Ryan Gomes

Power Plant Inspections

Taking that annual look under the hood
by Ryan Gomes

Well, unlike the unpredictable world we live in there is one thing you can count on every year, that approaching and dreaded date (for some) that lingers in the back of your mind every time you go for a flight - your annual. For some home-builders, this can be a daunting task, and for others not so much. The initial construction of the aircraft, which consisted of a lot of new parts and careful assembly, was a very well guided project. Most amateur aircraft kit manufacturers provide a nice step-by-step guide that will walk you through the process of building an aircraft. Hovwever in my honest opinion, where manufacturers really fail and hang their customers out to dry is in the maintenance department.

They do not provide a "maintenance manual" per se that manufacturers of the certified category would. I have the manual to a Cessna Turbo Centurion on my desk right now... 650 pages, at least. Amateur built aircraft manufacturers really only provide us with some of the standards for the aircraft, a pilot operating handbook and sometimes a set of plans. There needs to be more support for the homebuilder. I was taught that with inspections, there are two different types of mindsets. You either need to be like a hawk, or an eagle, and it really depends on the type of inspection. An eagle is looking for very particular things to hunt, as one would in a pre-flight check -easy things to pick up like water in your fuel and major oil leaks. A hawk however, flies

overhead inspecting a broader area, looking for things to pop out… It gets the bigger picture. That is key in thorough inspections. Do not try focus on one little area when you are inspecting the engine compartment. You want to keep your eyes open to anything that does not look right in the surrounding area. Take the time to really check every nook and cranny, as opposed to being fixated on one particular thing. Get the big picture!

Now that we have had an overview of the inspection mentality, let us actually discuss some of the considerations during the inspection. This is by no means a complete tutorial on how to do an annual, but a guideline and collection of tips to help in the inspection process and something to help with your judgment in completing your annual check list.

The first place we start is always with four key events. The run up, the compression test, the oil change and last but not least the inspection. Both the oil change and the compression test need to be done when the engine is still hot as this will get you the best results. Now I am sure that you all know how to do an oil change, so I am not going to get into much detail on that, but the run up and compression test are for sure things I am going to cover, because we can extract a lot of useful information that will greatly reduce the time it takes to perform an annual.

The Run Up

To perform a proper run up, you first need the engine idle until the oil temp is in the green operating region. Doing it any earlier than that is not advised - it will actually reduce your engine's life. Once the engine is warmed up we do a live mag check to ensure that the P-lead on the magneto is functioning correctly. This should be done at idle. Now increase power to 1200 (or 1700, there is much debate as to which rpm is best), and perform a mag drop test. You should see a drop of UP to 120 rpm per side, and a max differential between the left and right mag of 50 rpm. Any more means that your mag timing is off and you should obtain a box buzz to check the magneto timing. At this rpm, we are also going to do a mixture check, carb heat check (for non-injected models) and an alternator check. For the mixture check, slowly bring the mixture knob back to the idle cut off position (ICO) and observe the rpm. If the mixture is right, you should see an increase of 25 – 50 rpm. No drop means the engine is too lean, and more than 50 rpm means the engine is set too rich. I will not cover the science behind it in this article, because this is an overview of the overall engine.

The alternator check is easy enough. Turn everything on (e.g. Strobes, landing light, etc.), cut the alternator, and observe your ammeter. It should drop right off, and the alternator light (if your aircraft is equipped with one) should turn on. If you have a digital display, the voltage reading will drop from 14v and if it drops below 12v, it is indicating that the alternator is no long charging the battery and that the auxiliary equipment is running from the battery. If your light was on before you cut the alternator switch, then there is a problem with the alternator, the belt, or the voltage regulator. If the charging indicator was already reading below 12v, you get the picture, the alternator is not doing its job.

The carb heat check is just simply testing to make sure that the carb heat is working on your non-injected Lycoming. Pull the carb heat, and you should see a drop in rpm. This has to be done when the engine is warm, because there will be no drop on a engine that has just started.

Other things to note, is that if you are running gyro driven instruments, you must check your suction gauge. The vacuum pumps should be putting out about 5.0 in hg. If it is over the green arc, you need to adjust your vacuum regulator. Anything under the green arc and you should check for leakage, or the graphite vanes on the vacuum pump might be worn out.

This concludes the run up portion of the annual. The run up is a very useful part of the inspection and a lot of information can be gathered from doing these simple checks that should really be performed before each flight.

The Compression Test

So your plane is in the hanger, the cowling is off and it is time to perform a compression test. I must warn that without practice, confidence, and knowledge, this test can be deadly. It should only be performed by yourself if you have prior experience. I do it myself at work every day; I am safe, and always cautious. The key words in that sentence are every day. It is an awkward job and the last thing we want is for someone to not have a good grip on the propeller and to get hit by it. You really should perform this with a second person. This is why we did a live mag check also, to make sure your p-leads are working so the magnetos are grounded when the switch is in the off position.

