ENGINE BEAT

BY TIM KERN

DeltaHawk diesel—*ready for primetime?*

The DeltaHawk is one of those engines that I—and, no doubt, many others—wish would finally come to market. It always seems just a whisker away. "Full production and deliveries are nearly here, " is the mantra from the company. And it continued to be the mantra this year at Oshkosh. Fine, so what's different now? Is it finally ready? I'll get to that shortly.

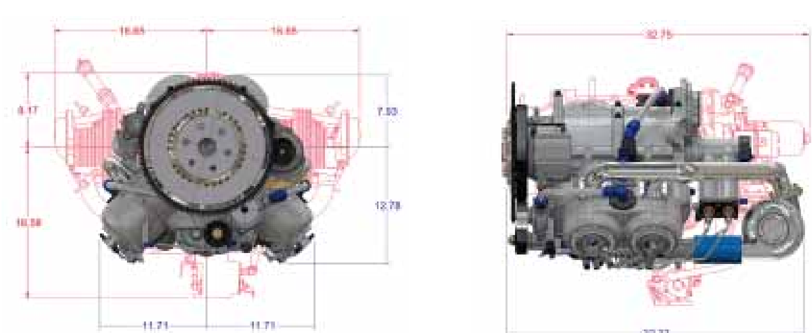
First, though, some background: The engine's roots extend to former fighter pilot J.P. Brooks, who decided that he wanted to set some endurance records in his Doug Doers-built Velocity. Brooks realized the engine he wanted didn't exist, but that a diesel held tremendous promise.

The theoretical benefits of the diesels—compression-ignition engines that burn diesel or Jet A fuel—stem from the fact that the fuel has more latent energy than gasoline and the engines typically carry very high compression ratios, which inherently improves efficiency. (A side issue is that 100LL has long seemed on the edge of viability.)

From Desire Comes an Engine

One thing to understand is that the DeltaHawk isn't a converted anything. It is a purpose-built, 90° V-4 aviation engine, a two-stroke with piston ports, running a supercharger *and* a turbocharger. The engine's static compression ratio is 19.3:1. Doug Doers, DeltaHawk's chief engineer, says that, because of the different rates of expansion of the pistons and cylinders at operating temperature (the cylinders grow more than the pistons), the real compression drops to about 16:1; but spin the turbo, and effective compression ratios up to 22:1 can be realized.

There is no classical wastegate on the DeltaHawk's turbo. Because the engine is a piston-port design, overboost is effectively impossible. Excessive inlet pressure blows too much of the potential combustion mix right past the ports; power drops and the turbo slows down! Further cutting component count is this: There is no electrical igniter—ignition comes from compression only, without glow plugs for starting. As a result, the engine needs about 160 rpm to get the fires lit, so there's a strong starter motor. One of DeltaHawk's recent changes was to upgrade its alternator and starter to 28 volts.



The DeltaHawk promises to be a compact, comparatively easy installation. Here it's compared to a Lycoming IO-360 for size.

Tim Kern's start in homebuilding came early, as he helped his dad build Luscombes and a wood glider as a kid. Since then, he's been involved in building three homebuilts: a Preceptor Pup, a Range Rider and a Baby Lakes. From a professional background in motorcycles and auto racing, Tim began his aviation career at Mosler Engines in 1990. Visit his web site at www.timkern.com.

This design point also creates the need for the supercharger, to get the induction pressures and combustion temperatures high enough for starting.

Combustion timing is controlled by a proprietary mechanical fuel injection system. A helix in the injector pump moderates the fuel amount and timing, based on where the throttle is set. The company plans to build 160-, 180- and 200-hp versions that will weigh a bit over 300 pounds, depending on power and configuration. With a 4-inch bore and stroke, the 202-cubic-inch DeltaHawk is roughly equivalent to a four-stroke diesel of 360 cubes. (Two-strokes have twice the number of combustion events as four-strokes, and so make more power for any given displacement.)

Special Metallurgy Issues

Dennis Webb, Acting General Manager, said that the engine's metallurgy is so modern it's largely secret. He can't talk about the materials used for sleeves or the wristpins. "Some names of the materials and coatings, I can't even pronounce," he said, but inside the DeltaHawk are titanium rods, plus aluminum pistons with screwed-on stainless steel crowns. These smash the gases against similar stainless firing plates that line the combustion chamber. He did volunteer: "Weight is everything in an airplane engine, so there's not a lot of iron in there."

Two-Stroke Advantage

The basic design of a two-stroke piston-port engine tends to light weight. With no valvetrain, it has about 40% fewer parts than a comparable four-stroke. The supercharger's main job is to provide high compression while starting. Once the engine is up to speed, the turbo is large enough to do all the intake charging duties. It's sized to maintain 100% hp to over 19,000 feet, and has been verified to just under 18,000.

Unlike two-stroke gasoline engines, which mix lubricating oil with the fuel,

Photos: Tim Kern and Courtesy the Manufacturer the DeltaHawk has an external lubricating-oil sump (and oil pump). That meant case-charging (using the downward stroke of the piston to pressurize the combustion mix) was not possible. Hence the supercharger, which also aids in airborne restarts at altitude.

The external oil pump performs both scavenge and pressure duties. The sump and oil pump will always be mounted right-side up, regardless of the engine's orientation. Webb noted, "That also allows various configurations: a V, an inverted V, or even a vertical V." He added, "And because it's a two-stroke, it really doesn't care which direction it's rotating, so it can also be configured to run the other direction." (Default direction is the same as Continental or Lycoming.)

