The Oil Report

February 2006

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416 E. Pettit Ave.

Everything else stays the same!

Spotlight on...

Aircraft Cylinders

by David Stovall

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Understanding aircraft cylinders is not rocket science. Except for some improvements in metallurgy and barrel plating, the technology found in aircraft cylinders has remained the same for almost 50 years. Nonetheless, here is information to help alleviate some of the confusion surrounding the subject.

New or rebuilt?

Almost everyone who owns a piston-driven aircraft must, at one point or another, make the decision to repair, rebuild, exchange, or buy new engine cylinders. If money is no object, new cylinders are probably the best choice. But for those of us trying to save every dollar we can to keep our birds flying, other alternatives are worth a look.

Begin by determining why you need cylinders in the first place. Are you doing a major overhaul or just a top overhaul? Is your engine high time and you're just trying to squeak some more flying out of it? The answer to these questions is in direct proportion to the amount of money you'll spend on your cylinders.

Major Overhauls

Both Lycoming and Continental have issued service bulletins stating exactly what parts should be replaced. The list includes almost everything in the cylinder except the cylinder itself.

A quick survey of cylinder repair shops around the country revealed the average cost of a completely rebuilt Continental or Lycoming cylinder with chrome or nickel plating and new parts installed, including valves, piston, rings, etc. to be between $700 and $850 plus a core charge of around $100. New cylinder prices begin at around $950 outright depending on the exact model.

Top Overhauls

Let's assume your engine is mid-time from TBO but compression is dropping, valves are leaking and perhaps there's a nice, slick coating of oil on your aircraft's belly. You're in need of a top overhaul.

All this leaking of gases and oil by your engine is usually due to worn out guides and rings and maybe valves. But buying new cylinders at this point is only throwing good money away. If your cylinders still have barrels measuring in the serviceable range and do not require welding of any major cracks, it is probably more economical to repair rather than exchange them. If an inspection reveals they need barrel plating and major welding, then you should seriously consider exchanging your basic cylinder, and having your pistons, intake valves, springs, etc. inspected and reinstalled in the rebuilt cylinder along with new exhaust valves. This is your most economical route to a top overhaul.

Cracks and Welding

Most cylinders will develop a crack within their lifetime. Victor Toledo, cylinder overhaul technician at Sentry Aircraft Cylinders, estimates that 80 percent of cylinders flying right now are cracked to some degree. Toledo says that 90 percent of the cylinders arriving at Sentry require some degree of welding.

Cylinder heads are made of cast aluminum, and while this is a fairly durable alloy for the application it lacks the flexibility to forever withstand the extreme temperature fluctuations that occur during normal engine operation. If a cylinder has more than 800 hours on it, it is probably cracked.

Keep in mind that a crack can be anything from a barely visible surface crack appearing on the head inside the barrel, to a gaping fissure in the port that extends to the outside of the head. Every type of cylinder has its individual weak points. Most cracks form in the exhaust port with small cracks around the spark plug bosses.

So now your cylinders need some major welding as well as some rings, seats and guide work. Can they be weld repaired? Probably, but most cylinder welding is very labor intensive. The intense heat of welding can warp the barrel, though this is correctable in the chroming process. Add to this risk the time involved, and cylinder exchange begins to sound much better. Most cylinder shops have a ready supply of rebuilt cylinders to fit your engine.

The true total time is one concern often heard when exchanging cylinders. Manufacturers want you to believe that rebuilt cylinders could have eight to ten thousand hours on them. Three runs to TBO is about the maximum for an aircraft cylinder and a good, reputable shop will scrutinize cores before repairing them. If a cylinder has excessive amounts of prior welding or excessive damage, it's probably ready for a new career on an airboat chasing alligators in Florida.

If you have first-run cylinders and are dead-set on having them rebuilt, be prepared for a turnaround time of three to six weeks.

That's the way it is and if anyone tells you differently they're stretching the truth. Cylinder overhaul is time and labor intensive and not something you want anyone to rush. Ads in trade magazines announcing "48-hour turnaround on most cylinder repairs" are simply hooks to get your business. The key words here are most and repairs. Rebuilding them takes considerably more time.