Pull the bottom (or top depending if it is easier) spark plugs, and place them in a tray in order. Now it is better to have a quick disconnect tester, but most require you screw the whole hose of the tester into the head. Find cylinder number 1; it is the forward cylinder on the right hand side of the engine for all Lycomings. Find top dead center, this can be easily done if you have Slick Magnetos with an impulse coupling, simply put your finger on the spark plug hole of the #1 cylinder, and rotate the propeller until pressure builds at your finger tip, and you hear the snap of the impulse coupling.

This will make sure the engine is at or near TOP DEAD CENTER. Ensure that all valves of the gauge set are in the

off position. With your hands holding both sides of the propeller with a sturdy grip, your friend can proceed to turn the FILL valve. While filling the cylinder the prop might start to move, indicating that the cylinder is not quite at TDC. Stop adding pressure and rotate the prop until the piston is at TDC. You will know that it is correct when the prop stops trying to move. Then continue to add pressure until the gauge reads 80 psi.

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There are two gauges on the tester, one for the amount of air going into the cylinder, one for the amount of air the cylinder is holding. The air going into the cylinder should be set to 80 PSI. The cylinder will now fill with air and you can move the prop slightly back and forth to try and achieve the best numbers on the regulator.

The cylinder should hold anything from between 60 to 80 PSI. Anything less than 60 means that the cylinder is unserviceable and needs to be overhauled… period. There is no room for budging on that number, at least not with me. If your cylinder is reading less than 60, it means that there is either problem with the cylinder, or the walls and rings are just worn. The cylinder has had a good life, and so have you, so don't fool around with a bad cylinder number; it can kill you.

Repeat for all cylinders, this concludes the compression test.

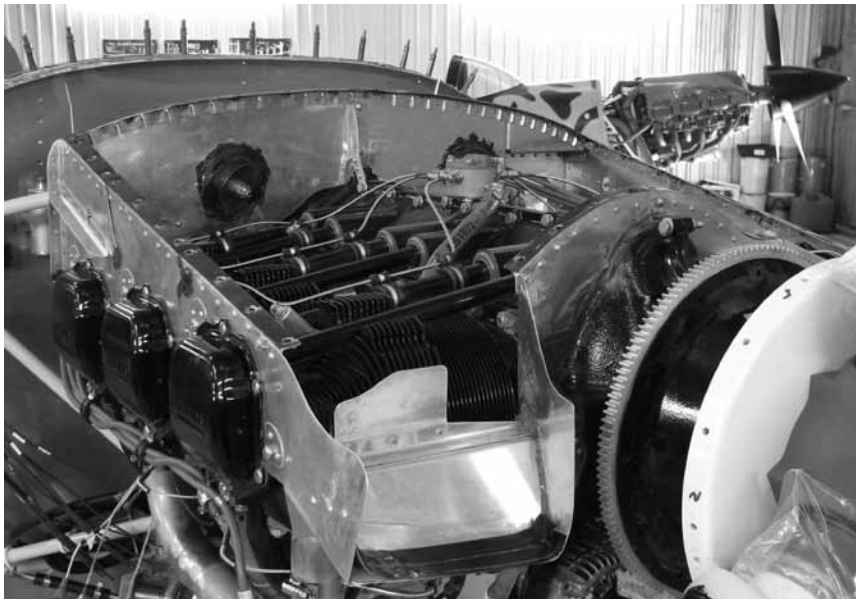
The Oil Change

Not much to say here, just some things to point out. If your engine is getting older, cut the filter… I can't stress enough the importance of cutting the filter in general. You can gather a lot of information… Brass, your main bearings are wearing, ferrous metals; your rings are on their way. Cut the filter with a proper aviation filter cutter (Can be purchased at Leavens, Aircraft Spruce, ATS, any aircraft parts store pretty much) pull the element out, cut it with box cutter, or a hack saw. Pull out the element and the trick is to get the oil out of it by squeezing it in the vice. Pull it out and take a look on the outside of the element, that is where you will find your stuff. Always ensure that the alleged piece of "metal" is in fact metal and not a chunk of carbon, which 9 times out of 10 it is.

If you are particular and have money to spend, take an oil sample while the engine is draining of oil, and send it for S.O.A.P testing. That stands for Spectro Oil Analysis Program. It can generate a lot of information about your engine, especially if done from an early age.

Filters, you want to get a brand name filter like a Kelly Aerospace, Tempest Filter from API, or for people who want a more expensive filter, Champion. One thing to note, is that all the numbers for the filters are in fact kind of standardized, in that a Kelly filter will be a ES48110-1 for an IO-360, and the Champion equivilant will be a CH48110-1, so if you wanted to switch filters you have an idea of what part number to look for.

