Engine Overhaul Fundamentals, Part Seven: PUTTING IT ALL BACK TOGETHER

You have fixed up all the firewall-forward components and have received your engine back from the overhauler. Now, it's time to reassemble everything, perform test runs and break in your new engine.

By Dennis Wolter

This month, it's time to check in on all the tasks your skilled, certificated aviation maintenance technician will be working on during the final portion of the engine overhaul process.

In today's world, most technicians will ship the run-out engine to a field overhaul facility or the original manufacturer for overhaul or exchange. It's important to realize that the overhaul process should include not just the basic engine itself, but all the accessories and support systems as well.

For the sake of having an inclusive discussion, I'm going to outline how your maintenance technician will typically manage vetting all of these components and systems for an overhauled or rebuilt engine.

Both Continental and Lycoming adhere to very comprehensive engine reconditioning processes as discussed in an earlier article. *(See "Engine Overhaul Fundamentals, Part Two: Field or Factory?" in the February 2019 issue. —Ed.)* These manufacturers will return an engine to the field with either overhauled or new magnetos, ignition harness, plugs, fuel controllers, carburetors, starters and starter drives. This leaves a fairly long list of other engine support items to be inspected, repaired or overhauled by your maintenance technician.

One accessory that is often overlooked is the propeller governor. I believe you should overhaul the governor when overhauling the engine. A failed governor can send metal particles through the entire engine lubrication system that will cause serious damage—ouch!

Engine installation

As discussed earlier ("Engine Overhaul Fundamentals, Part Four: Firewall-Forward Cleanup," April 2019), condition of the engine mounts is critical. They should be thoroughly inspected and cleaned prior to beginning the engine installation process. The reconditioned engine mount(s) should be mated to the airframe with new structural aircraft bolts and self-locking nuts that are tightened to manufacturer torque specs.

The more horsepower the engine produces, the more complex the engine preassembly process becomes.

Then, the process of reinstalling all the engine accessories begins. This list of components includes starters, engine-driven fuel pumps, engine instrument sending units for oil pressure, fuel flow, exhaust gas and cylinder head temperature probes, carburetor temperature sensors, vacuum pumps, control cables, propeller, propeller governors, exhaust systems and turbochargers, engine baffles and oil coolers.

The more horsepower the engine produces, the more complex the engine preassembly process becomes. It can take as little as a couple of hours to build up a simple four-cylinder carbureted engine, while a turbocharged, fuel-injected, highly-instrumented 300 hp big-bore six-cylinder engine can require a day or more before it's ready to be installed on its mount.

Air intake box

One very important item to inspect and repair is the engine combustion air intake box. On both injected and carbureted engines, this intake box is hard-mounted to the carburetor or the fuel injection controller. Its job is to direct all engine combustion air into the engine. These induction air boxes are built up using thin tempered aluminum that is prone to cracking and loosening of fasteners when subjected to hours of engine heat and vibration.

On a carbureted engine, the air intake box also has a fairly large carburetor heat door that is actuated by a pilot operated knob and cable system. This system allows the pilot to direct heated air into the carburetor to prevent carb ice.

Fuel-injected engines require a spring-operated automatic alternate air door to ensure that engine combustion air will still get to the engine in the event in-flight icing conditions block off the primary air intake.

It's very important that any cracks, loose rivets, worn actuator bushings, hinges, etc. are carefully inspected and repaired before the air induction box is installed.

Fuel pump

If the engine-driven fuel pump was not installed by the overhaul facility, the pump must be installed along with the appropriate fuel line fittings. The same process applies to the instrument vacuum or pressure pump, propeller governor and some generators or alternators.

Mounting the engine

With the new engine all dressed up, it's time to install it in the mount.

The process of securing the engine to its mount should include the installation of new rubber engine mount isolators that

are designed to isolate the engine mount and airframe from engine vibrations, as well as to hold the engine at a precise angle in relation to the airframe.

By the time most engines and these important rubber mounts have been in service for 10 or more years and 1,500 to 2,000 hours of flight, they've usually become hard and deformed, allowing the engine to sag in its mount. They are no longer doing a good job of isolating the airframe from engine vibration. Sagging mounts alter the thrust line of the propeller and reduce the aircraft's performance. On high-time engine installations, this sagging condition can be seen by observing the relationship between the aft edge of the propeller spinner and the nose section of the cowling.

On certain installations, the technician may install some or all of the cooling baffles to the engine at this time.

