

Lycoming and Sticking Valves

By Steve Ells

There are distinct differences between Lycoming and Continental engines. One of the most distinctive is the method each manufacturer uses to maintain acceptable exhaust valve temperatures.

Exhaust valves undergo tremendous pressures and temperatures. Internal cylinder pressures can climb as high as 1,000 psi and temperatures as high as 2,000 degrees F. Yet they must still be metallurgic ally stable—they can't warp or stretch under these conditions.

Continental chose to install a solid stemmed exhaust valve that is cooled by contact with the valve seat. This is the primary reason why Continental valve face-to-seat contact is critical. Whenever the valve face-to-seat contact is compromised—due to less than ideal machine work when fitting the valves, or when debris such as carbon or lead prevents a solid contact—valve cooling is compromised and valve overheating takes place. Over heating causes an easily identifiable metallic signature on the valve. This signature is the reason why a bore scope inspection of the valve is the number one engine health diagnostic tool for Continental engines.

Lycoming took a different route. It chose to use valves with sodium-filled stems. This feature is very efficient at transferring heat away from the valve face and up the valve stem. The heat path is up the valve stem then by conduction out to the valve guides to the head cylinder cooling fins.

Lycoming Valve Guide Reaming—Why and How

Since Lycoming depends on heat transfer up the stem part of the valve the temperatures at the exhaust port and exhaust side of the aluminum cylinder head are hotter than the same areas in a Continental cylinder. Therefore it's vitally important that the under cowling engine cooling airflow baffles and baffle seals on every air cooled aircraft engine—especially Lycoming cylinders—be maintain to very high standards. Cooling is critical. But even the best maintained baffling isn't a guarantee that a Lycoming exhaust valve won't stick in the valve guide.

Sticking is due to oil carburizing in the guide. The oil burns because there's not much oil there to begin with and because of the high temperatures. The carburized oil coats the bore of the guide, reducing the running clearance. According to studies, the amount of oil that flows to the valve guides is small, and it's smallest in the cylinders on the co-pilots side of the engine.

The most common symptom of a sticking valve (s) is an engine that doesn't run smoothly. Instead of bursting to life with willingness, an engine with a stuck valve comes alive grudgingly with coughs, pops and shakes. Early in the carbon build cycle the engine will smooth out as it warms up. This leads owners and pilots to think that their starting technique wasn't sharp that day, or they got a shot of "bad gas" or any number of other reasons. It's really a sign that must be heeded. If it isn't, the odds of an in-flight emergency due to valve sticking ramps up. The worst case scenario takes place during flight when the guide-to-valve clearance is reduced to the point that one (or more) valves stick solid in the guide. When a valve sticks something else has to give in the hydraulic lifter-to pushrod-to rocker arm- to valve stem train. Usually

the push rod will bend and either break the pushrod housing or displace it from the head.

Lycoming Upper Cylinder Lubrication

Bill Marvel, former president of the Grumman Gang type club of Grumman American airplane flyers and Bill Scott of Precision Engines in Owensboro, KY spent over four years investigating the reasons why there were many more instances of valve sticking in the cylinders of the copilot's side of Marvel's Grumman Tiger than on the pilot's side.

According to Marvel and Scott Lycoming engines do experience valves sticking for one reason—an insufficient oil flow to the upper cylinder and valve guide area. These two men further determined that the "mushroom" type hydraulic lifters used in the majority of Lycoming engines (except the 320-H, the 360 E, the -541 and the newer engines with roller tappets) were never designed to provide oil flow to these parts.

Marvel and Scott captured the amount of oil delivered to the upper end of the each cylinder by collecting oil in the cylinder head oil drain tubes. The results, published in a series of articles that first appeared in the Aviation Consumer magazine, and are now available at the Precision Engines website, showed that oil flow to the valve cover area of the cylinders (of the O-360 in Marvel's Tiger) averaged 54 cubic centimeters of oil for #1 cylinder, 38 c. c. for #3 cylinder, 122 c. c. for #2 cylinder and 116 c. c. for #4 cylinder. These figures are the average flows during a 7 minute engine run. One cup is 236 c.c. Marvel and Scott concluded that the reason that more valve sticking and valve to guide distress takes place in the #1 and #3 cylinders is due to less oil flow to these cylinders.

