Hawk 100R Test

A new engine with very impressive fuel efficiency

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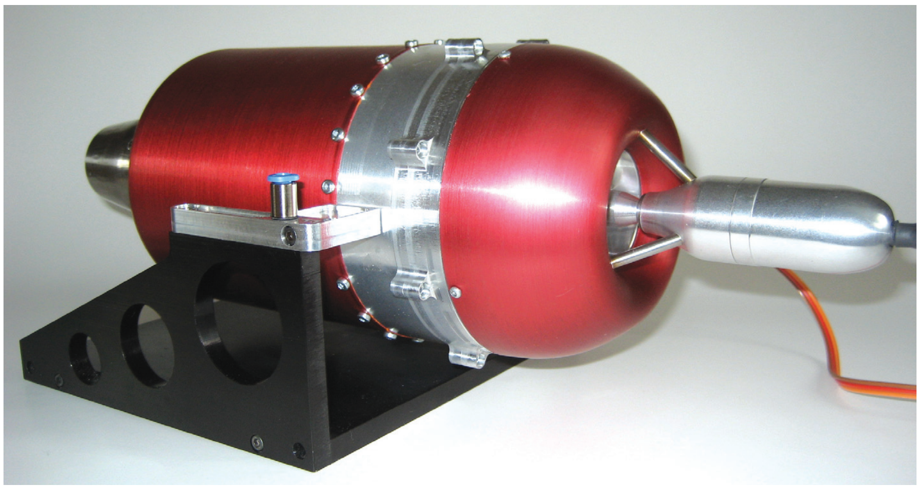


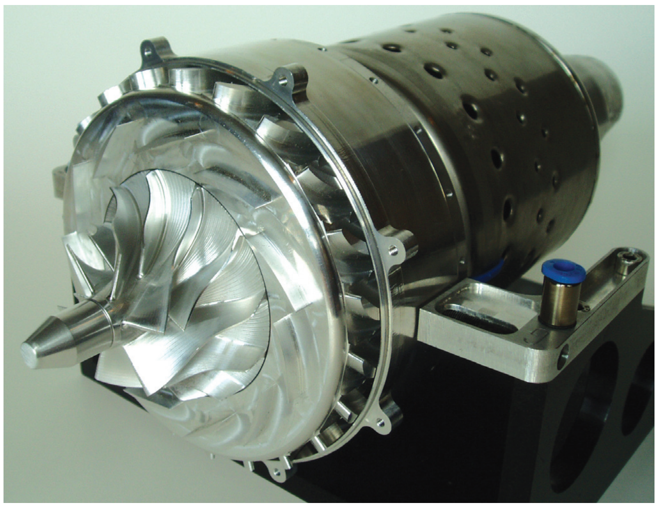
This engine review departs from normal RCJI practice because the engine tested is only just entering production. However, it has many design features that depart from those of the majority of engines in the market and a fuel efficiency that will be the envy of all, so we felt it would be of interest to the readers.

The Hawk 100R is not the first model aircraft gas turbine to use a turbocharger radial inflow turbine wheel, but in doing so it flies against the current 'conventional' configuration that uses an axial turbine wheel. Whereas most engines on the market use turbo charger compressors and purpose-made axial turbines, this engine does the opposite.

The Hawk 100R's radial inflow turbine wheel is from a turbocharger but the compressor is purpose designed to match it. At an early stage the Hawk design team found that no existing turbocharger compressor on the market had the required performance. A new transonic radial compressor had to be designed from scratch. The performance was achieved with a lot of aerodynamic and iterated stress and vibration calculations. The centrifugal compressor is machined by 5-axis CNC facilities. It is designed to operate with transonic airflow and the associated diffuser incorporates a low solidity airfoil.

The engine is built in three modules – the compressor section, the bearing section and the turbine section.

To achieve long bearing life the bearing system is designed for low vibration and low temperatures. An integrated damping and cooling system is employed to take care of heat and vibrations. All fuel that passes the bearing system is burned later on in the reverse flow combustion chamber, so there is no loss or wastage of fuel. The fuel and combustor system is also designed to be insensitive to air bubbles in the fuel line. The fuel line is connected directly to the unique engine mounting lugs, with connectors located outside the aircraft's ducting system. The robust module construction with three main sections gives the engine a low maintenance cost and fast turnaround servicing.



