OIL COOLER 101

Oil coolers are readily available in a wide range of sizes to accommodate the packaging and heat rejection needs of any airplane engine. Given minimal care, they'll far outlast the engine's TBO.

What the Homebuilder should know about oil coolers.

BY TOM WILSON

Oil coolers are one of those items that no one thinks about unless they are trying to decide where to hang one on the firewall or when high oil temperatures are a problem. But if you fall into one of those two categories, oil coolers can become a surprisingly dynamic interest in your life. A general lack of useful knowledge around the typical airport doesn't help matters.

Our interest in coolers was sparked by one that sprang a leak—in flight. Watching the oil pressure drop to zero while racing for the nearest airport can be highly motivational, and once safely on the ground, we set out to educate ourselves about oil coolers. Here are the practical highlights of what we learned.

How Hot is Hot?

Typical oil temperature recommendations from Lycoming, Continental and Rotax are for 190° F, as measured in flight. In reality, this means the oil inside the engine is hotter, above 212° F, which is necessary for evaporating the prodigious volume of water that accumulates as a natural byproduct of gasoline combustion.

The top of the green arc for mineral oil—and the bearings it lubricates—is about 230° F. Above that, the oil breaks down with increasing rapidity, and starting somewhere around 260° F, mineral oil goes south in a major way. Aim for 190° F as your normal operating oil temperature and accept a little hotter under adverse conditions, such as climbing out of Death Valley in summertime.

Continental oil coolers, left, are engine-mounted and of bar-and-plate construction. Lycoming engines use remote-mounted oil coolers, typically, but not necessarily, of drawn-cup build, as seen on the right. Remotely mounted coolers require more savvy from the aircraft builder to properly integrate into the airframe, but allow Experimenters more freedom in under-cowl packaging.

Easily the most common oil cooler in the sport aviation world is this seven-row drawn-cup unit found on everything from four-cylinder Cessna singles to RVs. AERO-Classic sells it under p/n 8000017. They report many calls regarding this cooler and conclude that while it's a good, inexpensive cooler for standard duty, it's marginal in warm climates or less-than-ideal installations.

Also worth noting is that cold oil is a lousy lubricant, and the molasses-like syrup used in air-cooled aviation engines is not on the job below 100° F. Warm your engine before that first morning take-off!

Lycoming vs. Continental

Continental engines use engine-mounted oil coolers while Lycomings employ remotely mounted coolers. In practical terms, this means oil cooler sizing and placement is predetermined for Continental drivers, while Lycoming pilots get to science out how much oil cooler to place and where.

Cooler sizing and installation is a fascinating, variable-filled corner of aircraft engineering that is far too complex to do justice to here. But take to heart that higher-performance engines need more oil cooling than the garden-variety versions. In other words, if you've added compression to your RV-8 engine, it's going to require more oil cooling than when the same engine putt-putted a Cessna 172 through the sky. To a large degree, this is because the oil cools the bottom side of the piston, and if you've added more heat to the combustion chamber, the bottom of the piston runs hotter. This phenomenon is illustrated by how oil temps cool dramatically with reduced power or lean-of-peak operations. It makes sense, as less fuel burned means less heat in the engine, and thus cooler oil.

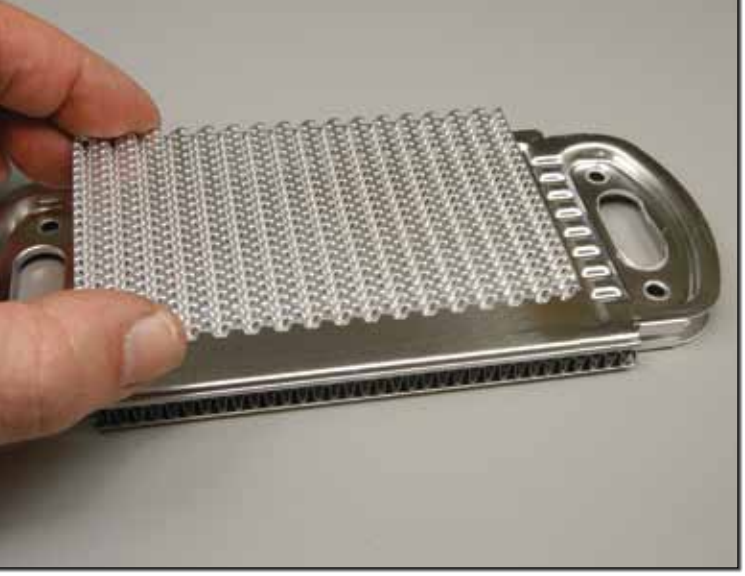
Don't forget that general engine cooling is interrelated to oil cooling. If the cylinder heads don't get enough cooling air, the oil cooler will be asked to pick up the slack. And vice versa.

Another major concern is how well the oil cooler is fed cooling air. Installations with dedicated cooler scoops tend to run cooler than those siphoning general under-cowling air, especially one with leaky air baffling, inadequate airflow and so on. Above all, a general lack of cooling air flow (too large a cowl opening and too small a cowl exit) is a recipe for hot oil because airflow over the oil cooler is choked.