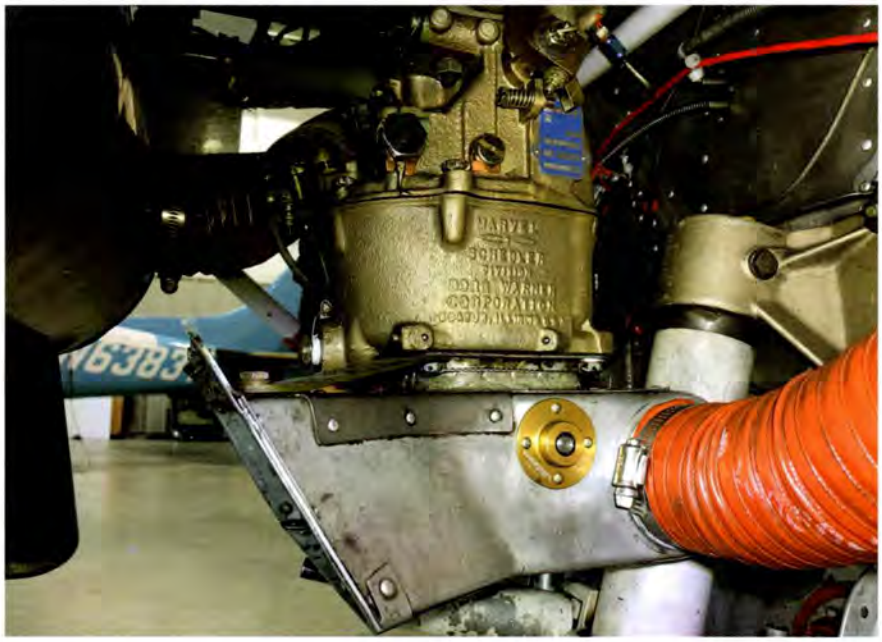
Reconnecting hoses, wires and cables

With the accessorized engine secure in the mount, it's on to inspecting, installing and connecting all the engine instrument sending units and probes. This involves careful attention to the process of routing and securing all these delicate wires and hoses so as to keep them from becoming damaged by heat and vibration.

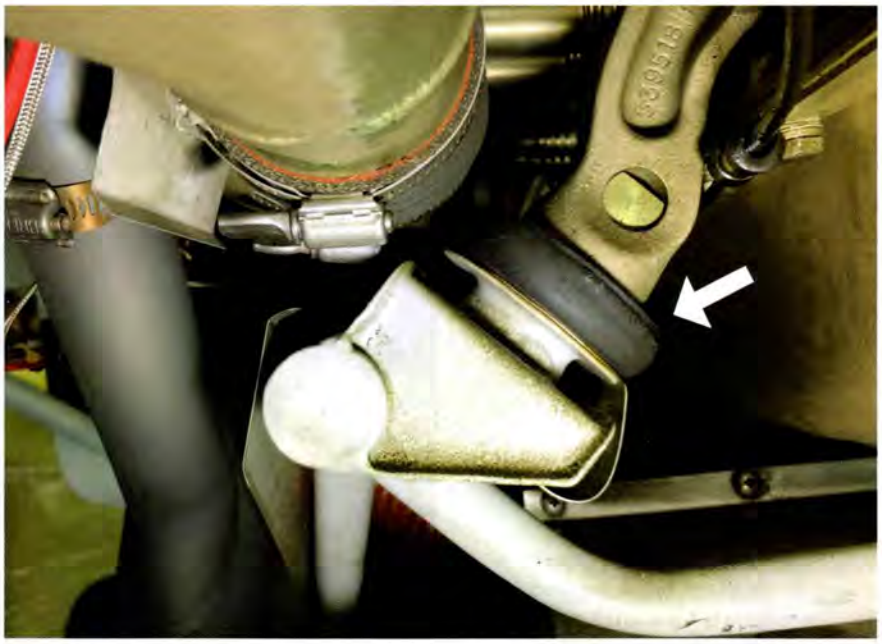
The next task in this process is to check the condition of all the engine control cables to ensure smooth and correct operation of each cable. Before these cables are hooked up to the engine controls, I think it's a good idea to pressure lubricate each cable from the engine end. I use a piece of rubber hose, a hose clamp and a pump-type oil can filled with 40-weight engine oil for this job. This step will increase cable life and help prevent corrosion inside the cable. Cheap insurance!

(Editor's note: According to Dave McFarlane of McFarlane Aviation, "early design engine controls with steel-on-steel conduit systems will benefit from the oiling process." However, "McFarlane does not recommend any lubrication of our controls, especially the throttle control... When lubrication is applied to the control (even at the engine end), the oil can work up the inner core cable and conduit to the leather packing area [a feature specific to McFarlane's design] causing loss of locking friction. McFarlane... recommends new controls at time intervals equal to engine overhaul.")

Then, the fuel, oil and vacuum system hoses are inspected and connected to the engine. It's crucial to confirm that these flexible hoses have not exceeded the manufacturer's recommended life.