The Hawk 100R laid bare, note the three-section modular form, the CNC machined compressor and fuel connector at the mounting lug

Despite the innovative design concepts the autostart engine was found to be conventional in its starting and operating procedures. The starting gas is delivered through a Festo LR-QS-4 pressure regulator valve fed from the gas canister (there are no facilities for on-board gas supplies). The pressure regulator is set quite low so that pressure variations due to variable temperature and volume of liquid gas in the canister are tolerated.

Engine control was handled by a FADEC AU-604 v5.20 ECU, which was contained within a machined aluminium case.

The engine in standard form is 346 mm long but it is possible to have longer or shorter exhaust nozzles to suit particular installations.

The test results are shown in Graphs 1 to 4. All data are corrected to International Standard Atmosphere conditions. The maximum thrust obtained (see Graph 1) was less than 2 Newtons below specification, well within the margins of measurement accuracy. For an engine in this thrust class the installed weight (engine plus essential peripheral equipment) was no heavier than its competitors, which will be a significant bonus because the fuel consumption is much lower, leading to lighter fuel loads and therefore lighter take-off weights. Graph 2 shows that, at maximum thrust, a litre of fuel will be consumed in three and a half minutes. This is nearly twice the time obtained for other engines of similar thrust. At idle it will take over 26 minutes to consume a litre – no worries when held up by flight line controllers before getting clearance to take off!

The thrust specific fuel consumption (TSFC) has set new standards. We used to expect benchmarks of around 0.05 gm/sec/N

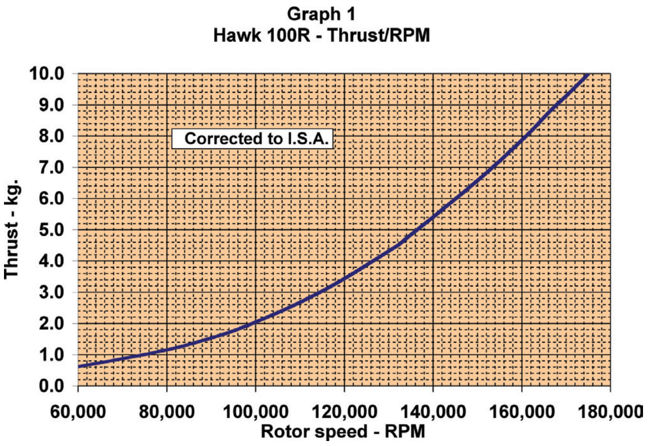
The Hawk 100R and airborne peripherals comprise:

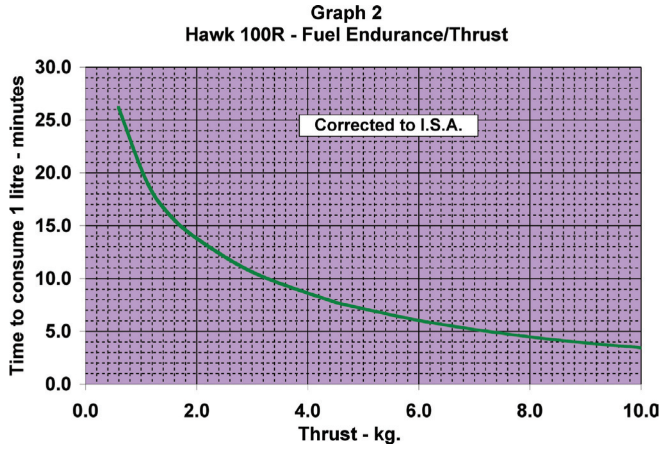
Engine, starter and integral mounting lugs: 1622 g (3.58 lb)
FADEC AU-604 v5.20 ECU: 46.2 g (1.63 oz)
2,200 mA-hr 7.4v Li-poly battery: 141 g (4.97 oz)
Sensor, signal and power cables: 29.7 g (1.05 oz)
Main fuel solenoid valve: 21.1 g (0.74 oz)
Starter gas fuel solenoid valve: 21.1 g (0.74 oz)
Fuel pump and connectors: 81.8 g (2.88 oz)
Total airborne weight: 1.963 kg (4.33 lb)

