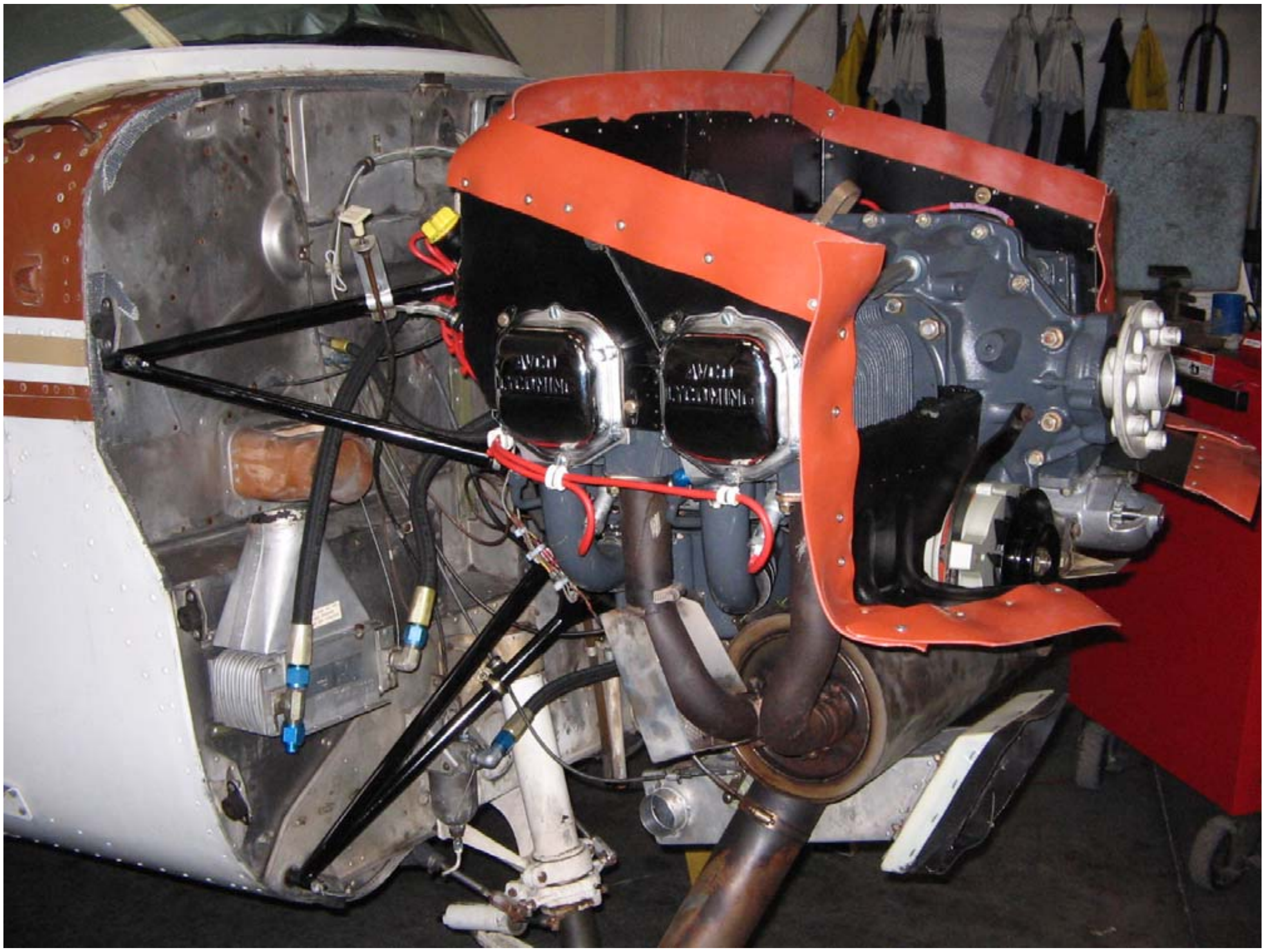
Engine Operation for

Lycoming

O-360 and IO-360 with fixed pitch propellers



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All information given in this presentation, spoken or written, will, in all circumstances, be superseded by the (POH) Pilot's Operating Handbook or (AFM) Airplane Flight Manual.

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Introduction

- Proper engine operation will not only make your flight safer, but extend the life of the engine.

- Consistently operating the engine, as outlined in the (POH) Pilot's Operating Handbook or (AFM) Airplane Flight Manual, and recommended by your Flight Instructor is the basis for safe flight and the best engine life.

- Certain ground procedures presented here, while not outlined in the (POH) or (AFM), are widely accepted. Before attempting a procedure not outlined in the (POH), you must have a clear understanding of the procedure, and decide for yourself, to use or not use the procedure.

- This presentation is a general review of engine operations for Lycoming O-360 and IO-360 engines with fixed pitch propellers used in Cessna 172s.

- The reference material included is provided by Lycoming, and will no doubt, bring to mind questions after reading the material, **GOOD, ask them !**

- The following three pages are included as notes, and not a substitute for the checklist in the (POH) or (AFM).