A typical air intake box. The large orange hose is the carburetor heat hose that brings hot air into the air box.



New rubber engine shock mount.

Propeller and spinner

Next on the list is installing the propeller and spinner. On some engines, the technician must carefully index the propeller in relation to the engine's crankshaft for proper dynamic balance between prop and crank shaft. I personally think that new prop mounting bolts and nuts should be installed at every overhaul.

Ground run and test flight

Now it's finally time to start that newly-overhauled engine. Lycoming, Continental or the field overhauler will provide service instructions outlining the first start-up process.

The first ground run is fairly short in duration and done at a low power setting, monitoring pressures and temperatures and adjusting engine idle fuel air mixture, idle speed and fuel pressures.

Newly-overhauled engines that are shipped to the field will have been test run prior to shipment, so these adjustments will be accomplished during the overhauler's test run process. That said, it's very important to double-check. After shutdown, the engine is thoroughly inspected for leaks, loose components, etc.

Next, the cowling is installed, and the airplane is flown for approximately 2 to 2.5 hours, following specific instructions detailed by the overhauler.

Checks and adjustments

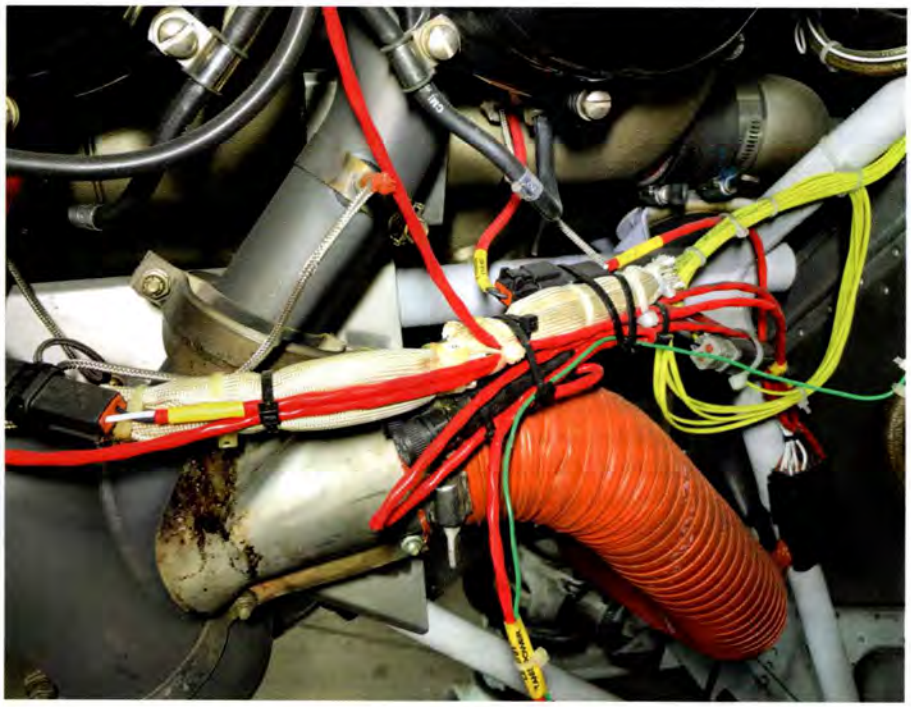
After the post-overhaul test flight, the cowling is removed, the oil is changed, and the oil filter is removed, cut open and inspected for unusual contaminates that could indicate an internal engine problem. Some engines have an external oil pickup screen that can also be checked for contaminates.

It's also a good idea to look at the cylinders with a borescope that allows a technician to check cylinder walls for any signs of scoring that could indicate that a piston ring may have been damaged during assembly.

