IS IT TIME TO CHANGE?

John Bristow of Deluxe Materials describes the development of an environmentally friendly gas turbine oil

words & photos » John Bristow

This story starts with Colin Straus at Ripmax (Deluxe Materials distributor). For several years he has asked me to design a dedicated model turbine oil that would be free of organo-phosphate in the emissions. As chemists and modellers we felt we had the ability to do this. Moreover, it would be a contribution to the model turbine industry. It might also protect the hobby and the health of modellers.

WHY DO IT?

We needed to formulate a new product for a number of reasons.

Full size turbine oils are hydraulic oils and are not meant to be burned. As they lubricate gear boxes they contain phosphorus anti-wear additives which are potentially harmful in vapour form. There is a history of organo-phosphates causing health concerns to airline industry employees.

Two stroke oils don't do the job as they do not have sufficient high temperature performance. There are also reports of them causing excessive carbon build up in the combustion chamber and sticky bearings that would inhibit start up from cold.

What was lacking was an oil of the right quality that the manufacturers could rely on and whose formulation would be consistent throughout the world.

Some chemical analysis confirmed that some full size turbine oils and indeed some products marketed for model use also contain phosphorus (Fig.1). Two stroke oils perform badly when subjected to high temperature tests.

PERFORMANCE TARGETS

So in discussions with manufacturers and top modellers, including Dave Wilshere and many others, we set ourselves the following objectives:

1. No harmful additives.
2. Soluble and readily miscible with kerosine and diesel fuels.
3. Provide visibility of mixing.
4. Clean burning base fluid capable of withstanding 300 deg C.
5. Turbine manufacturers written approvals.

WHY SYNTHETIC?

Fig.2 shows the flash points of mineral and synthetic lubricants. As you can see only synthetic materials will give flash points in the 200 deg C range. Mineral oils simply will not survive at temperatures which may be as high as 300 deg C found in the turbine bearings on shutdown. Mineral oils also evaporate rapidly.

From a study of synthetic fluid technology we identified a family of clean- burning, brand new synthetic materials which have strong environmental benefits, being highly pure and free of aromatics. From these we selected a product with very low volatility to match even the best mil-spec full size turbine oils from the top manufacturers. This same technology also finds its way into the formulation of cosmetics and use with food preparation equipment - that's how pure it is.

A study of oxidation inhibitors to stabilise the synthetic fluid was next and we chose 732, which gave an outstanding low temperature and high temperature performance right up to our target of 300 degrees centigrade (Fig.3).

The interesting thing came next. The 732 was not readily compatible with the base fluid, as you can see in Fig.7 and some adjustments were necessary in order to improve solubility of this additive.

High temperature oven tests where the oil is exposed to over 210 degrees centigrade for 22 hours showed that our synthetic oil performed very well compared with full size turbine oil and indeed better than another commercially available model turbine oil (Fig.4).

BURNING PROPERTIES

At this point we decided we had enough evidence and confidence to ask Turbine Solutions in the UK to try out our formulation. In their tests, after 35 hours of continuous running, the combustion chamber was examined and was found to be completely clean, backing up our laboratory tests.

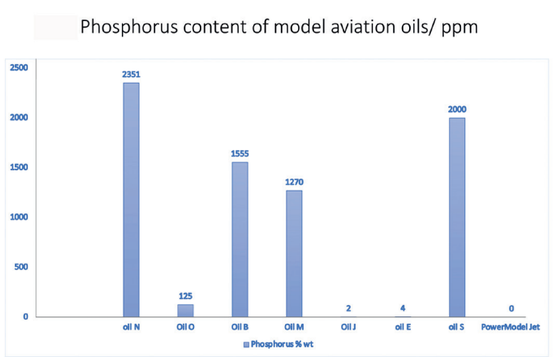
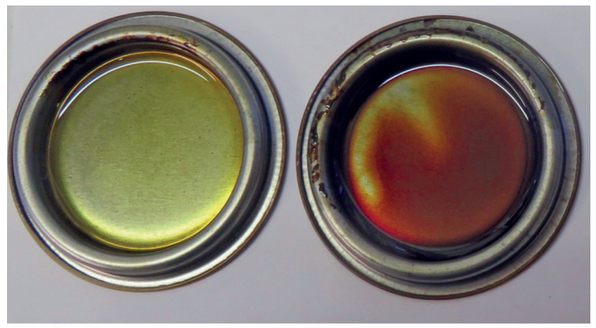


Fig.1: phosphorus levels in lubricants.



