AIRCRAFT DIESELS

Who among us ever thought we would live to see the day when airplanes—especially light aircraft—would be powered by diesel engines? But it is happening. All the more astounding, the successful aircraft diesel is derived from an automotive engine. Until now, automotive engines converted for use in aircraft have not had an illustrious history.

Thielert Aircraft Engines, also known as TAE and a division of the Thielert Group, has taken what initially was a four-cylinder engine used by Mercedes and, through extensive modifications, has engineered it for use in airplanes. A large number of critical parts were redesigned by Thielert and are now manufactured by the firm.

It is the first modern diesel engine to be fitted to a certified airframe, scheduled for actual production, and to have solid orders on the books. Thielert says that, based on German fuel prices, its diesel reduces the direct costs of flying by 70%, compared to what it costs to fly gasoline engines now installed in light aircraft.

One European aviation magazine says that diesels are the wave of the future in light aircraft. Not only are they cheaper to operate, they use fuel that is often more readily available, they have substantially increased range, and they are more durable as well as safer than gasoline engines. One twin-engine four-place diesel airplane, when operated at maximum economy, travels at 126 mph while racking up an astounding 42 mpg.

A Diamond Star DA40 diesel-powered airplane.

Adapted from an Automobile Engine

The Thielert Group is based in Lichtenstein, Germany. Thielert was formed in 1989 principally to optimize engines for Formula 1 racing and do advanced engine development for automotive companies. Along the way it branched into manufacturing components for high-performance engines and also began developing hardware and software for digital engine controls.

Just three years ago TAE was formed to adapt an automotive engine to aircraft. The program for the aircraft engine benefited from what Thielert learned in its automotive work and from the huge amount of money that has been invested in those efforts.

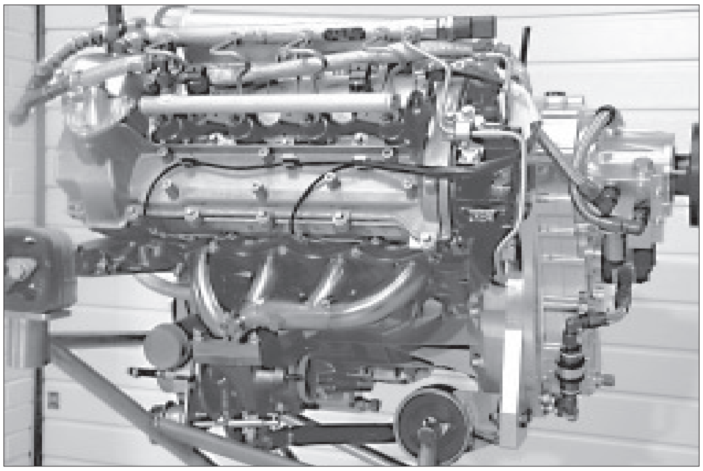
The lineage of the engine traces back through more than $200 million spent to develop the automotive engine and another $12 million to make it airworthy.

One thing that Thielert officials stress, however, is that its aircraft diesel is definitely not a car engine installed in aircraft. Every part of the diesel is certified for aircraft. The point is driven home because some companies supplying parts for TAE automotive engines, for reasons of liability, don't want anyone to think automotive components are ending up in aircraft. So in its contracts with suppliers, Thielert makes itself solely responsible for its engine and all components applied to aircraft.

A motivating factor for developing an aircraft diesel is the high cost of aviation gasoline in Europe and growing concerns about how available it will be as more and more refining capacity for aviation turns to jet fuel. In North America as well, there is concern about a shift in emphasis to jet fuel and the question it poses about the availability of aviation gasoline.

The Thielert aviation diesel was initially called the TAE 125, but in a simple act of badge engineering, it was renamed the Centurion 1.7. Both engines are identical, but the company feels the Centurion name has more cachet. The engine operates on diesel or Jet A fuel, but not aviation gasoline. Nor are biodiesel fuels approved. So far, the engine has undergone 10,000 hours of testing, with 1,500 hours of that time in aircraft.