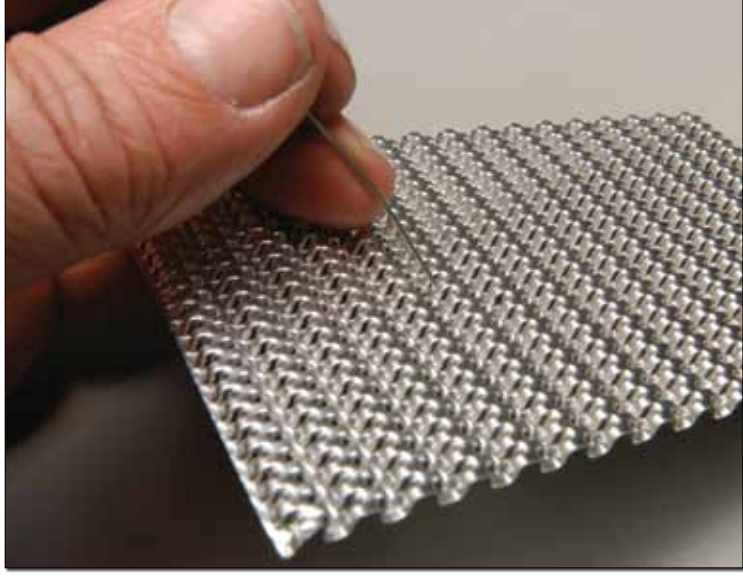
In the end, most oil coolers on Experimentals are selected and mounted under the cowl by looking at what others have done and following their lead. It's a practical strategy, especially for common applications such as RVs. Get exotic, with modified

Drawn-cup cooler, left, is identified by finned end tanks and lack of welds, while the bar-and-plate cooler at right has smooth, hydroformed tanks welded in place. Not visible here is the greater fin area of the high-efficiency bar-and-plate design sold by AERO-Classics, which gives it greater heat-rejection capability for its overall size.

Photos: Tom Wilson



A turbulator plate is placed into a recess in one section of a drawn-cup cooler. Oil flows along the major axis of the turbulator plate, squeezing through the numerous holes in it, thus increasing the oil's contact with the cooler's surface area. Cooling air flows through the sine-wave-shaped fins in the drawn-cup section.



Tiny passages in the turbulator plate form a mesh the oil must pass through, which is too tight for .032-inch safety wire to penetrate, save at an extreme angle. It's these many small orifices that accumulate gunk after years of service and aren't going to be cleaned by a few hours in a solvent tank.

airframes and hot-rodded engines, and there's a good amount of engineering to sort out the oil's thermal load and necessary cooling air mass that will require professional input. Often, data can be obtained from your engine shop, airframe kit maker and oil cooler manufacturers, most of whom are happy to assist in sorting out a specialized application using their in-house engineering resources.

Blow-By Kills Oil

Another truism is that worn-out engines with high blow-by past the piston rings absolutely heat the oil. The large diameter cylinder bores and loose piston-to-cylinder wall gaps inherent in air-cooled aircraft engines are prone to overwhelming blow-by when the rings and cylinders wear out. No oil cooler can handle that sort of heat. If your engine drinks a quart an hour, turns the oil black in three hours and routinely runs 240° F oil temps, you need an engine overhaul, not a larger oil cooler.

Drawn Cup vs. Bar and Plate

There are two basic types of construction for remote-mounted Lycoming oil coolers: drawn cup and bar and plate. The drawn cup was made popular by Harrison (part of General Motors) and Niagara (NDM) and is common. Characteristics of the drawn-cup design are low cost, moderate efficiency and a degree of fragility around the fitting bosses.

Bar-and-plate coolers were popularized by Stewart Warner (now known as Meggitt) and Positech. They are more expensive, tend toward higher efficiency and are robust around the fitting bosses.

Both cooler types have their place, and both styles are commonly available

Parts scrounging is a time-honored tradition in Experimental aircraft building, but it pays to be cautious when un-earthing veteran oil coolers from an A&P's dusty shelves or at the swap meet. This one has been yellow tagged indicating it was cleaned by, guess who, Pacific Oil Cooler Service. But who knows about the other coolers in the background?

These giant coolers are old-school tube-type units, likely off a DC-3. They're being internally washed in a flushing bench at Pacific Oil Cooler Service. Pacific runs coolers through four different flushing stations until nothing larger than 10 microns comes out.

Drawn-cup coolers are weak around the fitting bosses and absolutely require using two wrenches—one on the cooler's hex, the other on the fitting—during fitting install/removal to avoid damaging the cooler. Some coolers have round bosses (no hex), and although it leaves unsightly marks, these bosses must be backed up with large slip-joint pliers. Pacific says using only one wrench on cooler fittings is a major cooler killer, and that once fittings are installed, it's best to leave them there, even when sending them out for service.

