A Review of Proper Leaning Techniques-by John Blosser, CFI-A/CFI-I

This article is a review of proper mixture leaning procedures for power settings in various flight conditions. Many pilots have questions about the proper use of the mixture control or are not fully aware of when it is appropriate or permissible to lean. I will attempt to clear these issues up here.

First, we will review the function of the mixture control. Simply put, it controls the amount of fuel flowing to the engine. The leaner the setting, the less fuel flows to the engine. In fact, if you fly an airplane with a fuel-injected engine, leaning is done with reference to fuel flow. Normally-aspirated engines do not have a fuel flow gauge so other methods must be used. The purpose of leaning is to optimize the fuel to air mixture ratio as less dense air is encountered at altitude. All the engines in current GACE aircraft are normally-aspirated Lycoming models. Their operational range is approximately 16:1 air to fuel ratio at lean and 10:1 at full rich.

There are several advantages to proper leaning of the mixture. The engine manufacturer Lycoming divides these into two categories: 1) how it saves dollars and 2) how it aids safe flight. For illustration, they use a 180 horsepower engine, such as that found in our Archer. At 4000 feet density altitude and 75% power, this engine burns 11.9 gallons per hour at full rich mixture versus 9.7 gallons at best economy (i.e. peak EGT). At $5.80 per gallon (the price of 100LL the day this article was written), this is a difference of $11.60 per hour in operating cost. Lycoming also points out that engines operating at full rich in cruise tend to run rough, resulting in shaking of engine accessories and engine mounts, reducing their service life and often resulting in expensive early engine replacement. Proper leaning also helps prevent spark plug fouling, reducing maintenance costs by eliminating the frequent need to remove and clean them as well as prolonging their life. Badly fouled spark plugs can become a safety of flight problem. In the “theoretical” 180 horsepower Lycoming uses, endurance is 4.1 hours at full rich vs. 5.1 hours at best economy. If we look at our Archer, endurance goes approximately from 4.2 to 5.15 hours-almost another full hour. Efficient fuel management relates directly to flight safety. In fact, performance/endurance charts are based upon use of recommended lean mixture for cruise. If proper leaning technique is not used, there really is no accurate way to predict performance and endurance. Another possible side effect of not leaning is carburetor ice. The more fuel that is evaporated in the carburetor, the cooler the temperature in the venturi becomes. In certain conditions, a rich mixture could lower the temperature into the icing range when a properly leaned mixture would not.

Let’s review recommended general leaning procedures and also the specific ones for our airplanes. There are two general cases in leaning: best economy (peak exhaust gas temperature) and best power (maximum airspeed or maximum RPM for a given throttle setting). Engines may be leaned any time they are operated at 75% power or less. It is acceptable to fly at either of these settings during cruise; however, both Lycoming and the airframe manufacturers Cessna and Piper recommend a setting somewhere in the middle. For reference, best economy is arrived at by leaning to peak EGT if so equipped or leaning until the engine runs rough then enriching just to the point where the

roughness abates. Best power is obtained by gradually leaning until the RPM and airspeed peak in a direct drive engine or until airspeed peaks in a constant-speed propeller engine. If the airplane is equipped with an exhaust temperature gauge, lean to peak then enrich 100º F. Mixture settings should always be changes slowly and smoothly, both for accuracy and for passenger peace-of-mind.