The Centurion 1.7 is a turbocharged four-cylinder, four valve, in-line engine with common rail fuel injection. It is liquid cooled by readily available off-the-shelf antifreeze and puts out 135 hp and 302.4 ft-lb of torque. Displacement is 1.689 liters or 103.07 cubic inches, with a 3.15 inch bore, 3.31 inch stroke, and a compression ratio of 18:1.



Centurion 1.7 engine built by TAE in Europe is the first modern diesel to be fitted to a certified airframe and be scheduled for production with orders actually on the books. Although its heritage is in the automotive industry, it has been thoroughly reengineered and certified for aircraft.

In May 2002, TAE received certification for the engine from the German aviation authority Luftfahrt-Bundesamt. TAE then started serial production of the engine and began deliveries to customers.

Thielert anticipates FAA approval in the near future. The German certification meets the FAA FAR 33 requirement, and a validation request has been submitted to the FAA for approval under bilateral agreements between the FAA and German authorities. FAA approval is expected in early 2003.

The engine weighs 259 pounds dry. That is on the order of 6 to 9 pounds more than a Lycoming O320. The weight with all accessories is 295.4 pounds. Complete installation from the firewall forward in a Cessna 172 weighs 430.2 pounds. The engine is 30.6 inches wide, 31.2 inches long, and 23.2 inches high.

Gear reduction from engine to prop lowers prop speed to a more optimum value and also has the ancillary benefit of decoupling vibration between the engine and prop. The engine runs at 3,900 rpm and is reduced 1.69:1 to turn the prop at 2,300 rpm. Only a constant-speed (i.e., variable-pitch) prop can be used. The approved prop is the three-blade Muehlbauer. Neither Hartzell nor McCauley props are approved.

The engine comes equipped with 90-amp alternator and belt, starter, turbocharger, vacuum pump, and prop governor. The engine has a 12-volt electrical system, but it will become available with both 12 and 24-volt configurations sometime in 2003. The 24-volt system will cost approximately an additional $1,782.

Centurion engines use soft engine mounts which reduce vibration and noise. Therefore, in retrofits, the existing mounts cannot be used. Special mounts are required.

There are no special starting procedures for either a hot or a cold engine. This is in contrast to contemporary Cessna fuel-injected gasoline engines, which pilots sometimes find hard to start after a brief hot shut down on a warm day.

Aside from the engine's fuel economy, an attraction for pilots is that power is controlled by a single lever. There are no fuel mixture or carburetor heat controls requiring pilot attention in flight. The entire operating history of the engine is logged on a data recording device as part of the electronic control, and it warns pilots of impending problems and provides data for servicing.

The Centurion 1.7 is not to be overhauled other than at the Thielert factory, and it has to be replaced after 2,400 hours of operation. The engine is broken-in as delivered and costs $19,500. The engines are built with a one-man, one-engine approach instead of on an assembly line. Total operating cost of the engine over its lifetime is projected to be cheaper than that of gasoline engines.

Down the road is a further development from Thielert called the Centurion 4.0. It is slated to be a diesel putting out 310 hp.

Now Flying in Europe

Currently, the only OEM aircraft manufacturer preparing to deliver diesel airplanes is Diamond Aircraft Industries, with headquarters in Wiener Neustadt, Austria. Diamond is installing the Centurion in its Diamond Star DA40. This airplane is currently being delivered with a 180 hp Lycoming gasoline engine under the designation DA40-180. As one aviation expert observed, the DA40 with the gasoline engine is a beautiful new airplane but powered with 50-year-old technology.

Fitted with a diesel engine, the airplane is called the DA40 TDI Diamond Star. It has received JAR 23 certification by Austro Control, the Austrian Airworthiness Authority, and it is the first production aircraft powered by the Centurion 1.7.

Diamond Star DA40 TDI uses a TAE diesel engine to replace a Lycoming powerplant and is now in serial production in Autstria. A decision is being made regarding its possible sale in North America.