If you want an accurate estimate of the cost of rebuilding your cylinders, you must send them to a shop for evaluation. Calling around for estimates while your cylinders sit on your engine is like calling house painters for estimates without them looking at your house.

Inspection involves measuring the inside diameter of the barrels and guides and examining the seats. Dye penetrant inspection of the head for cracks is performed as well.

Don't pull your cylinders, call a cylinder shop and say, "They look okay to me." Cylinder guys hate that. There's not much you can tell about a cylinder by pulling it off the engine, still coated with oil and carbon and merely looking at it.

Again, if your engine is at least mid-time and/or is in need of a top overhaul, cylinder exchange is probably the most economical and sensible route.

Request that your springs, intake valves, pistons, etc. be removed, inspected, and re-installed with new rings into a rebuilt stud assembly. If you're buying steel barrel cylinders, make sure the barrels are new, not "serviceable," which means used. Put them on your engine and you're starting where you were with your own cylinders. It is recommended that cylinders' barrel surface be at factory new limits, whether they are chrome, nickel or steel. The only way to achieve this is to have fresh, unused, chrome, nickel, or new steel barrels.

Cylinder Barrel Plating

Cylinder barrel plating is a subject most mysterious among aircraft owners and mechanics. But it's really pretty simple, and there are only a few options available.

Like many great inventions existing in our society today, cylinder plating came about during or shortly after World War II, to extend the life of cylinders on military aircraft. When worn beyond serviceable limits, channel chrome, relatively inexpensive and very durable, saved an otherwise unsalvageable cylinder barrel. It worked so well that it remained the one and only cylinder plating process for almost forty years.

Chrome plating a cylinder is another labor-intensive process. This, combined with the environmental concerns of chrome, has seen the number of cylinder chroming facilities in the world dwindle down to four, three of which are in the United States. (Not included in the count is Engine Components, Inc. and their nickel-alloy plating process.)

The chroming process begins with measuring the inside diameter of the cylinder barrel to determine if it has already been worn beyond its limits. If not, it is mounted on an I.D. grinder and ground

until a perfectly round, clean surface is achieved. Choke, a narrowing of the end of the barrel for better performance, is added to the cylinder by tapering the grinding stone before grinding.

There are, of course, limits to how far a cylinder wall can be ground. Depending on the cylinder, the range is from .022 to .030. Cylinders with deeply pitted barrels or that have been previously oversized to +.015 are probably not eligible for chrome plating. If you have some irreplaceable cylinders off an antique engine, some chrome facilities will grind beyond the normal limit, if asked, in order to save the cylinder, but don't expect them to come back yellow tagged.

Next, the cylinder wall is sandblasted to provide the chrome an ideal surface to adhere to. The cylinder is dipped in wax up to the bottom of the barrel to protect the aluminum head from chromic acid present in the chroming process. An anode attached to a very heavy-duty looking steel rig is centered inside the cylinder and the whole thing is lowered using an overhead hoist into a boiling chrome bath. An electric current is applied to draw the chrome out of the bath and apply it to the cylinder wall.

It's interesting that a cylinder chroming facility is downright medieval in appearance. The chrome technician, wearing long black gloves and black apron, presides over an array of large electric rectifiers atop boiling chrome tanks. If you squint a little, the scene resembles a scientist's lab from an old black and white movie.

The amount of chrome applied to the cylinder is determined by how long it is immersed in the bath. Cylinders are only chromed to original standard bore size.

Once the chrome has been applied, the electric current is reversed. This is when the "cracks," or channels, appear in the chrome. Since chrome is harder than steel and does not absorb oil, these channels are critical for essential lubrication by providing the oil a place to travel. Too many channels will cause too much oil consumption, while too few will not provide enough lubrication. The amount of channels in a given surface area is called porosity, while the areas between the channels are called plateaus.

