Savvy Aircraft Maintenance

Mike Busch, founder and CEO of Savvy Aircraft Maintenance Management, Inc. and 2008 National Aviation Maintenance Technician of the Year, discusses his thoughts and observations about maintenance of owner-flown aircraft.

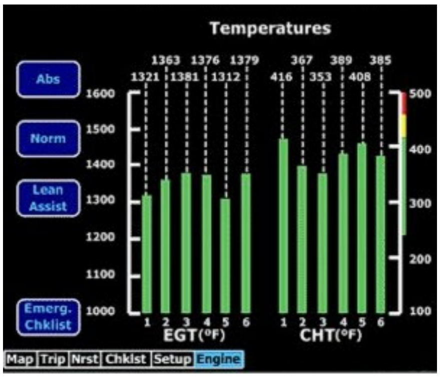
Sunday, March 7, 2010

Mag Check

If you fly a piston-powered aircraft, you undoubtedly were taught to perform a "mag check" during the pre-takeoff runup. But do you know how to do it correctly, what to look for, and how to interpret the results? Surprisingly, many pilots don't.

To begin with, most POHs instruct you to note the RPM drop when you switch from both mags to just one, and give some maximum acceptable drop. This archaic method makes little sense for aircraft that are equipped with a digital engine monitor (as most are these days), because EGT rise is a far better indicator of proper ignition performance than RPM drop. **You should focus primarily on the engine monitor, not the tachometer, when performing the mag check. What you should be looking for is all EGT bars rising and none falling when you switch from both mags to one mag.** The EGT rise will typically be 50 to 100 degrees F, but the exact amount of rise is not critical, and it's perfectly normal for the rise to be a bit different for odd- and even-numbered cylinders. You should also be looking for smooth engine operation and stable EGT values when operating on each magneto individually. **A falling or erratic EGT bar or rough engine constitutes a "bad mag check" and warrants troubleshooting the ignition system before flying.**

The "mag check" is poorly named, because because the vast majority of "bad mag checks" are caused by spark plug problems, not magneto problems. (It's really an "ignition system check.") How can you tell if the culprit is the plugs or the mags? Simple: **A faulty spark plug affects only one cylinder (and one EGT bar on your engine monitor), while a faulty magneto affects all cylinders (and all EGT bars).**



If you get an excessive RPM drop when you switch to one mag, but the EGTs all rise and the engine runs smooth, chances are that it's not a bad mag but rather retarded ignition timing. This is sometimes caused by mechanic error in timing the mags, but it can also be caused by excessive magneto cam follower wear (possibly due to inadequate cam lubrication) or some other internal mag problem. Retarded ignition timing also results in higher-than-usual EGT indications.

Conversely, advanced ignition timing results in lower-than-usual EGT indications, and also higher-than-usual CHT indications. Advanced timing is a much more serious condition because it can lead to detonation, pre-ignition, and serious engine damage. **If you observe low EGTs and high CHTs after an aircraft comes out of maintenance, do not fly until you've had the ignition timing re-checked.**

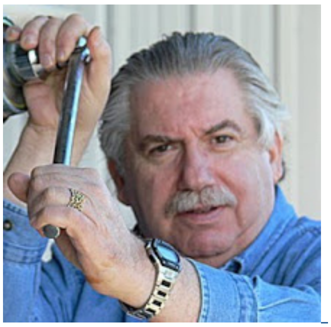
The usual pre-flight mag check is a relatively non-demanding test, and will only detect gross defects in the ignition system. To make sure your engine's ignition is in tip-top shape, we recommend performing an in-flight mag check at cruise power and a lean mixture (preferably a lean-of-peak mixture). **Because a lean mixture is much harder to ignite than a rich one, an in-flight LOP mag check is the most demanding and discriminating way to test your ignition system.** It's a good idea to perform one every flight or two.

The in-flight mag check is performed at normal cruise power and normal lean mixture (preferably LOP). Run the engine on each individual mag for at least 15 or 20 seconds. Ensure that all EGTs rise, that they are stable, and that the engine runs smoothly on each mag. If you see a falling or unstable EGT, write down which cylinder and which mag, so your mechanic or SAMM account manager will know which plug is the culprit.