Marvel and Scott focused on the hydraulic lifters during their study of oil flow and concluded the following. "When Lycoming adapted the automotive mushroom style hydraulic tappet assembly to their engine, they failed to provide a dedicated, unrestricted oil flow path to the rocker boxes that could carry sufficient oil for adequate cooling as well as for lubrication."

In 1978 Lycoming introduced the 160 horsepower O-360H/O-360E engine. This engine was a new clean sheet design that utilized barrel-type hydraulic tappet assemblies. These barrel-type assemblies are also used by Continental and are known to provide greater oil flow than the mushroom style assemblies. Marvel and Scott also gathered oil flow data on the H engine followed the same testing protocol used in the mushroom lifter engine. The oil flow to the upper cylinders of O-360H engine were 946 c.c. to the #3 cylinder and 744 c.c. to the #4 cylinder (the #1 and #2 cylinders were inaccessible for testing). These engines are equipped with oil coolers that are 50 percent larger than the coolers on the O-360A engines, as are the rocker box oil return tubes. The added oil flow from the barrel type lifters increases valve guide area lubrication and carries away upper cylinder heat.

Service Instruction SI 1479

Lycoming and Mooney worked together to develop a 270 horsepower turbo charged and fuel injected 540 cubic inch engine for the Mooney TLS. TLS owners experienced premature valve guide wear—some within as little as 100 hours— so Lycoming developed a service kit to oil cool the exhaust valve guides. This kit, 05K22169 included parts to modify the six cylinders and the engine to provide pressurized oil to the exhaust valves, and was provided free of charge for engines that were under warranty. The labor allowance for

installation of the kit was 42 hours. It's a very extensive mod. "Oil cooled exhaust valve guides have been used successfully in other Lycoming engines to reduce valve guide wear in high power and temperature environments," is a sentence in SI 1479A.

Clearly the barrel type lifter flows much more oil than the mushroom style lifter. Unfortunately barrel type lifters can't be adapted to the majority of Lycoming engines in today's fleet which still use the mushroom lifter.

Lycoming does not provide an oil cooled exhaust valve kit for its other engines. So what's the owner of a Lycoming engine with mushroom style hydraulic lifters facing in light of these findings?

Reaming Valve Guides to Open Clearances

As a consequence of, and in answer to the valve sticking problem, Lycoming issued service bulletin SB 388 which is titled, "*Procedure to Determine Exhaust Valve and Guide Condition.*" The common term for the procedures in this bulletin is the wobble test. The first line of the bulletin reads, "*To insure positive and trouble free valve train operation, the inspection procedure described in this publication should be accomplished. . . .*" It goes on to state, "*Failure to comply . . . could result in engine failure due to excessive carbon build up between the valve guide and valve stem resulting in sticking exhaust valves or; broken exhaust valves which result from excessive wear (bell-mouthing) of the exhaust valve guide.*"

SB 388B (updated in May 1992) applies to both parallel valve and angle valve Lycoming cylinders. The bulletin recommends that the tests be done every 300 hours on helicopter engines and every 400 hours on other engines or

whenever valve sticking is experienced. The 12 page bulletin has three parts; part 1 describes how to use the two fixtures to measure the clearance between the valve stem and the valve guide; part 2 describes how to modify the fixtures to use a dial indicator, and part 3 gives examples of alternate tools that can be locally manufactured to conduct the tests.

The tests are conducted on the exhaust valves only. If the tests determine that sufficient carbon has built up between the guide and the valve stem to close the clearance below a certain limit, the valve guide must be reamed to restore the bore. If the tests show that the clearance between the valve and guide is too great the valve guide is worn beyond limits and the cylinder must be removed for guide replacement.

