You work in a shop that specializes in turbine equipment. The few cabin class piston twins for which the FBO is responsible get their maintenance done elsewhere. From time to time, however, piston engine problems do arise that demand your attention. And since everyone else is busy, guess who the boss chooses to evaluate the problem? If you don’t do this every day, it can be a little intimidating; trying to rattle the rust out enough to remember the systems and what to do first. So let’s examine some troubleshooting fundamentals for piston engines that will both simplify and speed up the process.

CLARITY OF INFORMATION

This is the first and most important principle. A common mistake is to rely on unclear or vague descriptions of the symptom. Often, there are subtle events or symptoms which occur that someone else may miss, especially if they are otherwise occupied flying the aircraft. It is important to get information on as many other parameters as possible, even ones that seem unrelated. Many things are better sorted out later, in the shop. A good situational awareness is a great asset in this phase of troubleshooting.

The best way to get a good read on the symptom is to experience it yourself. Do your best to emulate the same conditions and duplicate the problem. This way you will find the problem and not create a different one; if you end up creating a different one, the old one will come back to haunt you. Remember, the same problem can give different symptoms in different conditions.

Sometimes it will be necessary to rely on secondhand descriptions of the symptoms. It is then imperative that clear and concise information is exchanged both ways. The person experiencing the symptom, usually the pilot, needs clear and definite instructions to troubleshoot when the symptom occurs again (provided safety of flight is not compromised).

Avoid wasteful speculation. This is different from hypothesizing. Speculation is where your mind sort of goes off without you and causes you to start working on things before a test has confirmed that what you are doing will actually fix the problem. Whereas, hypothesizing is based upon educated guesses that presupposes that one is well educated. This brings up the next important principle.

SYSTEMS KNOWLEDGE

Systems knowledge is somewhat similar to clarity of information in that good system information is a must when diagnosing a symptom. You don’t need to have mastery of all systems to be effective at this. Accurate systems information can come from any number of sources. Maintenance manuals, training materials, experienced personnel, or manufacturer customer service...
are some good starting points. Caution: Don’t let unqualified sources lead you down the wrong path.

DIAGNOSIS

At this point, sit down with your systems knowledge (whatever the source) and go through the system operation step by step. Note which component and situation would cause the symptoms you’re experiencing. List these possible causes and move to the next step.

TESTING

Start with the most likely and simple cause first and test to eliminate or confirm them. Tests should be limited in effect to the suspect component. Don’t apply a test that involves too many components or one you won’t narrow your field of suspects. Use as specific a test as possible; one that will eliminate possible causes. Accurate information is essential throughout this process. Reevaluation may be needed after testing a suspected cause.

If no test indicates the source of the symptom then the dreaded shotgun may be pulled out. Again, limit the replacement of components to those which will affect your symptom. Start with the most inexpensive ones first. If you have access to these components without having to purchase them, or have the ability to return them if not needed, the process will be much cheaper. This one, however, is a time eater. It may take a lot of shop time and shipping charges if it starts to go very far.

There are innumerable problems that can and do occur in piston engines. There is, however, a group of problems that are generally the most common. What follows is an aid to help quickly troubleshoot six frequently encountered problems. We’ll call them the top six.

1. NO START/HARD STARTING:

   There are three requirements to get an engine to start — fuel (in the right proportion), oxygen (air), and fire (timed spark).

   If the engine won’t run, one of these things is missing.

   Air is almost a given. Even with a significant intake obstruction there will be at least enough air getting into the engine to get it to fire at an idle speed. One exception here is a totally sealed off induction. This would most likely occur after the engine has been removed from storage and someone forgot to remove the intake plug. This source of

2. MISS/ROUGH RUNNING:

   The two most common sources of this symptom are ignition misfire and clogged fuel injector. The misfire most usually
shows up on the preflight mag check. To find the offending plug, run the engine on the magneto with the bad drop. If a four or six point EGT/CHT system is installed, note the cold cylinder. Trace the ignition lead back to the magneto with the miss. That plug circuit (plug, high tension lead, or tower in the distributor block) has a short or open. The most common cause here is a dirty/bad spark plug or a chaffed ignition lead.

