Parlez-vous français?

Maule brings a French diesel to America

BY ALTON K. MARSH

Here come the diesels, and first to arrive is the French-built 230-horsepower four-cylinder SMA SR305 piston engine. It is flying in Moultrie, Georgia, on a new model by Maule Air. Work began in 2001 and accelerated in 2002 as engineers tried to solve potential problems before the engine was ever mounted on an aircraft.

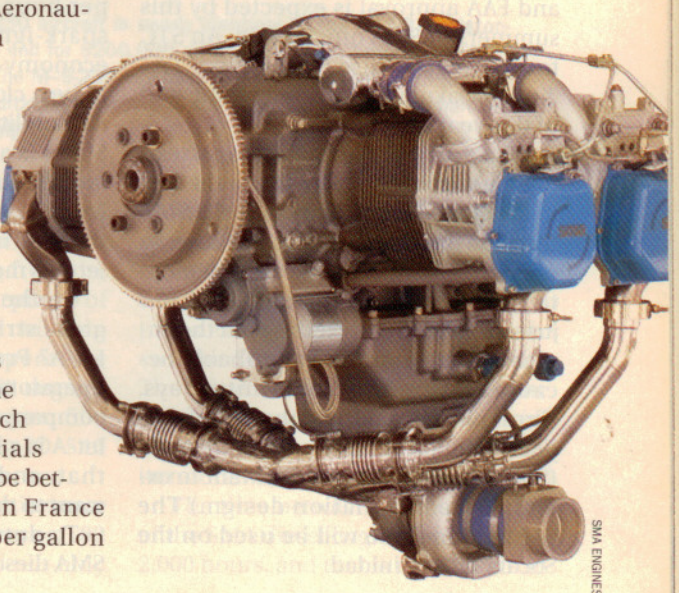
Maule recently invited *AOPA Pilot* to fly its new M–9-230 aircraft powered by the SMA turbocharged diesel engine. The M–9, based largely on the M–7-235 model now powered by a 235-hp Lycoming IO-540 engine, will be certified with the diesel engine. It will have a 300-pound-gross weight increase, partially to make up for the fact that the SMA diesel installation (including all related components such as propeller and cowling) weighs 70 pounds more than the Lycoming installation now used for the M–7 airframe.

The diesel mounts closer to the firewall than does the Lycoming engine, though, reducing potential center-of-gravity problems caused by the greater engine weight.

Maule engineers are favorably impressed by the engine—which SMA officials say is based on an all-new "blank sheet of paper" design—as were researchers at Embry-Riddle Aeronautical University at Daytona Beach, Florida, where initial testing on a Cessna 182 was performed.

But you're looking for the bottom line, right? Is the SMA diesel engine a better choice than a comparable-horsepower piston engine? It's a close call in the United States where Jet-A is only slightly less expensive than 100LL—so the decision will depend on each owner's needs. Maule officials think Europe and Africa may be better markets. For example, in France 100LL costs roughly $6.30 per gallon while Jet-A is about $2.58.

Huge amounts of air, provided by a specially designed engine cowling developed by LoPresti Speed Merchants, are needed to maintain the temperature limits of the diesel engine.



SMA ENGINES

PHOTOGRAPHY BY THE AUTHOR

Only three levers are needed to control the engine, and of those, only one, the power lever, will see much use. The other two are used in the event of computer failure or emergencies. Maule installed a JPI EDM 930 engine instrument display to record engine performance during testing. The aircraft has two batteries, two alternators, and electric attitude and heading indicators.

The SMA engine was designed under a partnership agreement by Renault Sport, developer of sports-car racing engines, and EADS, the company associated with the Airbus, and later optimized for aviation needs by Snecma, a supplier of large jet engines and aerospace equipment. The engine has been approved in Europe for installation on the Cessna 182 under a supplemental type certificate, and FAA approval is expected by this summer, an SMA official said. An STC for the engine's use on the Piper PA–28-236 Dakota is expected by the end of this year.

