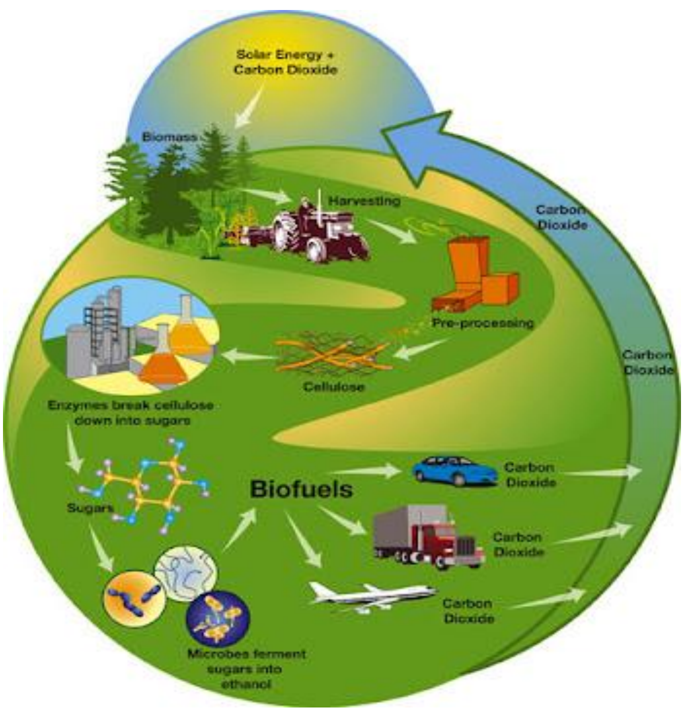
## 1. Introduction

Chris has 30 years experience of working with jet fuels and he began his talk by introducing three key requirements of modern bio jet fuel –

- Suitability – does the fuel have the correct energy density and chemical composition for use with modern gas turbines?
- Sustainability – Is the biofuel production process truly beneficial in terms of reduced $CO_2$ emission and carbon footprint when compared with the established refining process? Does production of the bio fuel crop significantly change local land and water usage or significantly affect food crop yields?
- Production Capability – can the bio process produce sufficient yields on an industrial scale, and does the finished product meet the requirements of modern jet turbine engines

## 2. Sustainability

Chris introduced the group the concept of closed and open loop fuel life cycles, where the bio fuel production represented a closed loop system whereby carbon emissions produced by jet fuel consumption is balanced by $CO_2$ re-uptake by the feed stock used to produce the fuel itself. Current methods of fuel production, based on refining crude oil, represent an open loop life cycle whereby $CO_2$ produced by fuel burn is not removed from the atmosphere by any step in the refining process.




*An illustration of the closed loop biofuel cycle*

Chris emphasised that the impact of biofuel feedstock production on the local environment must be carefully evaluated. Careful study of the source crop and its yield, the resources required to produce the fuel, its effect on the local economy and local community impact (especially the potential effect on local food production) is required in order to assess the true sustainability of the product.

*Romania aims to provide a bio fuel which is sourced from a plant called Camelina, a plant from the Brassicaceae family.*

**3. Suitability – The Technical Requirements**

Chris highlighted that the technical requirements of aviation fuel will become increasingly stringent as engine design advances. Modern jet fuel can be regarded as a “multifunctional fluid providing energy storage (high energy density is required for good range and payload), acting as an airframe and engine as well as providing fuel for combustion.

The physico-chemical properties of any modern fuel are of prime importance, they must be capable of satisfactory performance over a wide temperature range (-47°C freeze point to 38°c flash point) and have good thermal stability for heat management. The high heat environment of modern engines places greater demands on fuel stability, for example, any chemical degradation of fuel components resulting in the formation of waxes or lacquers can lead to injector blockages. Also Modern engines and the advanced materials and alloys used in their construction are very sensitive to fuel composition.