The general recommendations in the paragraph above are translated into specific ones in our Approved Airplane Flight Manuals/Pilot's Operating Handbooks. For the Cessna 172, the "recommended lean" is 50 º F rich of peak (a kind of midway point between best economy and best power). Mixture should be full rich until 3000 feet during climb and may be leaned above 3000 feet in climb for smoother operation or to obtain maximum RPM. In cruise, mixture may be leaned to recommended lean (or even best economy) any time the power is 75% or less. If cruising at more than 75% power, mixture should not be leaned more than is required for maximum RPM (i.e. best power setting). If the airplane is not equipped with an exhaust gas temperature gauge ("EGT"), recommended lean is arrived at by leaning until RPM peaks then drops 25-50 RPM. Again, if using an EGT, lean to peak EGT then enrich to 50 º F richer (i.e. cooler). Looking at performance charts, we see that at 2000 feet pressure altitude and standard temperature, 2500 RPM provides 75% power and 2400 provides 67%. As altitude increases, power developed for a given RPM decreases. From this, it is apparent that it is permissible and desirable to lean even when cruising at 2000 feet. The manual for the Archer is somewhat less specific that that for the Skyhawks; however, it does recommend leaning for cruise at all times above 5000 feet and at lower altitudes when 75% power or less is used. At 2000 feet and standard temperature, 2500 RPM again provides 75% power, so as in the case with the 172, it is permissible and desirable to lean even when cruising at 2000 feet. The R182 manual gives basically identical recommendations to those in the 172 manual, i.e. recommended lean is 50 º F rich of peak. During climb, note the EGT at 3000 feet and lean to match it for the remainder of the climb. An alternate way to arrive at best power is to lean until the engines runs rough, then enrich to smooth operation, then enrich an equal amount (i.e. if you had to turn the mixture control 2 revolutions to go from rough to smooth, turn and additional 2 after that). In actuality, I have noted both techniques in our R182 provide the same result. At 2000 feet and standard temperature, 2400 RPM and 23" manifold pressure (the recommended climb setting!) produce 76% power. As in the other two cases then, it is permissible and desirable to lean even when cruising at 2000 feet. I also have been told by a Lycoming factory representative that a good cross-check in leaning is that application of carburetor heat will lower RPM in a properly leaned engine. If it increases RPM, the mixture is set too lean. This is so because the warmer, less dense air gives a richer mixture.

Lycoming makes the following general recommendations as limits for continuous cruising for maximum engine service life: 1) engine power setting 65% of rated or less; 2) cylinder head temperature 400º F or below; 3) oil temperature 165º F-220º F.

Lycoming also recommends the following procedures for increasing or decreasing power in constant-speed propeller equipped airplanes (such as our R182): 1) to increase power, first enrich the mixture, increase RPM, then follow with throttle; 2) to decrease power, first reduce throttle, reduce RPM, then adjust mixture. I would add that Cessna recommends that cowl flaps be opened before increasing power and closed after decreasing power once cylinder head temperature is within range.

To sum up all of the above information and adding in some of my own observations and experiences, I recommend the following:

1) Lean any time you are operating at 75% power or less. This includes taxi, climb above 3000 feet and cruising at almost any altitude and power setting. It also includes descent-you needn't return to full rich until you are in the traffic pattern. In fact, in our R182, I leave the mixture lean until short final approach because it is very prone to spark plug fouling if operated full rich at low power settings. However, you MUST return to full rich for landing to prepare for a possible go-around or missed approach. When I make my final gear check, I also return the mixture to full rich.

2) Follow the recommended procedure to lean for "recommended lean" setting, preferably using an EGT and setting to 50º F rich of peak. Alternatively, lean until roughness is detected, then enrich for smooth operation, then enrich the same amount it took to get rid of the roughness.

3) Make mixture changes slowly-it makes for more accurate mixture settings and decreases passenger anxiety.

The information presented here was derived from the Approved Airplane Flight Manuals/Pilot's Operating Handbooks for our current GACE aircraft as well as two publications produced by Textron Lycoming: Lycoming Flyer Key Reprints and Lycoming Publication SSP700: Experts Are Everywhere to Help You: The "New" Old Leaning Technique. Both of these publications may be viewed or downloaded at http://www.lycoming.textron.com/support/tips-advice/index.jsp. They contain a lot of good information on many aspects of engine operation.

If you have any questions about this article or proper leaning techniques, do not hesitate to contact me or any GACE flight instructor-we are happy to help.