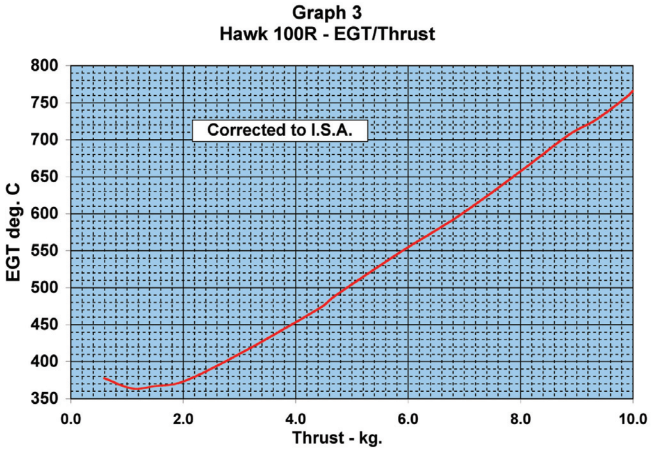
Diameter: 108 mm (4.25 in)
Length: 346 mm (13.62 in)

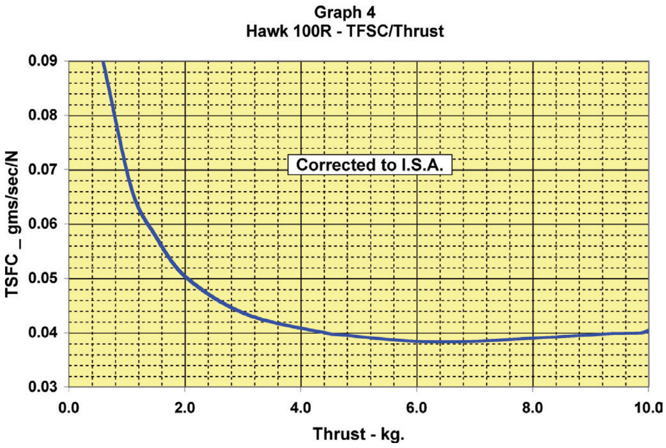
Test Results

Idle thrust:	0.59 kg (1.31 lb) [5.81 Newtons]
Maximum thrust:	10.0 kg (22.05 lb) [98.1 Newtons]
Fuel consumption at maximum thrust:	290 ml/min
Best thrust specific fuel consumption:	0.0384 g/sec/N at 6.9 kg thrust
Fuel used:	Premium paraffin
Lubrication:	Two-stroke motorcycle oil
Fuel/oil ratio:	67:1 (1.5%)









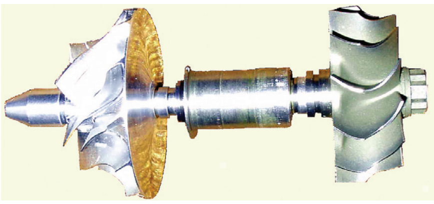
The latest FADEC ECU has a machined aluminium case

– the Hawk 100R is better than this by 24%! It's best TSFC is 0.0384 at 6.6 kg thrust. In fact it betters the established benchmark figure over a thrust range from 2 kg to 10 kg. See Graph 4. The Hawk 100R has a high-pressure ratio, which is very significant in terms of fuel efficiency. Throughout the whole of the test programme we never detected any odour from the exhaust gases, this is one model engine that does not smell like the local airport – one scale-like feature we can do without! The very low amount of readily available and inexpensive two-stroke oil needed (only 1.5% to be added to the fuel) further enhances the economy and convenience of operation.

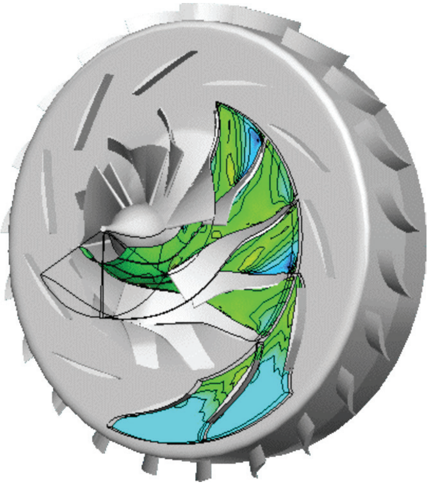
The engine is very tolerant of bubbles in the fuel line, so much so that if a large filter clunk is used in the fuel tank the engine gives warning of a low fuel state. As the fuel uncovers the clunk air is mixed with the fuel and the engine just slows down – even if it was being operated at full thrust. If the operator reduces the throttle when the engine first slows there may well be sufficient fuel remaining to make a safe landing. Not the recommended fuel management technique but a useful facility nonetheless.

The exhaust gas temperature shows a linear relationship with thrust over almost the entire operating range, such a straight line has not been seen with other engine designs and, surely, must be indicative of a well-designed engine.

The Hawk 100R is an engine to look out for in the near future.



The rotor shaft is short with a special bearing damping system



A graphic from the computational fluid dynamics (CFD) analysis that has benefited the compressor and diffuser

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