Thermal stability of formulation P1 versus two stroke oil, tested for 20 minutes at 200 deg. C.

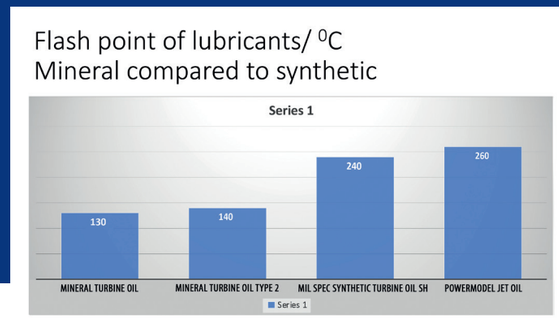


Fig.2: flash points, mineral versus synthetic.

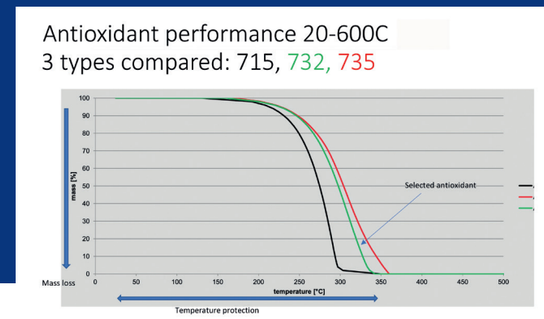


Fig.3: antioxidant performance.

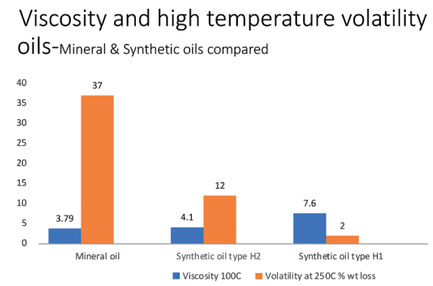
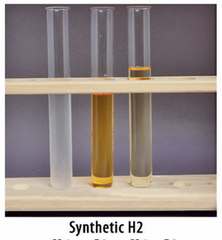
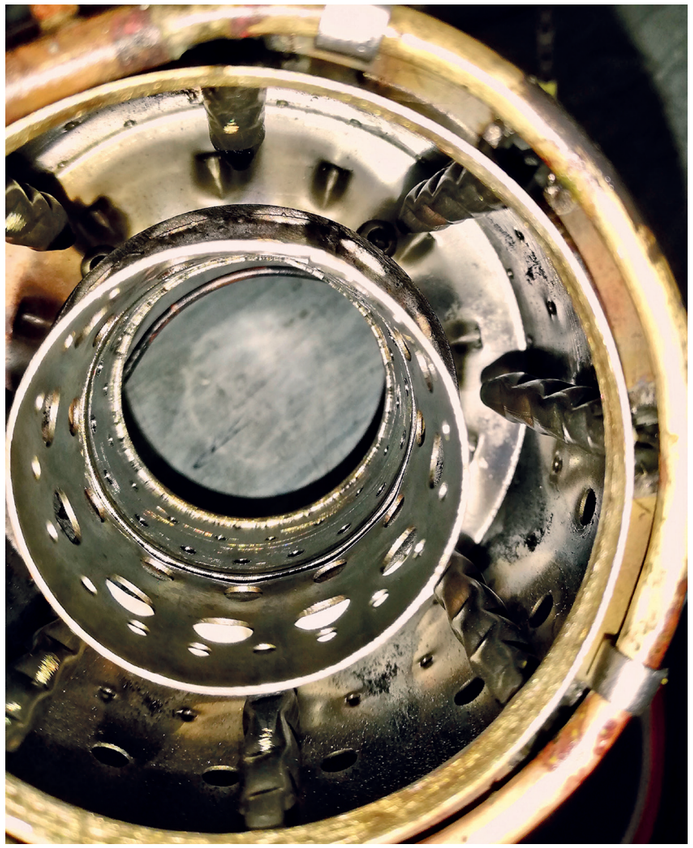


Fig.4: viscosity and volatility.