A clogged injector will act very similar to the misfire. The miss is always apparent if the injector is fully clogged (or nearly so). If the injector is partially clogged, the miss will show up while leaning the engine for cruise. (On the multiple point EGT check for a very early peak and a higher head temperature on one cylinder.) In either case, run the engine in the configuration with the noted miss (rich or leaned out) and note the cold cylinder the same as you would for a misfire. Hint: If the aircraft is not equipped with a four or six point EGT/CHT or some of the probes aren’t working, run the engine in the configuration with the noted miss. While running with the noted miss or immediately after engine shutdown, use a squirt gun or bottle and squirt a small, fine stream of water on each exhaust collector approximately one inch from the cylinder exhaust port. The cylinder with the miss will show up with a much colder exhaust collector at this point.

Another common malfunction that is difficult to troubleshoot on the ground is the altitude miss. This is where a plug circuit will misfire only when the aircraft is at or above a certain altitude. If the aircraft has the four or six point EGT/CHT, you can find this one in the air. If not, the “shotgun” method should be used on the ignition system.

The most common culprit is large plug gaps. Clean, gap, and test all the plugs. Also, test the ignition high tension lead harness with a high tension lead tester. Check the distributor block for cleanliness, tracking, and cracks.

If none of these are the problem, other but less common sources are things such as improper E-gap (magneto internal timing) and weak rotating magnets or coils. For these internal mag problems, the magneto(s) must be removed and troubleshot on a test bench. Note of caution: Do not attempt to do in-flight mag checks for high altitude miss diagnosis. Very often high altitude misses turn into crossfires. Crossfire is when the electrical energy from a miss-fire finds a path of least resistance in one of the electrodes next to it. A mag check while attempting to diagnose which magneto is miss/crossfiring can literally blow the exhaust system into pieces. This is especially true of turbo-charged engines. Mag checks at even low cruise power settings will over-temp most cylinder and exhaust components.

A note on bad mag checks for Cessna 180/182s. In very cold weather the O-470 will show bad mag checks (200-300 rpm drop). This is because of the poor fuel atomization in very cold air. Try pulling the carb heat on, releaning (if altitude requires) and rechecking. Rough running of these engines during cruise in cold weather can sometimes be cured by flying with carb heat on to bring induction air temperatures back up to normal. A carb air temp gauge is perfect for this malady.

3. HIGH CYLINDER HEAD TEMPERATURE:

You may have run into this with a partially clogged injector. If not, try these other sources. Baffling: Bad inter-cylinder or cylinder head baffling can cause localized cooling air loss. Check for stiff or loose baffle seals.

The classic birds nest is often a common culprit here too. A healthy starting can build a very effective air block in 15 to 30 minutes.

If a cylinder has recently been changed, expect higher head temps on that cylinder for the next 30 to 50 hours of operation.

If all the head temps are high look for a more generalized problem. Check for numerous gaps and holes in the baffling. A small air leak goes a long way in dropping the cooling air pressure and causing temperatures to rise. Also, check the cowl flaps for proper rigging. Some models of aircraft have different cowl flap rigging for different years and engines in the same model.

Another, but less common cause of high cylinder head temps, can be magneto to engine timing. Advanced timing is generally characterized by smaller than normal mag drops and higher than normal cylinder head temperatures. A simple timing check will confirm or eliminate this one.

4. HIGH OIL TEMP:

High cylinder head temperatures and high oil temps often go together. In this case look for the common causes of both: bad or damaged baffling or its seals, cowl flap rigging, mag timing, or cooling air blockage.

If just the oil temp is high and cylinder head temps are normal, look for these common sources:

Birds are culprits here, too. A favorite spot for nests is the pockets formed above or in front of the oil cooler. Rags or other debris also lodge here easily. The oil cooler to baffling seal is also important. Air going around instead of through the cooler cuts down on the volume and velocity of the flow through the cooler as well as the cooling air pressure in front of it.