A channel chrome cylinder that has been run on an engine might still measure in its serviceable range but be unable to provide adequate lubrication. This is because the plateaus have worn down, reducing the depth of the channels. After chroming is complete, the cylinder is honed to ring finish, then inspected dimensionally for correct size and tagged.

It is important to closely follow break-in procedures for channel-chromed cylinders. Failure to do so may cause problems with rings seating properly, and result in excessive oil consumption. If rings have not seated within 25 hours and oil consumption is high and increasing, it may become necessary to remove and re-hone the cylinders and install new rings.

New Cylinders

Four companies manufacture engine cylinders for aircraft. They are Lycoming, Teledyne Continental Motors, Superior Air Parts and

Engine Components, Inc. Superior and ECI produce cylinders for use on the most common Lycoming and Continental engines.

Who makes the best new cylinders? As with any product, each manufacturer claims its cylinders are top-of-the-line when compared to the others. In reality, they are all very similar in overall quality.

Superior Air Parts has developed an investment cast process for its Millennium line and, while more expensive, appears to perform well with strong resistance to cracks.

Over the years, all the cylinder makers have learned where their products are prone to form cracks and have beefed up those areas with extra metal in the casting process. All offer similar warranties. When it comes down to it, look for the big distributors with lots of cylinders in stock, and shop for price. Several types of alternative barrel plating are available to choose from.

Nu Chrome

Nu chrome is a process that improves upon channel chrome by virtually eliminating break-in problems. The term 'Nu' is a trade name and the process is a closely guarded secret at chrome facilities. With Nu chrome, the cylinder goes through the same procedure as channel chrome but stops before the channels are created.

The cylinder is removed from the chroming tank and silicon carbide 'mush' is mechanically honed onto the surface. This silicon carbide layer is very thin. The result is a surface that absorbs oil and is slightly abrasive, facilitating lubrication and ring break-in. Identified by orange paint visible on the top of the cylinder, Nu chrome has excellent break-in and oil consumption characteristics. It is not known for its ability to reach TBO intact, however. As with the old Cermichrome, the silicon carbide coating tends to wear away prematurely leaving only the slick, unchanneled chrome underneath.

Satin Finish

Satin Finish is the trade name for the combination of channel chrome and Nu chrome. After the cylinder is channel chromed, a thin layer of silicon carbide is applied, giving the barrel surface a dull finish, hence "satin."

The advantage is that the slight abrasiveness of the silicon carbide assists ring seating, and the channels ensure proper lubrication. Satin finish is recommended for those concerned with break-in difficulties sometimes associated with channel chrome. It is also identified by orange paint on the cylinder.

Cerminil Process

Not to be confused with the now discontinued Cermichrome, Cerminil Process is a nickel alloy cylinder bore coating developed by Engine Components, Inc., of San Antonio, Texas.

After electrochemically depositing the nickel-silicon carbide composite, the cylinder bore is machined to size and given a ring

finish. A teal and silver colored band painted on the barrel identifies the cylinder as Cerminil.

Cost is more than the chrome processes but Cerminil offers excellent performance and wear characteristics, and deserves consideration when looking for replacement cylinders.

Cermichrome

Discontinued in the early ’90s, Cermichrome was a process invented by Engine Components, Inc., to overcome occasional break-in difficulties associated with channel chrome. Shortly after Cermichrome made its debut in the cylinder world, aircraft owners and mechanics began reporting loss of compression after only a few hundred hours. In most cases, upon inspection it was discovered that the silicon carbide coating was worn away, a deep ring step had formed, and barrel dimensions were out of limits.

A number of engines with Cermichrome cylinders are still out there. Many are on planes used infrequently by their owners, not flown enough since installation of the cylinders to develop problems. A double orange band painted on the cylinder, visible from the top, identifies the cylinder as Cermichrome. Should you replace them? Probably not, unless you’re experiencing low compression and/or abnormal oil consumption. Some people have never had problems with Cermichrome, and you may be one of these lucky ones. If you do have to remove them though, Cermichromes can be re-chromed using the correct process (as with any chrome cylinder).