The Lycoming tools specified in the bulletin are very expensive. Aircraft Spruce and Specialty (www.aircraftspruce.com) sells a "valve wobble test fixture" (12-21500) that works on both parallel and angle valve cylinders. I've used this tool and it works well.

The reaming procedure is outlined in Service Instruction 1425. And, although it's a little difficult to envision, the procedure involves dropping the exhaust valve down into the cylinder, reaming the guide and re-installing the valve without removing the cylinder from the engine.

Hi-Chrome Exhaust Guides

At about the same time Lycoming addressed the guide distress problem in the Mooney TLS, it also introduced a new improved exhaust guide. Service Instruction SI 1485A states that these guides were initially introduced in April 1996; since March 1, 1998 all engines, cylinder kits and spare exhaust guides

are "Hi-Chrome" guides (part number 16R22291). These guides are identifiable by the letter "C" stamped inside a circle on the boss of the drain back fitting of the cylinder. Individual guides made of the improved material can be identified by the 5 degree chamfer on the top of the guide.

If these guides are installed the compliance time for the wobble test inspections is increased to every 1000 hours or halfway to TBO, whichever occurs first.

Lycoming's Quiet Fix

Marvel and Scott write that Lycoming made some simple changes in two areas to address the low oil flow/valve sticking problem. First, it increased the red line oil pressure on the new Lycoming powered Cessna aircraft. The May 2012 revision of the Type Certificate Data Sheet (TCDS) for the Lycoming 360 series of engines cites a maximum oil pressure for any of the 360 series engines as 115 psi at start and warm up and 95 psi during normal operation. The previous oil pressure red line was 90 psi.

The other change relates to where the oil pressure reading is taken. Marvel and Scott discovered that oil pressure readings on the new Cessnas is taken off the forward end of the right side (#1 and #3 cylinder side) oil gallery; instead of the previous location at the outlet to the oil pump. The pressure differential between these two locations is approximately 10 psi. These two changes have the affect of significantly increasing the oil flow to the valves of the #1 and #3 cylinders.

The Owner's Solution

A CPA member alerted me to his experiences with an on going series of valve and guide problems in the IO-360 engine in his Cardinal RG. He also passed on recommendations from Bill Scott at Precision Engines. While some of these suggestions such as boring the lifter assembly bosses in the engine cases to the maximum allowable limit to maximize the oil quantity delivered to the valves and valve train are not practical except during an over haul there others that can be done to day to better lubricate and slow the rate of carbon build up in the guide area.

One of the easiest is to lean aggressively during taxi and ground operations to cut back on the amount of fuel-borne lead deposits in the combustion chamber and on the exhaust valve stem.

Secondly, move the oil pressure pick up from the back of the engine to the front of the right oil gallery and make sure the oil pressure relief valve is set to provide 90 psi during cruise—it's the maximum permitted on older aircraft; 95 is only legally approved on the newer Cessna 172, 182 and 206 models.

Scott also says that heat is the biggest enemy of Lycoming valve guides. He recommends using 65 percent power as the maximum cruise power setting.

Make sure that the engine cooling system—the baffles and baffle seals are in excellent shape. Put a light up behind the engine and look in the airflow cooling inlets. If you see any light leaks, address them

Try to limit cylinder head temperatures to a maximum of 380 deg F.

Install an oil filter adapter and an oil filter to trap contaminants before it's deposited on the valve stems.

Scott recommends the use of straight weight Aeroshell oil. Use the proper viscosity for current weather conditions.

Although the majority of Cessna aircraft are powered by Continental engines, many of these suggestions especially the ones related to oil filters, baffle sealing, ground leaning, and controlling CHTs are applicable to all flyers.

URLs:

<http://precisionengine.home.mindspring.com/engine1.htm>