Posted by Mike Busch at 1:04 PM 11 comments

Changing the Oil

Archive of Mike's blog posts



Mike Busch

About Me

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I normally recommend oil changes every 50 flight hours or 4 months, whichever comes first. (If you fly less than 150 hours a year or your flying tends to be seasonal, the 4 months will usually come first.) I often suggest shortening the oil-change interval after certain engine maintenance (e.g., cylinder change) or if oil analysis results reveal elevated wear metals.

It's important to understand why the oil needs to be changed so often. It's not primarily because the oil breaks down in service and its lubricating properties degrade. Petroleum-based engine oils retain their lubricating properties for a long time, and synthetic oils retain them nearly forever. Consider that cars typically go 7,500 miles between oil changes, which is the equivalent of 150 to 200 hours. Studies have shown that synthetic automotive oil like Mobil 1 can go 18,000 miles without appreciable degradation, and that's equivalent to 400 to 500 hours.

The reason we change oil in our aircraft engines every 50 hours or less is not because it breaks down, but rather because it gets contaminated. In fact, it gets downright filthy and nasty. That's because compared to automotive engines, our piston aircraft engines permit a far greater quantity of combustion byproducts -- notably carbon, sulfur, oxides of nitrogen, raw fuel, partially-burned fuel, plus massive quantities of water -- to leak past the piston rings and contaminate the crankcase. This yucky stuff is collectively referred to as "blow-by" and it's quite corrosive and harmful when it builds up in the oil and comes in contact with expensive bottom-end engine parts like the crankshaft, camshaft, lifters and gears.
To make matters worse, 100LL avgas is heavily laced with the octane improver tetraethyl lead (TEL), which also does nasty things when it blows by the rings and gets into the crankcase. (Back in the days that cars ran on leaded gasoline, oil change intervals were typically 3,000 miles instead of 7,500.) So one of the most important reasons that we need to change the oil regularly in our Continentals and Lycomings is to get rid of these blow-by contaminants before they build up to levels that are harmful to the engine's health.

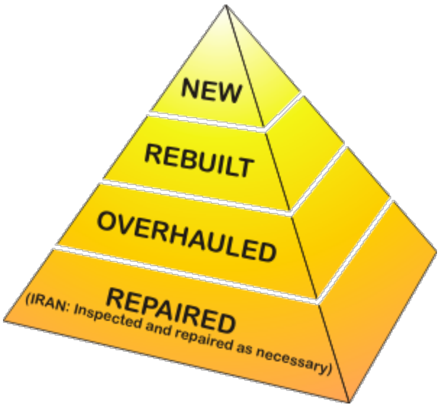
Another reason we need to change the oil frequently is to replenish the oil's additive package, particularly its acid neutralizers. When sulfur and oxides of nitrogen mix with water, they form sulfuric and nitric acids. If you remember these dangerous corrosives from your high school chemistry class, you'll appreciate why you don't want them attacking expensive engine parts. To prevent such attack, aviation oils are blended with acid neutralizer additives. These are alkaline substances that neutralize these acids, much as we might use baking soda to neutralize battery acid. Because these acid neutralizers are consumed by the process of neutralizing acids, it's imperative that we replenish them before they get used up to an extent that might put our hardware in jeopardy.

At each oil change, it's essential to change the oil filter and cut open the old filter for inspection. We also strongly recommend sending an oil sample to Blackstone Laboratories in Ft. Wayne, Indiana, for oil analysis. Although there are a number of different labs that do such analysis, we think Blackstone is head and shoulders above the rest, and we urge our clients to use this lab exclusively.

Posted by Mike Busch at 1:02 PM 9 comments

Watch Your Language!

When an aircraft component becomes inoperative or unairworthy, we usually have a number of options. We can replace the bad component with a ***new*** one, a ***rebuilt*** one, an ***overhauled*** one, or perhaps send out our defective component to have it ***repaired***. These four words -- new, rebuilt, overhauled and repaired -- have distinct, specific meanings in the context of aircraft maintenance, and it's important to understand precisely what they mean and how they differ:



- **New** means never used. Dimensionally, a new component meets new fits and limits (obviously).
- **Rebuilt** means a previously used component that has been **overhauled to new fits and limits** (possibly using approved oversize or undersize parts) **by the original manufacturer.** (For example, only the TCM factory can "rebuild" a TCM engine, although any A&P mechanic can "overhaul" one.)
- **Overhauled** means disassembled, cleaned, inspected, repaired as necessary, reassembled and tested in accordance with the manufacturer's approved technical data (normally the overhaul manual). The word "overhaul" implies conformance to service limits, not necessarily new limits, so if you want new limits you have to specify "new-limits overhaul." (A new-limits overhaul is essentially the same as "rebuilt" except that it doesn't have to be performed by the original manufacturer.)
- **Repaired** means inspected and repaired as necessary ("IRAN") to restore the inoperative compoment to proper working condition. This term implies nothing about fits and limits, because there is no requirement to measure anything when performing a repair. One could, for example, remove a cylinder, replace the exhaust valve and guide, and then put the cylinder back on the engine without measuring anything, and call it a "repair." A repair differs from an overhaul primarily in that there's no obligation to follow the fits, limits, mandatory replacements, and other procedures in the manufacturer's overhaul manual.

The words "overhauled" and "rebuilt" are defined in FAR 43.2, and have very specific regulatory meanings as described above. If a mechanic documents that something is "overhauled" and hasn't complied with every jot and tittle of the overhaul manual, he can lose his A&P certificate. However, if he documents it as being "repaired," he can do as much or little as he sees fit to do, so long as he is satisfied that his repair work is airworthy.

In short, if you ask for a "repair" you give the mechanic or technician considerable discretion to do only as much work as he believes needs to be done. If you ask for an "overhaul" you eliminate his discretion and require him to do everything precisely "by the book."

Repair is almost always the lowest-cost method to get a problem resolved. Often, the cost of having something overhauled will be much higher than the cost of having it repaired. For example, a propeller "overhaul" is typically twice as expensive as a "reseal repair." In some cases, having a malfunctioning gyro flight instrument "overhauled" can cost ten times as much as having it "repaired." The "O-word" is one of the most expensive and overused words in aviation maintenance. It is invariably a waste of money to have something overhauled if a simple repair will suffice -- often a lot of money!

Of course, the "R-word" is even more expensive than the "O-word" and the "N-word" is the most expensive of all. The object of the game is to use the least expensive word that will get the job done. So be careful to use these words carefully when approving maintenance work on your aircraft.

Posted by Mike Busch at 12:57 PM 5 comments

Fast, Good or Cheap: Pick Two

There's an old saw in product design that goes, "fast, good or cheap: pick two." It means that:

- If you want both quality and fast turnaround, expect it to be expensive.
- If you want both quality and low cost, expect it to take a long time.
- If you want both low cost and fast turnaround, expect inferior quality

The same principle usually applies to aircraft maintenance. When my company manages maintenance on behalf of aircraft owners, we usually use our best efforts to obtain the highest quality maintenance at the lowest possible cost. In other words, "good" and "cheap." To the extent an owner applies time pressure to get the maintenance done quickly, there will have to be a sacrifice in either quality or cost. Since sacrificing quality is often not an option in aviation maintenance (especially if it could compromise safety), faster usually implies more expensive. But since rushed maintenance invites mistakes, faster sometimes results in errors that wind up causing additional downtime and expense to correct.

Occasionally, getting the airplane back in the air as quickly as possible is worth increased maintenance cost. But often, aircraft owners apply time pressure to maintenance providers without giving any thought to the adverse consequences of doing so. It's always a good idea to think carefully before you ask for quick turnaround. There's no such thing as a free lunch.

Posted by Mike Busch at 12:51 PM 5 comments

Saturday, November 21, 2009

Turbos, oil temp, and overboosting

The owner of a Florida-based 1977 Bonanza V35B with a turbonormalized TCM IO-520-BA engine contacted me with concerns about fuel flow. He described a recent instructional flight involving a takeoff on a "coolish day" that showed 31" MP, 2700 RPM, and 31 GPH fuel flow. Later in the flight, a full-throttle go-around was executed, and the owner that fuel flow was 3 GPH below red line on the factory analog fuel flow gauge, and only 27 GPH on the Shadin digital fuel flow gauge. After landing, the owner described this situation to his mechanic and suggested that the fuel flow be adjusted up. The mechanic was concerned that if he adjusted the fuel flow, it might be excessive on takeoff.

I explained to the owner that his turbonormalized engine has a hydraulic wastegate actuator and controller that uses engine oil as its hydraulic fluid. A byproduct of this is that regulation of upper-deck air pressure (UDP) is not precise, and the system delivers higher UDP when the oil is cold than when it is hot.