Differences

O-360 has a carburetor.

Advantages
Relatively simple in design, has fewer parts, and less expensive.

Disadvantages
Prone to icing.

IO-360 has fuel injection.

Advantages
Improved fuel distribution to each cylinder, not prone to icing, will operate at any attitude.

Disadvantages
More moving parts, more costly to maintain, and more difficult to start when hot.

Preflight

O-360 and IO-360

Fuel tanks and strainer— sample for clean fuel.
Air filter— inspect for condition.
Oil— check for proper level.

Start

O-360

Preflight— Complete.
Prime— Cold weather only.
Mixture— Rich.
Throttle— Open 1/4 in.
Brakes— Hold.
Propeller area— Clear.
Starter— Engage.
Throttle— Pump while starter engaged.
Oil pressure— Within 30 seconds after engine is running.
Throttle— Adjust.

IO-360

Throttle— Open 1/4 in.
Mixture— Idle cut off.
Propeller area— Clear.
Master sw.— On.
Auxiliary Fuel pump— ON.
Mixture— Advance until fuel flow just starts to rise, then return to idle cut off.
Auxiliary fuel pump— Off.
Ignition sw.— Start.
Mixture— Advance smoothly to rich when engine fires.
Oil pressure— Check.

If engine is warm

IO-360

Throttle— Open1/4 in.
Mixture— Idle cut off.
Propeller area— Clear.
Master sw.— On.
Ignition sw.— Start.
Mixture— Advance smoothly to rich when engine fires.
Oil pressure— Check.

Flooded start

O-360 and IO-360

Throttle— open one half.
Mixture— Idle cut off.
Ignition sw.— Start.

When engine fires, advance mixture to full rich, and retard throttle promptly.

Taxi

Throttle— As needed to maintain safe speed. Brakes are for stopping, not for speed control.

When stopped for run-up or holding for taxi clearance.
Throttle— 1000 RPM.

Run-up

O-360

Brakes— Hold.
Mixture— Full rich.
Throttle— 1700 RPM
All gauges— In normal range.
Magnetos— Check drop, 125 RPM maximum, smooth running, and within 50 RPM of the other magneto.
Carb. heat— On, check for RPM drop and smooth running.
Throttle— Reduce slowly to idle, check for smooth running.
Carb. heat— Off.
Throttle— Adjust.

IO-360

Brakes— Hold.
Mixture— Full rich.
Throttle— 1700 RPM.
All gauges— In normal range.
Magnetos— Check drop, 125 RPM maximum, smooth running, and within 50 RPM of the other magneto.
Throttle— Adjust.

If magneto check is not normal

O-360 and IO-360

Brakes— Hold.
Mixture— Full rich.
Throttle— 2200 RPM.
Timer— Start, run for 90 seconds.
Throttle— 1700 RPM.
Magnetos— Check drop, 125 RPM maximum, smooth running, and within 50 RPM of the other magneto.
Throttle— Adjust.

Alternate method

Brakes— Hold.
Mixture— Full rich.
Throttle— 2000 RPM.
Mixture— Lean slowly to slight roughness.
Mixture— Enrich slightly to obtain smooth running.
Timer— Start, run for 60 seconds.
Mixture— Full rich.
Throttle— 1700 RPM.
Magnetos— Check drop, 125 RPM maximum, smooth running, and within 50 RPM of the other magneto.
Throttle— Adjust.

If magneto check is not normal, after this procedure, **DO NOT FLY !**

Shutdown

Throttle— 1200 RPM
Timer— Start, run for 15 seconds.
Mixture— Idle cut off.

Carburetor Ice and carburetor heat usage

Carburetor ice can occur when the relative humidity is 50% to 60% and outside air temperature is 20o F to 90o F.
Ice forms more rapidly at lower power settings.
Icing may not be immediately noticeable, possibly a slight reduction in RPM at cruise.
If ice has formed, application of carb. heat will result in an additional RPM loss followed by an increase in RPM.
All thing considered, play it safe, use carb. heat !

Mixture Leaning

If the EGT probe is installed, lean the mixture to 100oF on the rich side of peak EGT for best power operation. If roughness is encountered, enrich the mixture slightly for smooth engine operation.

When leaned, engine roughness is caused by misfiring due to a lean fuel-air mixture which will not support combustion. Roughness is eliminated by enriching slightly until the engine is smooth.

Keep RPM and temperatures, within the recommended values, as outlined in the (POH) Pilot’s Operating Handbook or (AFM) Airplane Flight Manual.

Please take time to read the reference material on the following pages.

Lest we forget -The engine will not run without air
Induction icing and other obstructions

Rewritten and combined with article "Induction Icing"

The gasoline engine operates on a fuel/air mixture that is ignited by the spark plugs. Engines do not run when any of these elements are missing. Pilots know positively that they must refuel the aircraft on a regular basis if they want to fly without incident, but the possibility of losing the air part of the fuel/air mixture is not always considered and understood as well as it should be. Perhaps the personal experience of several individuals, and some facts about induction system icing can be used to help Flyer readers avoid an accident caused by lack of air for their engine.