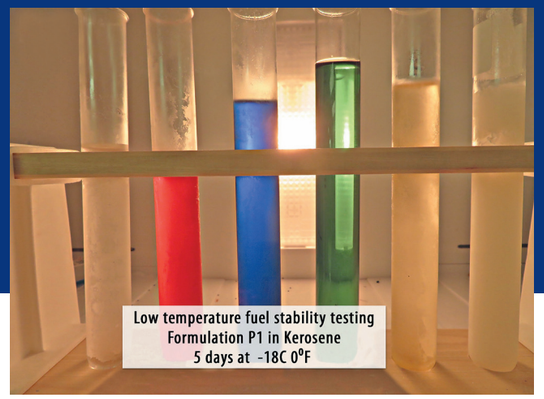
Additive design.



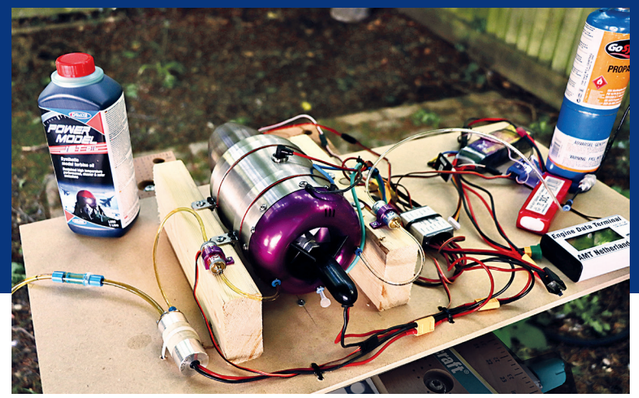
Synthetic H2
H1 S2 H1+S2
Synthetic base oil -
Additive compatibility studies



Combustion chamber after 35 hour test.



Low res, low temp solubilty at -18 degrees C.



AMT test rig.

Oil mix at 20-1.

Bob Petrie's Wren 44 powered L-39.

SOLUBILITY, MISCIBILITY & VISIBILITY

A very important property is the ability of the oil to mix readily with both diesel and kerosene and to stay in solution over time. Tests at minus 18 degrees centigrade showed there to be no separation issues. These stability tests are still running today after two years. We also added to the oil a distinctive green dye at the right concentration for rapid recognition in fuel.

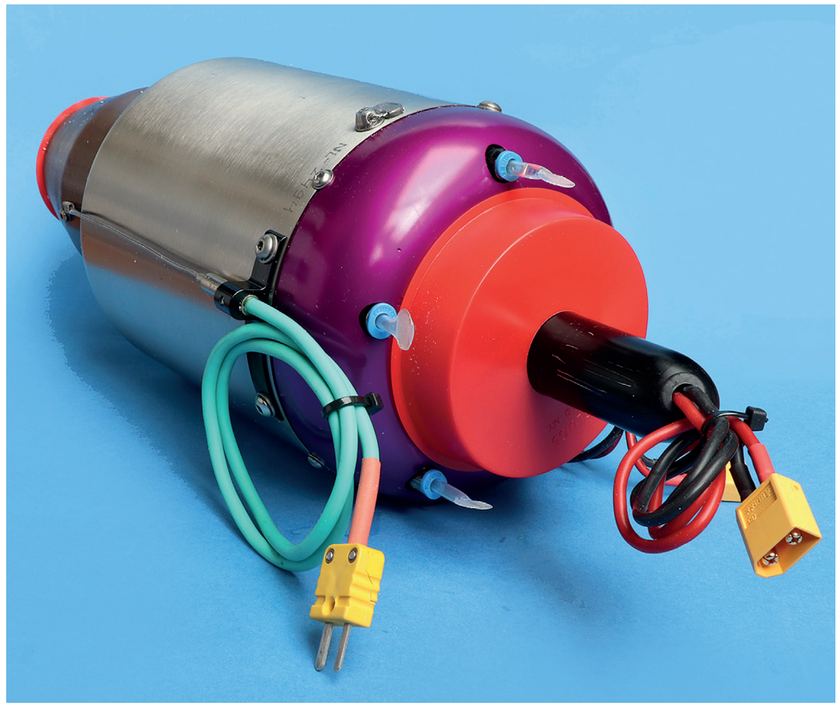
FIELD & BENCH TESTING

I would like to thank, for further experience and help with testing, Kristien Milne and Bob Petrie for the flight tests and Geoff Leigh for the bench tests with their own Wren 44 and Jet Cat P100RXI turbines.