Always refer to an engine's maintenance manual for specifications on the oil and filter. Most Lycoming engines run 15W50 during the winter, and in the summer most people switch to a W100. I personally like to use Aeroshell when I work on an engine, that is just my preference. It is a Semi-synthetic multi weight oil, and I haven't had any type of compatibility issues with it for any Lycoming, regardless of size or aspiration type. Again check the maintenance manual for all types of fluids and servicing requirements.



What you want in baffling isn't tight clearance, but that it is air tight. Wayne Hadath Photo.

The Inspection

Last but definitely not least is the engine inspection. This is generally where people get lost - they do not know what to look at, or where to focus their attention. I will guide you to some key areas to check on the Lycoming engine, and this applies to pretty much ALL of them.

First off, and this should go without saying, get your engine's serial number, model, and type certificate from the data plate, which is usually located on the oil pan/air plenum. Check for all Airworthiness directives, service bulletins, and service letters that have been issued for it and have not been complied with or check out. I know we are talking about uncertified aviation here, but these really are good practices that will not only improve the overall up keep of the engine, but it will increase its life, and make the owner better aware of what is ahead of the firewall.

Look carefully at the oil dipstick tube - they are notorious for coming loose and leaking oil onto the engine mounts. Oil on the engine mounts is not a good thing and should be cleaned off as soon as possible - oil will deteriorate the engine mount and you will start getting vibration issues. If need be re do the lockwire on the tube to ensure that it is really tight.

Valve cover screws on Lycomings come loose all the time, especially if you have the old style cork gaskets. These will develop a leak at the bottom of the cover and start ruining the cork gasket. Give those screws a tightening, and I can pretty much guarantee a quarter of a turn for most of the screws, every annual. I recommend replacing the star washers if you find it is a persistent problem.

Check for leakage at the crank seal, and this goes for pretty much all engines. Replace if necessary. Check for leakage at the case halves. There is not gasket between case halves; it is literally a silk thread with some gasket sealer. Interestingly they use a silk thread, as to not change the deck height of the cases.

Lycoming engines have their cam shaft at the top of the engine, and with the push rod tubes being at the top of the engine, Lycoming had no way to let the oil drain back to the sump. Because of this Lycomings have oil return tubes at the bottom of every head. Check those for leakage and tightness.

There is an AD out to check for the fuel lines to the injectors on fuel injected models. Just check that the clamping on top of the engine has not caused them to corrode and break apart. Any sign of corrosion is usually a good time to replace them.

Check for blue Avgas stains around the injectors. Fuel injectors have small ports that lead to a place call an emulsion chamber. This is used to help atomize the fuel. Blue staining around the injector means that there is a blockage at the ports of the fuel injector, and that they need to be cleaned. This will also indicate a higher than normal fuel flow rate on your fuel calculator… This is in fact not true. If you are using the "gage" tap from the fuel manifold on top of the engine for fuel flow indication, this is actually fuel pressure, and gives a flow indication. A blockage at an injector will read a high flow, when in fact it is just a build-up of pressure in the manifold and you are running a cylinder very lean. That being said, low fuel flow rate, can mean the emulsion chambers are blocked and your fuel is just dripping into the engine and not atomizing. Confusing huh? I will get more into this, in a more fuel oriented article.

Baffling is very important because it keeps the engine cool. Tight baffling is okay, but it isn't essential. What you want in baffling isn't tight clearance, but that it is air tight! That is a common misconception with baffling. Some people try to design theirs (if

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they are home building) so it hugs the cylinders. They don't need to be like that, I can tell you off hand that the Cessna 172 has at least half an inch between the back baffling "wall" and the cylinder. Make sure that your baffling is not chafing against the engine, and that the strip along the top is making an air tight seal with the cowling. Good baffling will help keep the engine cool.

Look at the wiring for your alternator and starter to make sure nothing is chafing. Check the wiring on your thermocouples. If they have chafed and are not exposed… they should be replaced. Check the wiring to your starter solenoid, and your battery. Batteries should actually be enclosed in their own separate box despite what many people do. The off gassing from the battery will corrode whatever it touches, including your firewall. If you have not already done so, you are best to put the battery in its own box with a drain.

Check all your fluid lines for chafing and proper heat shielding. Provide a means to prevent hoses from chafing too. It is actually acceptable to use a bit of high temp silicone, but it is best to use wire wrap and some type of standoff.

Check all oil lines, fuel lines, vacuum lines etc. for leaking, and tighten as required. When I inspect lines I always put on a dab of witness paste (Torque Seal). This will make inspections easier year after year, as you can see what has come loose.

Conclusion

This is by no means a complete guideline for an annual, but it gives a very good basis as to what you should be checking. Anyone performing his own annual should really track down the applicable maintenance manual for his particular engine and follow the 50 hour, 100 hour and 200 hour inspection intervals, not only the for engine but also for components like magnetos, alternators and vacuum pumps.

The best way to prepare for the annual is by reading the manuals to thoroughly understand the engine. I hope that this article has provided you with a overview of what you should be checking during your annual. RAA