Dirty or excessive paint on the fins will slow heat conductivity and allow the temperature to rise more than normal also. This one will be seen mostly on hot summer days where the cooler needs all the help it can get. A quick visual inspection will cue you to this culprit.

Another common source here is what’s called the “Vernatherm” or temperature bypass valve. This unit is a thermostatic valve that works much the same as the coolant thermostat in your car or truck. As the oil gets hotter, the valve closes harder, forcing more oil through the cooler.
LOW OIL PRESSURE:

Worn on high time units but obvious contact or wear on the expanding medium (some sort of wax). Wear of the valve face and seat, or loss of check. The culprits here are abnormal temperatures and oil damage. The wrong oil age.

The three most important factors that determine oil pressure in any given engine are: oil pump volume, engine internal clearances/leakage, and oil viscosity. The two most common causes of this symptom are oil viscosity and internal clearances/leakage.

Oil viscosity is affected by oil grade, temperature and oil damage. The wrong oil grade for ambient temperatures or high oil temperatures will often cause low oil pressure. Oil can be damaged by excessive heat and/or excessive operating time before oil change. All these factors will tend to thin the oil and cause a pressure drop.

Any excessive internal leakage in the engine will also cause a drop in pressure even at normal operating temperatures. The most common culprit here is debris under the oil pressure relief valve. This acts to hold the valve off its seat and bleed off oil, dropping the pressure. Remove the valve and clean the face and seat. Note the type of debris that was caught in the valve. This may be an indicator of larger problems as noted in the next section.

Excessive clearances from worn bearings, worn valve lifter bores, worn oil pump gears, bad prop oil transfer collars, or missing/loose internal oil passage plugs (just back from the engine shop) will cause a drop in oil pressure. An oil analysis and a look at the oil filter will usually cue you to internal engine problems from worn parts as the cause of this symptom.

Oil pump volume is not something we can change in the field usually, but is an aggravating factor on some engines. Engines with standard volume oil pumps but high flow demands are very sensitive to viscosity and clearance/leakage factors. This is most common on naturally aspirated engines that have been turbo-normalized by someone other than the engine manufacturer. If a higher volume oil pump is not a part of the package, the oil pump may be hard pressed to deliver normal pressure when the viscosity gets lower (higher temperatures, aggravated by hot turbochargers).

Some aircraft have flow restrictor orifices in the turbo supply line just to keep the oil pressure up. In these engines, any change in flow demand, clearance, or leakage is directly reflected in the oil pressure when at normal operating temperature.

LOW CYLINDER COMPRESSION:

This problem is usually found during a scheduled engine inspection. However, excessively low compression on one cylinder is usually noticeable when running the engine as well.

The three most common leakage points are intake valve, exhaust valve, and rings. If an intake or exhaust valve is leaking it will be plainly audible in the intake (intake valve) or exhaust (exhaust valve) system. If the leakage is not bad the valve may be relapped without pulling the cylinder. The valve may also be sticky and just require some cleaning of the guide to devolve deposits. This can be found by checking the looseness of the valve in the guide when the valve rocker cover is removed.

Worn or sticky rings will cause a loss of compression and power also. This is called "blowby." There is always a certain amount of blowby present in every engine. The best way to determine if blowby is excessive is to make sure the intake and exhaust valves aren't leaking when the compression test is done. Remove the oil fill cap and listen for escaping air past the rings.

Continental allows compressions much lower than Lycoming but only under special conditions, namely no valve leakage and using a special compression tester. Consult Continental service bulletins for more details.

Excessive blowby is almost always accompanied by higher oil consumption and slightly higher oil temperature than normal.

A not so common but serious cause of low compression is a bad crack in the cylinder. This one is a serious safety issue and deserves a little attention here. If hissing is heard outside the cylinder, make sure the source is pinpointed before you go any further. This kind of crack sounds just like an air leak (it is). A crack this bad is immediate cause for cylinder removal and replacement before further flight.

Books have been written on this subject, but my hope is this article has given you a few pointers on making the piston engine troubleshooting experience a little more hassle-free. When you get good at it, it will be gratifying and even fun.

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