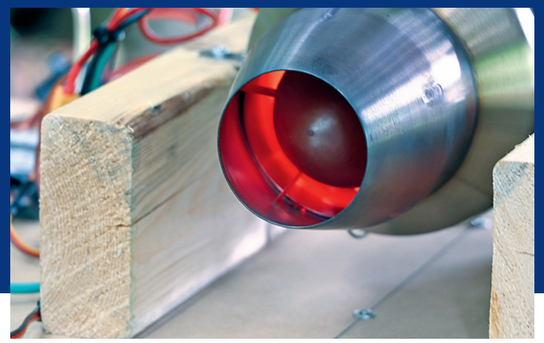
5.1 MILLION REVOLUTIONS WITH AMT

Of particular interest was the work we did for AMT, the turbine manufacturer in the Netherlands. This company challenged us to run a 10 hour sequence test representing a service period. Geoff White also helped us by providing a suitable test engine, a Pegasus HP. This was factory prepared for the test work. The test method was agreed with AMT and designed to evaluate combustion deposits and bearing lubrication over 10 hours.

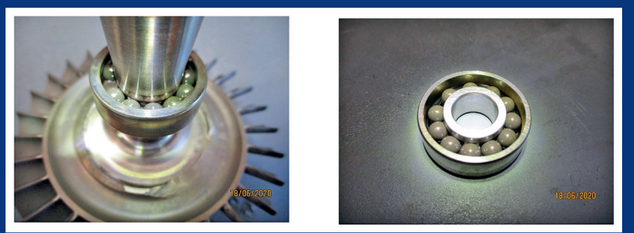
Duration and details of test sequences 1 to 10 is shown below in Table 1. A total of 283.5 litres of aviation kerosene and 13.5 litres of oil were consumed in this continuous 10 hour test that ran from 10:15 AM one morning through to 8:00 PM at night.



AMT Pegasus HP test turbine, factory prepared.



Left: Feeling the heat at 119k revs!



Above: Post test bearing check.

Table 1 running details of each sequence

Sequence	1	2	3	4	5	6	7	8	9	10
Start time	10.15am	11.07	1215pm	1.15	2.15	3.25	4.25	5.25	6.50	7.50pm
Finish time	10.57	12.00	1.02pm	2.00	3.10	4.10	5.10	6.10	7.35	8.35pm
Running Period at max rpm mins	42	53	47	45	55	45	45	45	45	45
Cool /soak time/ mins	10	15	13	15	15	15	15	40	25	In storage for inspection by AMT.

One picture shows a dramatic shot at dusk of the Pegasus running at maximum 119,000 rpm. The same evening the engine was removed from the test stand, sealed and shipped back to AMT for examination.

We received a great email from AMT favourably reporting on the engine inspection with photography:

"Both ball bearings were in good condition after the 10 hour test cycle.

In my opinion there is no need for additional tests at AMT to prove the quality of the oil."

HIGH APPROVAL

To date we have received eight manufacturers' approvals and we believe the product is greatly appreciated by many modellers. Here is one reaction:

"Travelling in my car with my plane there is a lot less odour. That is really a big bonus. There's also less odour when the turbine is running - I no longer need to hold my breath!"

Chris Jackson undertook field trials with his Behotec 220.

Fuelling up a Gravity Industries jet suit.

Our developed oil is also being used by Gravity Industries, manufacturers of jet suits for human flight.

It has been quite a challenge and we would like to thank all the modellers mentioned in this article, along with Nexus Models, Chris Jackson in the USA and Leon Mare in Hong Kong, all of whom have helped spread the word.

Jet suit in action. Photo: reddot media and drift limits

Gas turbine manufacturers approvals.

ACKNOWLEDGEMENTS

Chris Jackson for field trials with Behotec 220.
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Geoff White for loan of AMT Pegasus.
Reddot Media and drift limits photography
Gravity Co.