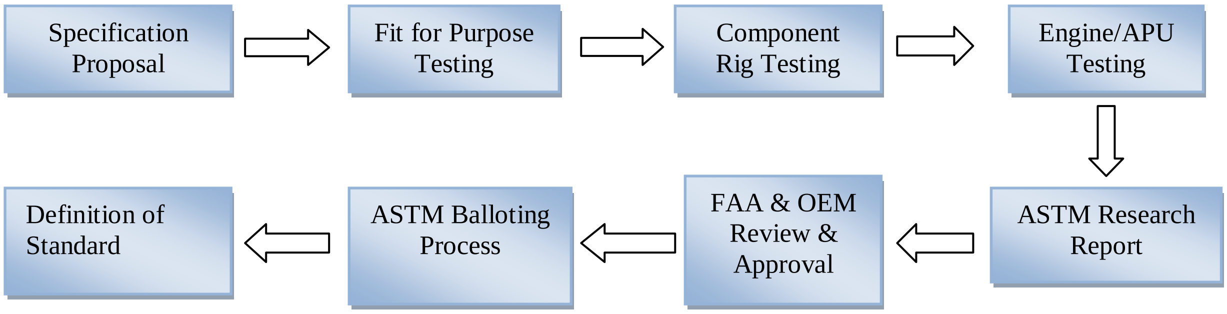
Above all else the main consideration when developing biofuel alternatives to refined kerosene is safety.

Certification of Biofuel Alternatives (ASTM D4054)

Any new aviation fuel, whether from a sustainable source or not, must meet engine certification requirements and match the appropriate quality specification to be considered fit for purpose. A typical fuel specification includes –

- A clearly defined chemical composition
- Properties and performance
- Defined allowable source materials and processes
- Appropriate Quality Assurance measures

To be viable, any new jet biofuel has to be deemed to be “drop-in” i.e. match the specification of standard refined kerosene closely enough to be considered identical. Given that there are often significant differences in the composition of bio sourced “kerosene” compared to normal refined kerosene this presents a significant technical challenge. There are three phases to development of a suitable biofuel, the R&D phase, certification and qualification phase and finally the business phase. All new fuels have to be evaluated against the requirements of ASTM D4054.




*Industry Qualification Process ASTM D4054*

In addition to this process, Rolls Royce conduct their own review to ensure that all submitted data satisfies an internal QA check, and this data must satisfy the requirements of this process before Rolls Royce can approve a new fuel in the ASTM process.

Fuel Composition

Chris outlined the importance of the chemical composition of the fuel, and how its constituents can affect key operating parameters like freeze point, fuel density and compatibility with materials and elastomers used in modern gas turbines.

Synthetic paraffinic Kerosenes - like biofuels or coal to liquid refining via the Fisher-Tropsch processes (SASOL South Africa) - have a high concentration of straight chain paraffin’s relative to refined kerosene, which tend to be rich in “napthas” and aromatics such as benzene. These differences often lead to differences in elastomer swelling (causing seal integrity problems) even though synthetic paraffinic kerosene have high fuel energy content.

**4. Production Capability -Biofuel Feedstocks**

The talk highlighted the diversity in source feedstocks for production of biofuels, covering both current (eg plant/nut derivatives) and future feedstock sources like switch grass, sugar and forest waste. The key reason for such diversity in source material is down to regional differences in crop/plant poduction. Chris put the supply issue into perspective by pointing out that in order to achieve a 50% reduction in $CO_2$ production by 2050, 14 billion barrels of bio kerosene will be required. Current production runs at less than 1 billion, and the challenge presented by the need to produce the required yield of biofuel by 2050 is clear. The magnitude of this challenge justifies the diversity in the study of new source feedstocks eg from plant algae.

**5. The Future**

It is clear that research into finding suitable biofuel derivatives will continues. In addition to the quest to find a diversity of source feedstocks to satisfy future demand for bio kerosene, the push to design more efficient gas turbines and improvements in air traffic management will also contribute to more efficient use of jetfuels in the future. Rolls Royce play an active role in alternative fuel programmes, forging links with both the oil industry and academia

(Sheffield University Technical Centre). Rolls Royce participated in the first Gas to Liquid Kerosene flights which took place in 2008, and more recently the second generation biofuel transcontinental flight of 2009 with Air New Zealand.


*The second generation biofuel flight took place in 2009 in which an Air New Zealand Boeing 747 undertook a transcontinental flight with one of its four RR Trent engines using biofuel*

**6. In Conclusion**

Chris gave the RAeS Loughborough branch an entertaining and highly informative talk on the complex challenge of producing sustainable biofuel. He made it clear that it is not just a question of finding suitable feedstock for refining the fuel; the true sustainability of the biofuel cycle must be considered, along with the socio-economic impact of giving over land to feedstock production. Add to this the technical challenge of producing biofuel blends that are compatible with modern gas turbine engines and it is clear that much more research and development is required before we can achieve the target of a 50% reduction in $CO_2$ emissions from jet fuels by 2050.