Diamond also has a North American plant in London, Ontario, Canada. However, installation of the first 100 Centurions will be limited to Europe to keep the installed equipment close to the factory in the event customers need technical assistance. The company is evaluating the possible sale of the Diamond Star TDI in North America, and says it will come to a decision in the near future.

Another Diamond airplane under development with the TAE Centurion is the twin-engine, retractable gear, Diamond DA42 Twin Star. It first flew on December 9, 2002. The first flight with gear retracted was February 13, 2003. In that flight, the craft reached 18,000 feet. Useful load of the DA42 is 900 pounds with full fuel. The Twin Star and the Diamond Star are both four-place aircraft. Target price of the DA42 for North American deliveries is $360,000. Deliveries are projected to begin in mid 2004.

Diesel-powered twin-engine Diamond DA42, operated at maximum economy, a speed of 126.6 mph, gets what amounts to an astounding 42 mpg.

Two other aircraft models, a Piper PA 28 and various Cessna 172s, have been retrofitted in Europe with the Centurion diesel. These retrofits require what is called Supplemental Type Certification, or STC, and various models of 172s have gained this certification or are near to it. Certification has also been granted for kit planes and experimental models.

The Cessna 172 is the first certified piston-engine aircraft for general aviation able to operate on jet and diesel fuel. The STCs have been available since November 2002 for the European market and are expected to be available in the second quarter of 2003 for the United States market. The cost of an STC conversion is $40,000, including engine and labor.

Cessna 172s are one of the aircraft to which the Centurion diesel has been retrofitted. One of the test aircraft registered fuel economy of 27.4 mpg at 126.6 mph.

The Cessna 172s and Piper PA 28 are the only two installations Thielert has in its immediate plans for retrofits. However, because of certain engineering features involving torque, gear reduction, and prop pitch, the Centurion can replace conventional aircraft engines up to 180 hp. Thielert says it is working with other OEM airframe manufacturers, but confidentiality agreements prevent naming any other than Diamond.

It is expected that toward the end of 2003, people building experimental craft will be able to install their own Centurion engines. The Centurion, however, is regarded as being too heavy for ultralight aircraft.

Interestingly, an inquiry to Cessna about corporate reaction to the Centurion retrofit provided only a cursory response devoid of meaningful specifics. An inquiry to Piper was not answered. About a month earlier, another reporter's inquiry to Cessna was met with an equally noncommittal response.

Personnel at both companies were undergoing the trauma of major downsizing at the time, yet the apparent blackout on information from the firms could be meaningful. It could, for example, indicate that both companies somehow see the Centurion as a threat. Is it possible Diamond will begin eating their lunch in the light aircraft market? What would large-scale movement to the Centurion do to the overhaul business of its dealers who operate maintenance facilities? On the other hand, have the firms, like Diamond, embraced the engine and included it in proprietary strategic plans?

Astounding Performance

The twin-engine DA42, at 80% power and 18,000 ft altitude, reached 201 kts true airspeed with a fuel consumption of 11.8 gph. That means it got 19.6 mpg while traveling at over 231 mph.

At 80% power and 10,000 ft., the plane achieved 181 kts at 10.7 gph. That is 208 mph and 19.47 mpg. At 60% power and 10,000 ft., the airplane reached 166 kts with fuel consumption of 8.0 gph, which translates into 23.9 mpg at 191.0 mph. At 50% power and 10,000 ft., it reached 147 kts or 169 mph at 6.7 gph, or 25 mpg. At maximum economy, it reached 110 kts or 126.6 mph at 3 gph, which means it achieved a fuel consumption of 42 mpg. All flights were performed with Jet A fuel.

At 75% power and 10,000 ft., the airplane has a no-reserve range of 1,012 miles with standard 52 gallon tanks. With optional long range tanks holding 74 gallons, it has a range of 1,440 miles. With the standard tanks and minimum power settings, the theoretical maximum endurance is 19 hours and 2,532 miles. To put that distance in perspective, it is farther than from Chicago to Los Angeles.