I further explained that engine has an aneroid-compensated fuel pump whose output pressure is a fuction of two variables: engine RPM and UDP. Therefore, if RPM is held constant at 2700 RPM (red line), the fuel pump will put out more fuel flow when the oil is cold (and the UDP is high) than it will when the oil is hot (and the UDP is lower).

For safety's sake, I explained, the turbo controller should be adjusted so that it gives full red-line MP when the oil is hot -- so that, for example, if a full power go-around or missed-approach is executed, full rated power is actually available.

If the system is adjusted in this fashion, then when full power is applied with cool oil (e.g., first takeoff of the day), there will be some "overboost" (MP above red line) by an inch or two. This is okay. Momentary overboost will not harm the engine, and is a quickly self-correcting condition as the oil warms up during the takeoff roll. I suggested that the owner NOT try to manually limit the MP to red line under these conditions, and simply accept the brief overboost. (TCM has a SB that states that momentary overboost up to 3" is a non-event.)

Under such brief overboost conditions (MP over red line), if the system is adjusted properly, fuel flow will also be over red line momentarily until the oil warms up and the MP comes down, since the fuel pump is compensated to follow UDP. This is the way things are supposed to work. If the engine is momentarily producing a bit more than 100% power, then it needs a bit more than 100% fuel flow. The system knows what it's doing, so the pilot shouldn't try to help it.

The turbo controller should be adjusted so that it will give full red-line MP with hot oil. Making this adjustment will automatically increase fuel flow as well, because higher UDP commands higher fuel flow. Once the turbocontroller has been adjusted, full red-line fuel flow should be seen when full power is applied with hot oil. If fuel flow falls short of red-line, the high unmetered fuel flow (the adjustment screw on the fuel pump aneroid) should be adjusted to achieve full red-line fuel flow.

On takeoffs with cool oil, there will be 1" or 2" initial overboost above MP red line, and momentary FF above red line. All this is good.

It is essential that the turbocontroller and fuel pump adjustments be made when the engine and oil are hot.

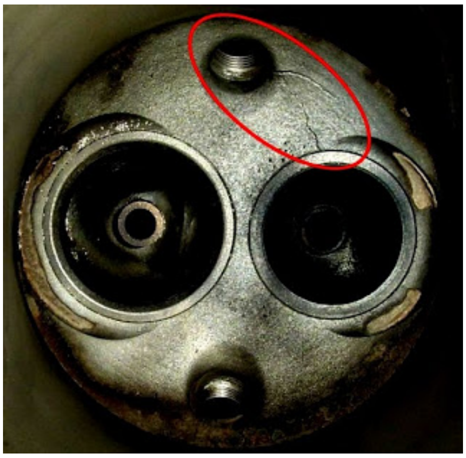
Posted by Mike Busch at 11:58 PM 6 comments

High CHTs and cracked cylinder heads

A member of a German flying club wrote me about a Robin DR-300 that the club used in about a 50-50 mix of cross-country flying and towplane operations for the club's sailplanes.

When towing gliders, the airplane climbs at full power and very slow airspeeds, and CHTs regularly register in the high 400s Fahrenheit, close to Lycoming's 500F CHT red line. Once the glider releases, the engine is throttled back to idle and descends rapidly to land and hook up for the next tow.

The Robin's Lycoming O-360-A3A engine is now at 1,200 hours, just 60% of TBO. One cylinder started to show declining compression readins, so the mechanics reduced the compression-test interval from 100 hours to 50 hours. At the next check, the cylinder compression had fallen into the 40s, so the cylinder was removed and found to have a cracked cylinder head, with cracks running between the top spark plug hole and the exhaust valve seat.



The club member's questions for me:

1. Why did the cylinder head crack?

2. Should the other three cylinders be removed?

3. Should the mechanics have caught this earlier?

I explained that any non-ferrous metal component (like an aluminum alloy cylinder head) will eventually crack if subject to repetitive stress for a sufficient period of time. The component will crack sooner if the repetitive stress is more intense and/or if the operating temperature is greater. Extended full-power operation during glider tows obviously increases the intensity of the stress, and the very high CHTs reduce the tensile strength of the cylinder head. (The head's tensile strength is reduced to 50% of its room-temperature value at a CHT of 400F, and to about 33% at 500F.)