Pacific Oil Cooler Service notes their number-one issue with installations is thread-galling aluminum AN fittings (left). They are adamant all fittings must be steel (right) because steel fittings never gall the cooler's aluminum threads, even after many decades. They install steel fittings dry, or with red Loctite. If steel fittings seem too tight to remove safely, Pacific says a little heat from a torch does the trick.

in the Experimental market because AERO-Classics, arguably the most well-known oil cooler maker for Experimental (and many certified) owners, makes both styles. AERO offers their drawn-cup coolers under the remote-mount banner and their bar-and-plate coolers as the HE Series.

We'll cover the differences between drawn-cup and bar-and-plate units with a more in-depth article in an upcoming issue, but for now, the more challenging applications would seem to be naturals for the bar-and-plate cooler.

Cooler Lifespan

In normal operation, oil coolers have unlimited life spans and do not time-out

due to internal erosion or other use-driven issues. What kills coolers is corrosion on the *outside* of the unit. It's tough to corrode the inside as it always has a coating of oil on it. Deformation of drawn-cup units during installation of the fittings, and thread galling on all coolers due to using aluminum fittings are also wear issues. It's also possible to burst a cooler with excessive oil pressure, but you typically have to work at that by installing gaskets incorrectly so that unregulated oil pressure is directed to the cooler during a cold start.

As the photos show, the working passages of an oil cooler are surprisingly tight and sinuous, and because of the constricted internal clearances, the cooler does a fair impression of an oil filter. Over time, junk builds up in the cooler and its effectiveness is reduced. Furthermore, engines making metal can fill a cooler with abrasive debris, which is why you absolutely don't run an old cooler with unknown history on a fresh engine without professionally servicing the cooler.

Corrosion starts on the outside of oil coolers when moisture-trapping dirt becomes lodged in the cooling fins. Pacific Oil Cooler Service says the cooler core should be cleaned with soapy water and blown dry at annual time. Work gently around the fragile fins, but otherwise this is a simple job an owner can do. Corrosion is what caused our cooler to spring a leak in flight, something you want to avoid.

Cooler Servicing

Because oil coolers are built from a stack of components that are furnace-brazed together, they are monolithic, one-piece parts, once they leave the factory. Some weld repairs of small cracks are possible, but once a cooler is assembled it cannot be disassembled for servicing.

As Pacific Oil Cooler Service explained, what can be done is that the cooler can be externally cleaned, pressure checked for leaks, fins straightened, some minor damage weld repaired and the big one—cleaned internally using specialized equipment. Pacific details their process on their website *(www.oilcoolers.com/overhaul_process.asp),* but the take-away point is that the big job of internal flushing is done using chemicals pumped at 80 gallons a minute, changing direction of flow every minute, for 40 hours. Pacific has specialized cleaning benches that automate this process, with the coolers moving through

Pacific Oil Cooler Service/ AERO-Classics

Paul Saurenman and family run two business under one roof in La Verne, California. On one side, AERO-Classics, Inc. builds new oil coolers and heat exchangers; on the other, Pacific Oil Cooler Service cleans and repairs existing coolers. Both enterprises are FAA certified, and while military, industrial and automotive heat exchangers are occasionally found on both sides of the building, the core—no pun intended—business is overwhelmingly general aviation. This includes growing OEM work for Cessna and Robinson helicopter, plus after-market Experimental, certified, classic and warbird applications.

Pacific/AERO's command of the oil cooler realm is extensive; this article was written in large part from their accumulated knowledge and photographed courtesy of their large stock of coolers.

Large enough to have good resources such as vacuum-brazing ovens and an in-house engineer, but still family run for quick responsiveness, Pacific/AERO seems a good resource for kit builders. They can be reached at *www.aero-classics.com*, 909/596-1630 or *www.oilcoolers.com*, 800/866-7335.

— T.W.

If aluminum fittings are the only option, anti-seize lubrication is a must. Even with this thread lube, the chances of galling the threads in the cooler are a near certainty. There's slim hope of repairing such damage with a thread insert because its installation generates too many metal chips.

Straightening fins is a tedious, time-intensive job, but necessary for maximum cooler performance. It's also something you can do as there is no special skill or tools involved; simply guide the bent fin straight with a thin metal or wooden tool.

four different machines—ultrasonic and then three different flushing benches using different pressures and volumes. The final-stage fluid must clear a 10 micron screen or the cooler is re-cleaned until it does—or it is rejected.

Pacific reports that this extended cooler flushing is necessary to dislodge the crud from the cooler's tiny internal passages, which makes it obvious that directing your solvent tank's discharge into a used cooler for a couple of hours isn't going to come close to doing the job.

There's plenty more to oil cooling that we'll explore in future stories, but much of the practical advice is right here: Keep the cooler's exterior clean, always use back-up wrenches when installing fittings, only use steel fittings, and once fittings are in the cooler leave them there. Also have the cooler professionally serviced at engine overhaul.

Beware of used coolers with unknown histories—they should be professionally serviced before being plumbed into your engine—and ask for pro advice if deviating from common kit aircraft construction. With minimal effort, you should be rewarded with no-worries oil cooling and near-zero maintenance. +