Loaded to just 15% below maximum gross weight, the DA42 climbed at more than 2,000 feet per minute at 90 kts. Cruise climb at 110 kts was 1,700 fpm. The airplane took less than eight minutes to reach 12,000 ft. At that altitude, under so-called standard pressure and temperature, maximum speed was over 200 kts. Single-engine climb rate at 12,000 ft. averaged 600 fpm.

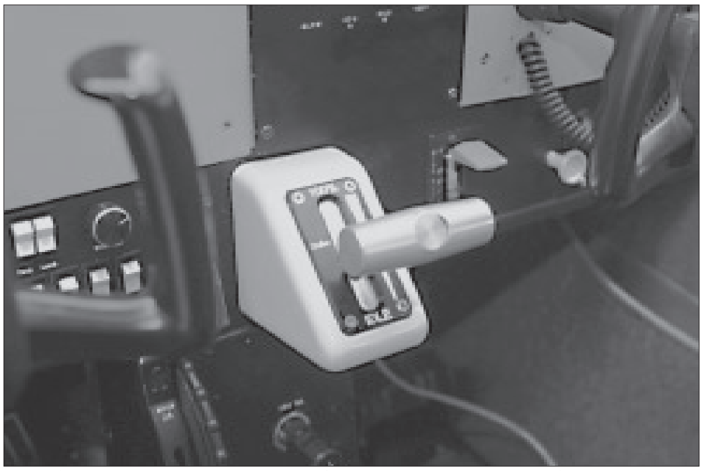
In a Cessna 172 retrofit with a takeoff weight of 2,299 pounds, maximum speed at 10,000 ft. is 129 kt, or 148 mph. Fuel consumption at 10,000 ft and 110 kt (126.6 mph) is 27.4 mpg. Range with standard tanks and 45-minute reserve at 10,000 ft. is 954 miles. With long range tanks under the same conditions, it is 1,212 miles. The take off distance to clear a 50-ft. obstacle is 1,548 ft.

That means it got 19.6 mpg while traveling at over 231 mph.

Why Diesels Are Special

One of the big differences between aircraft and automotive engines is that aircraft engines are more heavily loaded; but they tend to run at a constant speed which, in turn, reduces wear. Automobile engines are more lightly loaded, but they suffer immense wear from the fact that they are running at a wide variety of speeds as they constantly accelerate and decelerate.

For example, the Centurion 1.7 operates at only three conditions: take-off power, cruise power, and idle. Thus, mechanical components as well as electronic engine management and propeller operation can be optimized for these three conditions. This permits an airplane to get more usable power from engines, and they tend to be more durable than those in cars.



One knob does it all in aircraft powered by the diesel Centurion. There is no fiddling with mixture control or carburetor heat.

Although rated at only 135 hp, the Centurion 1.7 can replace more powerful gasoline engines because the diesel provides more of what is termed static thrust. This thrust is what is felt when you push the throttle forward and depends on engine torque, gear reduction to the propeller, and the pitch of the blades. All of this provides what you feel in a car by virtue of sending engine torque through gear reduction in a transmission and differential.

The Centurion static thrust, for example, is actually greater than that of a Lycoming O320 and equal to that of the more powerful Lycoming O360. Beginning a take-off roll in an airplane with a fixed-pitch prop is much like trying to accelerate a car from a stop in high gear. The constant speed (i. e, variable-pitch) prop of the Centurion provides somewhat of an aerodynamic “gear reduction” and is more efficient than the fixed-pitch props used with the Lycoming engines. This leads to better take-off performance of the Centurion 1.7 as compared to a PA 28 or Cessna 172.

Under so-called standard conditions, the climb rate of the Centurion will be slightly less, but will still meet FAA standards. And because of turbocharging, the Centurion can be expected to perform better operating in hot weather or from high-altitude airports, both of which degrade the performance of engines that aren’t turbocharged.

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