Although towplane operations are inherently very stressful on the engine, I suggested that cylinder longevity could probably be increased by making flatter, higher-speed climbs and less rapid descents. However, as a glider pilot myself, I understand that gliders generally have a fairly low Vne, and that glider pilots usually want to spend minimum time on tow, so engine longevity considerations may have to be subordinated to operational demands.

I recommended to the German club member that the other three cylinders NOT be removed. Instead, they should be inspected for cracks internally using a good borescope and externally by direct visual inspection. Just because one cylinder cracked does not mean that the others will crack any time soon. In the 22 years I've owned and flown my 1979 Cessna T310R, I have had to retire 2 of the 12 cylinders because of head cracks. One crack occurred at about 2,000 hours time-in-service, and the second did not occur until about 4,500 hours. The remaining 10 cylinder heads have not cracked (yet), although they all will do so if kept in service long enough. It certainly would not have made any sense for me to pull all 12 cylinders when the first cylinder head crack occurred about 18 years ago!

Finally, I suggested that it sounded like the club's mechanics had done a good job, but that had they performed regular borescope inspections of the cylinders they probably would have detected the cracks earlier. TCM requires at least annual borescope inspections (TCM SB03-3), but Lycoming does not. Nevertheless, I believe frequent and regular borescope inspections are an essential part of engine condition monitoring.

Posted by Mike Busch at 11:06 PM 2 comments

Welcome to my new blog!

For more than two decades, I've been helping aircraft owners deal with their thorniest maintenance problems, first as a technical representative for the 12,000-member Cessna Pilots Association, and more recently through the 10,000-member American Bonanza Society and the 2,000-member Cirrus Owners & Pilots Association.

I also write monthly maintenance columns for the magazines of these three "type clubs," as well as for EAA's *Sport Aviation* and the online aviation magazine and news service *AVweb* which I co-founded in the mid-90s and served as editor-in-chief for more than seven years (at which point it was sold to Belvoir Publications).

Mike Busch

I find my technical support activities to be both rewarding and frustrating, rewarding because I love helping aircraft owners, but frustrating because those owners tend only to ask for my help after repeated trips to the maintenance shop, repeated expensive invoices, and repeated discoveries that their squawks remained unresolved. By the time they contact me, they are often desperate and angry, and I can't help but think (although I try not to say) "why didn't you contact me earlier?"

Six years ago, in an attempt to do something more pro-active to prevent owners from enduring these kinds of frustrations, I started going around the country teaching in-depth 17-hour weekend seminars to help owners learn to manage their maintenance better. About 1,000 owners have graduated from this seminar. Some have become excellent maintenance managers, but many have been unable to take full advantage of the training, either because they are too busy to do a proper job of managing their maintenance, or because they're just too uncomfortable managing the work of their shops and mechanics, telling them what they want done (and not done) instead of the other way around. Many owners find the whole subject of maintenance quite intimidating and far outside their comfort zone, and so they put themselves at the mercy of their shops and mechanics to make their maintenance decisions, and then are often quite unhappy with the outcome and sometimes feel taken advantage of or even victimized.

Consequently, about 18 months ago, I decided to start a new firm to provide professional maintenance management to the owners of owner-flown GA aircraft. Starting from scratch, we're now managing the maintenance of nearly 200 airplanes, mostly high-performance piston singles, light piston twins and cabin-class piston twins. To maintain these airplanes, we're working with hundreds of different maintenance shops throughout the U.S. Some of these shops are terrific, some are terrible, and some span the spectrum in between. One of our most important tasks is to try to persuade our aircraft-owner clients to patronize the good shops and avoid the bad ones. Once the shop has been chosen, we manage their work closely, making sure that they everything that is necessary and nothing that isn't. We scrutinize their estimates and invoices to make sure that our clients are getting maximum value for their maintenance dollars. Typically, we save each of our clients thousands of dollars a year in reduced parts and labor costs.

In the course of my type-club support activities, my writing, my teaching, and my professional maintenance management work, Not a day passes that I don't encounter and interesting maintenance-related war story. Some of them are just too valuable not to share. I decided to start this blog to share these stories with my fellow aircraft owners and mechanics. I hope you find them educational and enjoyable.

--Mike Busch A&P/IA CFI/A/ME
2008 National Aviation Maintenance Technician of the Year
President, Savvy Aviator, Inc.
President, Savvy Aircraft Maintenance Management, Inc.

Posted by Mike Busch at 3:57 PM 6 comments