Never use chrome-faced rings or any rings intended for use in steel bore cylinders in a chrome or Cerminil cylinder. Doing so will create a "corduroy" look on your cylinder walls and cause engine failure, usually within the first hour of operation.

Here are the key points to remember when considering rebuilding or exchanging your cylinders:

1. For top overhauls, consider exchanging your stud assembly; use your parts with new rings, and have new exhaust valves installed.
2. For major overhauls, new cylinders are great but rebuilt units can save you $100 or more per cylinder over new ones. That’s $400 to $600, depending on how many cylinders your engine has.
3. If your cylinders require barrel plating, welding and overhaul, the cost of rebuilding is likely to be equal to or greater than the cost of exchange cylinders.
4. Seek out and buy from a reputable cylinder repair shop. Several shops have their own web pages on the Internet. Just type in “aircraft cylinders” on your favorite search engine.

Terminology

Here are some terms to use when consulting with a cylinder shop so you can sound like you actually know what you’re talking about:

Stud Assembly

Contains seats, guides, and rocker shaft bushings (if applicable).

Cylinder bore is either standard or oversized steel, chromed. The cylinder is painted and ready for assembly.

Valve Assembly
Same as a stud assembly but with valves, springs, and spring retainers installed.

Complete Assembly
Same as a valve assembly but with piston, piston rings, and piston pin installed. Rings are gapped and positioned.

Choke
The reduction in diameter of the cylinder barrel at the head end at ambient temperatures. The heat of combustion allows the barrel to expand more at the head end than at the bottom, causing the barrel to be virtually straight during normal engine operating temperatures.

Report of the Month

What's wrong with this Lycoming IO-540-C4B5 engine? See the caption below for an explanation. Don't look right away -- take a good look at the report first.

(To learn where the various elements might be coming from, click here.)

Elements in Parts Per Million

MI/HR ON OIL	46	UNIT/ LOCATION AVERAGES	30	30	25	45	UNIVERSAL AVERAGES
MI/HR ON UNIT	406		294	177	236	148	
SAMPLE DATE	4/4/05		3/17/04	11/24/03	10/29/03	1/10/03	
ALUMINUM	27	17	**23**	15	24	45	7
CHROMIUM	4	6	3	3	3	10	8
IRON	68	39	**36**	**37**	**38**	76	36
COPPER	18	8	12	12	13	25	7
LEAD	6200	3491	**4263**	**5132**	**4398**	7898	3084
TIN	5	1	4	0	2	4	1
MOLYBDENUM	4	1	2	2	3	7	0
NICKEL	16	13	12	12	12	32	4
POTASSIUM	0	0	0	0	0	0	0
BORON	0	0	0	0	0	0	0
SILICON	5	8	9	8	9	13	6
SODIUM	1	1	1	1	2	2	1
CALCIUM	14	3	6	9	14	9	2
MAGNESIUM	28	7	16	12	15	23	4
PHOSPHORUS	879	698	797	780	729	585	537
ZINC	11	4	7	7	9	7	4
BARIUM	0	0	0	0	0	0	0

TEST	cST VISCOSITY @ 40 C	SUS VISCOSITY@ 100 C	cST VISCOSITY@ 100 C	SUS VISCOSITY @ 210 F	FLASHPOINT IN F	FUEL %	ANTI-FREEZE %	WATER %	INSOLUBLES %

Properties										
	VALUES SHOULD BE				82-105	>440	<1.0	-	0.0	<0.6
	TESTED VALUES WERE				110.9	505	<0.5	-	0.0	0.8

This engine hadn't looked right in a long time. They were able to keep the wear metals on the lower side (though still higher than avreages) by keeping the oil changes at 25-30 hours, but once they went back to 46 hours on the oil it became quite clear that the piston scuffing (aluminum and iron) and exccessive blow-by (lead) was from some kind of alignment problem. In the end they only got 406 hours out of the overhaul they had done in 2002, as they had to replace six cylinders and rings. In the higher viscosity and insolubles, you can see that the oil was suffering physically from the extra heat generated by the problem.

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