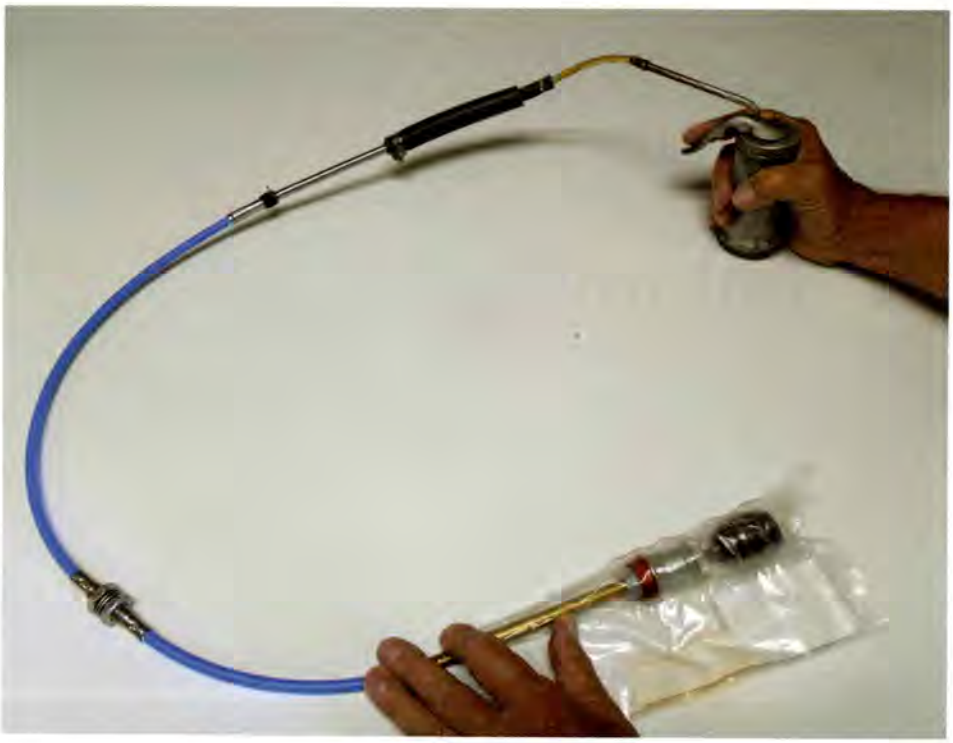
Finally, a thorough inspection of every engine control, exhaust, external, fuel, oil system, electrical and instrumentation system component is performed, checking for function, condition and leaks. The engine is filled with recommended break-in oil, and a new oil filter is installed. The engine is started one more time to check idle speed, idle air mixture, fuel pressures, etc. The technician should make any additional necessary adjustments. I recommend dynamic prop balancing (DynaVibe) after major firewall-forward work.

It's important to point out that I have

Misaligned propeller spinner indicates old and sagging rubber engine shock mounts.



A typical collection of instrument wiring. These wires go to temperature gauges for measuring cylinder head, exhaust, oil and carburetor temperatures.



Pressure-lubricating a throttle cable before installation on a new engine. Early design engine controls with steel-on-steel conduit systems will benefit from the oiling process; however, McFarlane Aviation does not recommend lubrication of any of its cables. Always check the manufacturer's recommendations.

described this process in very general terms. Every technician will have techniques and procedures that experience has led them to follow. And remember, the purpose of so much testing and checking is to ensure that the customer receives a safe, durable and thoroughly-vetted engine overhaul that will perform as designed all the way to TBO.

Doing the paperwork

Now for the fun part—paperwork. Logbook entries for engine overhauls come in many forms. Some entries reference only the FAA regulations and Airworthiness Directives that the work conforms to. Any specific information as to new parts installed and component repairs is listed on the work order kept on file at the overhaul facility. Other overhaulers will prepare a detailed and inclusive logbook entry listing every component installed and every repair procedure, such as welding crankcases and regrinding cam shafts.

What about warranties? The best advice here is look closely before you decide who should overhaul your engine. Factory-overhauled engine warranties range from pro-rated coverage for 12 months to full coverage for 24 months as long as the engine is not run past stated TBO hours. Some field overhaulers go beyond these limits and offer long-term pro-rated warranties all the way to TBO.

One consistent feature of almost all these warranties is that the engine break-in and operating procedures stated in their service instructions must be followed. The point I'm trying to make is that one almost needs a legal education to truly understand some of these long-winded documents. The best advice I can give is talk to mechanics and owners who have had engine warranty issues. You will soon discover that not all warranties are created equal.

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If you are replacing your run-out engine with an exchange unit, the overhaul facilities may require that some big-dollar components be in reusable condition in order for the overhauler to refund a full core credit. Some overhaulers only require that the core be in a runnable condition. Be sure to understand all terms and conditions. Your technician will be knowledgeable on these details.

The purpose of these engine articles has been to bring some clarity to the firewall-forward renovation process, helping an informed airplane owner get a relevant overhaul conversation started with their maintenance technician.

In my next article, I'm going to get back to the schedule I outlined in an article last summer, and move into renovating interiors. Covering the process of interior renovation will expose everyone to the relationship between your interior and avionics, window installations, passenger restraint upgrades, and other installations that can be efficiently completed while your interior is removed.

Until next time, fly safe! PF

IMPORTANT: This article describes work that may need to be performed/supervised by a certificated aviation maintenance technician. Know your FAR/AIM and check with your mechanic before starting any work.

Industrial designer and aviation enthusiast Dennis Wolter is well-known for giving countless seminars and contributing his expertise about all phases of aircraft renovation in various publications. Wolter founded Air Mod in 1973 in order to offer private aircraft owners the same professional, high-quality work then only offered to corporate jet operators. Send questions or comments to editor@piperflyer.org.