Maule Air is in the final stages of testing the engine and hopes to be the first in the United States to include the SMA diesel in an aircraft type certificate, as opposed to an aftermarket supplemental type certificate. Cirrus Design has just completed early testing but the engine ran intermittently, probably because of extremely cold winter days, Cirrus officials said, and the aircraft has been shipped to France for more tests. (SMA officials disagree and want to examine the installation design.) The SMA engine also will be used on the Socata TB20 Trinidad.

The M–9-230 is still in the Experimental category and there may be further engine tweaking, but the general impression among Maule officials is favorable. There are several factors to consider, such as economy of operation (fuel price), engine price, and performance.

My test flight shows that the SMA compression-ignition engine burns between one and three gallons less fuel per hour than a comparable-power spark-ignition engine. As noted, the economy-of-operation battle appears to be a close one in the United States. Availability of 100LL outside the United States is another issue: In England the largest hub airports do not sell avgas. In India pilots may have to travel 200 miles or more in search of avgas while Jet-A is more readily available.

On the other hand, does your tiny grass strip in the United States sell Jet-A? Probably not. Can the airport operators just put up a new tank? Oil company officials say the handling of Jet-A is a little more complicated than that, and not all small airports will want to do it.

To determine how much fuel the SMA diesel engine saves, I filled the left inboard tank (the M–7/M–9 has four) prior to takeoff and then refilled it after a 1.2-hour demo flight with company pilot Ray Maule: The burn was 9.6 gallons per hour, versus an estimated 12 gph for the 235-hp Lycoming IO-540 that normally powers the M–7. Maule said he experienced a 10.6-gph fuel burn on a flight from company headquarters in Moultrie to Oshkosh. That was in warm weather. My test flight was conducted at 8,000 feet where the temperature that day was 50 degrees Fahrenheit, and I flew at reduced power for part of the flight.

What about performance? I let Maule pick the altitude for the airspeed test. At 8,000 feet we recorded a true airspeed of 135.5 knots—a few knots slower than the Lycoming IO-540. The SMA engine is turbocharged and achieves 230 hp at takeoff, but its computer immediately begins a reduction to 200 hp by the time the aircraft has reached 5,000 feet. That stems from an earlier development period for the engine when maximum takeoff power was time-limited, but that restriction has been lifted. SMA officials said they do not plan to reprogram the computer.

The pilot leaves the power lever at the full power setting (fully in). Since the power lever only sends messages to the computer, it does not do what a conventional throttle does and therefore gets its new name: *power lever* instead of *throttle*. The engine has a computer-controlled system but not a whole FADEC (full authority digital engine control) system because it lacks some of the features of a full FADEC. However, like the FADEC system, there is no mixture control and no prop control, just a power lever.

The turbocharged SMA engine can maintain 200 hp (87-percent power) all the way to 10,000 feet. The normally aspirated IO-540 is reduced to less than 70-percent power by 8,000 feet. Aside from lower operating cost, this is considered to be the prime advantage of the diesel engine. Above 10,000 feet the SMA diesel-engine power curve slopes downward as altitude increases.

The propeller governor (not controlled by the pilot and locked at 2,200 rpm) maintains that rpm even with the power lever fully forward, a setting that reduces cabin (and environmental) noise compared to the higher rpm used with avgas-fueled piston engines. The computer only controls rpm at idle and also prevents overspeed if the governor fails. In the case of the Maule, when the engine/propeller installation is rigged the governor set screw is adjusted to 2,200 rpm and locked in position. (On the Cessna 182 STC, a propeller cycle control allows the pilot to cycle the propeller on the ground during runup.)

The service ceiling at the time of the test flight was set at 12,500 feet because of concerns about air restarts. Like all diesels, the engine uses compression ignition (thus, it has no magnetos), and the air above 12,500 feet may not be dense enough for ram-air forces to rotate the propeller fast enough to overcome the high compression ratios of the diesel engine and achieve a successful restart. That limit is expected to be raised to 18,000 feet once engineers have examined a number of options for fixing the problem: That could occur by the middle of this year. The engine has flown successfully at 25,000 feet, but a restart during that test flight was accomplished only at a lower altitude where the air was denser. An air restart might be necessary in the event a pilot inadvertently runs a fuel tank dry.