Another advantage of two-stroke design is the relatively smaller power pulses. Diesels produce big power pulses, but the DeltaHawk promises to be easier on the prop and airframe, so much so that a major prop manufacturer is now testing an aluminum constant-speed unit on a DeltaHawk. (Traditionally violent diesel power pulses have, until now, prohibited metal prop use.)

One testbed has been this Velocity, which flies with a three-blade composite MT propeller.

The combined turbo and supercharger layout is neat and tidy. The supercharger helps get the engine started, but the turbo can handle all the flow loads to 100% power.

Two-Stroke Gas Scrooge

Doug Doers extolled other virtues of dieseldom. At idle, for instance, a diesel uses almost no fuel. "We burn 0.3 gph at idle versus 2+ for a gas engine," he said. "In my Velocity, at most-efficient airspeed, which is only 108 knots, we burn 2.2 gph." He noted that the DeltaHawk can also hold higher power settings longer than most gasoline applications. In a real-world comparison, Doug saw that against a 360-cubic-inch, 200-hp Lycoming in a similar Velocity, "During climb, we use 10 gph; the gas engine uses 14. At 170-knot cruise, the numbers are 6 and 10, respectively. That fuel savings ratio is pretty constant at flying speeds." According to his numbers, the Delta Hawk uses about 60% as much fuel by volume as the IO-360.

Development Continues

The first flight took place in May of 2003. The flight-test engine has accumulated several hundred hours, but it is hard to say how many hours are on which pieces, as running changes are introduced whenever the engine is torn down. The teardowns rarely yield any significant signs of wear, but they do provide useful insight. For instance, the piston crowns and wrist pins were early troublemakers. Now they squirt a bit of oil inside the piston, cooling it and continuously lubricating the wrist pin.

"People like air-cooling because it's simple, but it has costs in machining tolerances, shock cooling and so on," Webb said. "With water cooling, you don't have a shock cooling problem. That's one of the great things when you're making an engine for a specific purpose—you can do it right for the job." The Delta Hawk's combined oil/water cooling scheme means that you could actually lose a water hose and continue to run the engine at 50% power (much like the Rotax 912). Customers are also expected to use the water for cabin heat, though oil or even turbocharger bleed air could be employed.

The turbocharger and supercharger are semi-redundant, as well. Although the turbo is sized to run the engine at full power and the supercharger is just for starting, loss of the turbo would still allow "limp-home" power near 50%, using just the supercharger's boost. Conversely, if the supercharger conks out, the turbo will make 100% power available (but you won't get it started again without fixing the supercharger). Each cylinder has its own fuel injection pump. You can run reduced power with a pump or two dead—and get to a safe landing.

The engine is unusual, being both simple and redundant. Simplicity translates into operation, too. In addition to the advantages for the ham-fisted shock-coolers in the crowd, the DeltaHawk's single-lever control (think of it as a full FADEC, but without electronics—no spark, remember?) removes more variables, which is good for pilot workload and long life. Webb summed up the philosophy: "Simplicity means you have fewer chances of having things fail. Redundancy means that when something does break, you have a better chance to make it to a safe landing."

Everything is made by DeltaHawk's contractor, except the outside systems—among them the supercharger, turbo, alternator and starter. The engine will come to the customer with its starter, a 60-amp alternator, turbo, supercharger, exhaust pipe (to the turbo), intercooler (for intercooled models) and all lines engine-to-engine (but not to radiator or intercooler, due to mounting vagaries).

The DeltaHawk will first fly in customers' Experimentals, rather than manufacturers' kits or certified aircraft. It is priced in the low $30K range, and is targeted at the big four-cylinder gas-engine market. DeltaHawk predicts at least a 2000-hour TBO, though no one engine has has been run that long.

Certification talks with the FAA are underway, and Webb said that, "After certification, it is likely that all engines that get delivered will be certified."

So, Where *Are* the Engines?

Diane Doers, DeltaHawk's president, noted that five engines are doing field duty (in UAVs and a manned helicopter). Two more were delivered mid-August. The helicopter program triggered significant changes. "The helicopter needs 100% power, 100% of the time," she said, "and that required some major work." In 2006, the fuel system had to be redone, due to a supplier problem. Perhaps spooked by these items, Delta Hawk decided in 2006 to run a comprehensive 300-hour test (double the FAA certification test) to see what else they needed to work on. Good news so far.

Some of the beta-test engines in the field (five more engines were slated for delivery in September) are several years old, and none has experienced any failures. But the latest estimate for bulk, real-customer deliveries is now February 2007. "The bad news is we've slipped," Webb said. "The good news is we're not going to ship an engine until it is ready to ship."

I talked in August with Dean May, a DeltaHawk investor, whose own Velocity has been promised an engine since mid-2005. His assessment was sanguine. "My impression is that they're meticulous," he said. "They don't want to send out a bad engine. Every major problem has been solved; whatever's left is minor. Sure, money is a problem. They have four people doing the job of 10." He added, "They've had my airplane over a year, and it's no closer to having an engine on it than when it came. I'm frustrated, but I still have tremendous faith, and I'm glad they're so meticulous."

President Diane Doers summed up: "Our enthusiasm and naiveté have led us to be over-optimistic in the past, but we're so much closer now, and we know we will do it right." The engine holds so much promise, looks so good, and is, indeed, so close—I'll keep the faith another few months. +

For more information on the DeltaHawk engine, call 262/634-9660. A direct link to the company's web site can be found at www.kitplanes.com.