Can the SMA engine, with additional tweaking, wring out those last few cruise-speed knots now achieved by the avgas engine? That is problematic. Early flight tests of the engine by Embry Riddle Aeronautical University in the Cessna 182 showed that the diesel had temperature and vibration problems, Maule officials said. (It wasn't a matter of the engine running hot, but rather the necessity to keep temperatures within a rather narrow margin allowed by the diesel's specifications.)

Maule engineers are pleased that their installation has no vibration problem. "It just worked out for us," said Ray Maule. The heat-control problem was solved when Maule engineers used a cowling similar to one built for Embry-Riddle's 182 by LoPresti Speed Merchants. Large holes in the front make the airplane look like a shark attack about to happen, and the molded, permanently open cowl flap beneath the engine is huge. The drag from the cowling design robs the airplane of a few knots, yet it is needed to maintain the low cylinder-head temperature limits of the diesel engine (358 degrees F for a diesel-fueled engine vs. 500 degrees F for the Lycoming IO-540 engine).

Not all SMA engine installations are the same. Maule and the Cessna 182 tested by Embry-Riddle used not only an intercooler and an oil cooler, but a fuel cooler as well. The fuel pump also uses fuel for cooling and lubrication, and the excess fuel either must be returned to the wing tank or routed to a cooler.

SMA decided to shroud the fuel filter to cool it on the SMA diesel certified in Europe for the Cessna 182, but Maule followed Embry-Riddle's example and used a fuel cooler for its M–9-230. Embry-Riddle and SMA, by the way, parted ways over the Cessna 182 project when their planning systems "failed to mesh," an SMA official said. That's why the work was taken over by SMA.

Other early problems included stress on metal propellers. Power pulses from the diesel engine—it's just the way that engine works—were hard on the tips of two-blade aluminum propellers, and during early testing the time between propeller overhauls had to be reduced to 300 hours. Knowing most owners wouldn't stand for overhauling their props every 300 hours, SMA engineers switched to lighter composite props. The lighter weight and nonmetal materials are better able to handle the stress, and the composite propeller can reach its normal TBO, but the cost is greater.

The time between overhauls (TBO) of the SMA diesel engine, by the way, is 2,000 hours, and that is expected to in-

The diesel-powered Maule M–9-230 aircraft is nearly identical to the M–7-235 piston-powered model. It is targeted to sell for $200,000, or about $40,000 more than the avgas nonturbocharged model. The M–9-230 will have a 300-pound maximum gross weight increase and requires additional structure in the fuselage and wing to handle the higher 2,800-pound gross weight.

crease to 3,000 hours in the future, perhaps by the end of 2005. When that happens the operating cost may dip well below that of comparable avgas-powered engines.

Early in the demonstration flight I was cautioned by Ray Maule to avoid rapid power lever movements. Did that mean I could not advance it rapidly to recover from an aerodynamic stall? No, says an SMA official. In an emergency you can advance it as rapidly as needed. The engine may emit a bit of smoke when that is done because of a temporary imbalance in the mixture, but power will kick in quickly.

Finally, the Maule airplane is placarded against performing negative-G maneuvers. That is because the latest certification tests for new engines require that there be no oil pressure drop for five seconds during negative Gs (such as might be encountered during an extreme downdraft). The SMA diesel hasn't passed that test...yet. An SMA official predicted some of today's piston engines could not pass such a test.

SMA has a temporary solution involving the addition of two accumulators (which prevent intermittent loss of pressure) and associated plumbing. Maule has elected to placard the test airplane against negative Gs instead. However, a new pump will be tested by SMA and is expected to result in the removal of the "no negative G" restriction on the Maule M-9.

The initial purchase cost is one area where the avgas engine appears to have the advantage. (SMA would argue that over the lifetime of the engine the diesel will have lower maintenance costs and thus be less expensive to operate than an avgas engine, especially since it will have a longer TBO.) The announced price for the firewall-forward kit for the Cessna 182 will cost $77,000, but that includes the engine, engine mount, cowling, composite propeller, and computer-control system. A new Lycoming IO-540 costs about $50,000 including the core credit, but it does not have a turbocharger or a computer-control system. The SMA engine can be overhauled in the traditional way and that cost is expected to be $15,000.

So what's it like to fly a diesel engine? Simple, and that is one of the major owner benefits. It starts as easily as a car. There are three controls, two of them not needed very much. The power lever is like the thermostat in your home: You set it, and the computer does the rest. In case the aircraft's computer fails, you can pull out a control that switches from electrical mode to manual—at that point the pilot controls fuel flow. A third selector can be pulled if an emergency shutdown is required.

Boiling down the start checklist to its essentials, you verify that the power lever is placed at idle for start. A detent separates the two position—idle and cutoff—on the power lever (a push knob on the Maule installation allows the pilot to pull the control from idle position to the fuel-cutoff position). The pilot must verify that the mode control is in Electrical, verify that the emergency shutoff lever is not pulled, and turn the key. Glow plugs then heat to assist in engine start (especially in cold weather), the same as with most diesel engines. The engine is run at no more than 1,500 rpm until the oil temperature reaches 140 degrees F. Then you can move the power lever to full power for takeoff and never touch it again until it is time to descend; it is worth repeating that there's no mixture to control or prop lever to set.

It was quiet and smooth during warmup, but at full power during takeoff I felt that it had about the same rumble and vibration as a six-cylinder avgas engine (the SMA has only four cylinders). But it is definitely smoother than an avgas four-cylinder aircraft engine. There was nothing unique about the smell of the engine to report—perhaps that's because of the drafty cowling that quickly vents any operating odors overboard.

Climb was between 500 and 1,000 feet per minute, a little less sprightly than a few of the other Maule models I have flown. Despite the heavier engine out front I noticed no difference in handling compared to previous Maule aircraft. The only unusual part of the day was nosing the big Maule up to a tank that said "Jet-A."

Pilots familiar with manifold pressure settings of 36 inches or so with a turbocharged avgas engine will be surprised. During the climb I saw 82.5 inches of manifold pressure and 2,175 rpm (Maule engineers had intentionally set the rpm just below 2,200 rpm). The fuel flow on the JPI EDM 930 electronic instrument display was 11.1 gph during the climb and 11.4 at full power during cruise. That could have been reading a little high because as mentioned above, the burn was shown to be considerably less when the left tank, the one used for the demo flight, was refilled after the flight. After letting Maule fly the aircraft for the full-power speed test, I reduced power to 67.8 inches of manifold pressure to test slower operation. In actual practice most owners will fly the diesel with the power lever fully forward. The total fuel burn for our 1.2-hour flight was 11.5 gallons of Jet-A. Lest you think the engine might be modified to run on some other fuel such as automotive diesel fuel, think again. A refinery executive said the engine requires aviation diesel fuel like Jet-A. Use of automotive diesel fuel would most likely result in restrictions being placed on the operation of the engine, SMA officials said.

Will the SMA diesel make it? Maule Air is betting that it will, and has committed to purchase dozens of the engines. The motivation is there for Maule to make sure the installation works so that it can recoup its investment. Obviously the engine is reaching the market behind the schedule SMA anticipated two years ago: The engine took longer to develop, and installation in individual aircraft required overcoming temperature range and vibration problems. But the solutions appear to be in hand. The end result will be more economical operation and an option for the day when 100LL is no longer around. AOPA

E-mail the author at alton.marsh@aopa.org.

Hits and Misses

Hits

- It uses Jet-A fuel.
- It is quiet, partly because of its low rpm.
- It starts easily and runs smoothly.
- Computer control lowers pilot workload.

Misses

- It is heavier than a comparable avgas engine.
- Its service ceiling is currently limited to 12,500 ft.
- The oil pump currently does not pass negative-G testing.

i Links to additional information about diesel engines may be found on AOPA Online (www.aopa.org/pilot/links.shtml). Keyword search: diesel.