Remember that any material that reduces or cuts off the flow of air in the induction system has the potential to cause a loss of power. A material failure of the air filter is one problem which is reported all too often. The filter is very necessary to keep dirt out of the engine; it must be inspected frequently and should be changed on some regular schedule. A filter which is several years old and has filtered the air during hundreds of hours of operation may be tired. One pilot reported that on turn up of the engine before takeoff, he could not get the static RPM that his engine and fixed pitch propeller should have produced. He wisely elected to return to the line and have the engine inspected. The air filter had pulled loose from its supporting frame and was lodged in the intake system where it was cutting off the air supply.

If this incident had occurred in flight, the engine would possibly not have been producing enough power to maintain altitude. Depending on the particular airframe, there are some options which might be utilized to regain some of the lost power. An alternate air system or carburetor heat system is designed into the induction system primarily to combat induction icing, but use of these systems may possibly help when intake air is blocked by other foreign materials. In some cases, just leaning the mixture may help to regain a little of the lost power.

Several years ago there was a reported loss of engine power in heavy rain. In that case, a paper air filter was being used. When saturated with water, the paper filter element became swollen so that airflow was impeded. In this case, the use of carburetor heat to bypass the filter and releaning to achieve a better fuel/air mixture were successful tactics that kept the aircraft flying until a safe, on airport landing could be made. We should keep in mind that it is not the ingestion of water through the engine that causes a serious loss of power; it is the reduced airflow.

Some pilots of aircraft that utilize a fuel injected engine believe that this engine makes them immune to induction icing. This is not so. Although the pilot flying with a fuel injected engine does not have the same threat of icing at the venturi as those with a carburetor, rain, snow, slush, and cold temperatures may cause a blockage (impact ice) to air flow in other parts of the induction system.

As an example, the pilot of a fuel injected single reported flying at 11,000 feet in light drizzle. The temperature was slightly above freezing and water readily ran off the windscreen. Although this would seem to be a no problem situation, the engine started to lose power. After consideration of the available options, the manual alternate air system was activated. The engine immediately regained power and flight was continued to the home base destination. After landing, the aircraft was taken into the hanger for examination. It was found that the air filter was covered with a layer of ice that had cut off the airflow. This is not an isolated or unusual case. When water is near freezing, movement of the water molecules may sometimes cause instantaneous freezing. This glazing over of the air filter is a known phenomena which pilots should expect and be ready to cope with. Again, bypassing the blockage of impact ice by use of alternate air proved to be a successful tactic for this pilot.

The most subtle and insidious of the airflow blockage possibilities is probably refrigeration ice , known more commonly as carburetor ice, that forms in the vicinity of the "butterfly" or throttle plate. Unfortunately, there are many pilots who are not fully aware of what carburetor ice can do or what to do about it when it does occur. An indication of this are statements made by pilots involved in power loss accidents who have said that they tried carburetor heat, found it did not work, and then returned the control to the cold position. Carburetor heat does not provide instant relief when applied after ice has formed in the carburetor. Once heat is applied, it should be left on until engine power returns. Left uncorrected, ice accumulation in the carburetor may cause complete engine stoppage.

Every pilot who flies an aircraft powered by a carbureted engine should be thoroughly educated about carburetor ice.

They should know that under moist conditions (a relative humidity of 50% to 60% is moist enough), carburetor ice can form with any outside air temperature from 20o to 90oF. It is most likely in the 30o to 60oF range. Temperatures in the carburetor can drop 60o to 70oF (refrigerator effect) as a result of fuel vaporization and the carburetor venturi effect. It also happens that carburetor ice forms more readily when the engine is operated in the lower power range. It will form while taxiing and this makes it very important to check engine power before takeoff and to remove the ice if necessary. Care should be taken to avoid dusty or dirty conditions when utilizing carburetor heat on the ground.

Next, it is imperative that the pilot recognize carburetor ice when it forms during flight. The loss of power that occurs will cause a reduction of RPM when flying with a fixed pitch propeller, and a loss of manifold pressure when a controllable pitch propeller is used. In either case, a loss of altitude or airspeed will occur. These symptoms may sometimes be accompanied by vibration or engine roughness. In any case, it is a good idea to consider carburetor ice as the cause of any unexplained power loss during cruise flight. Once a power loss is noticed by the pilot, immediate action should be taken to eliminate ice which has already formed in the carburetor, and to prevent further ice formation. This is accomplished by applying full carburetor heat which will initially cause a further loss of power (perhaps as much as 15%) and, possibly, engine roughness. The additional power loss is caused by the heated air that is being directed into the induction system. Heated air makes the mixture richer and also melts the ice which then goes through the engine as water. The throttle may be advanced and the mixture may be leaned to help get some of the lost power back, but immediately after the application of carburetor heat the pilot must be patient and keep the airplane flying until the ice has completely melted and normal power returns. How long this will take depends on the severity of the icing, but the pilot should expect a delay of 30 seconds to several minutes. Under the circumstances, this period of time will be stressful and always seems longer than it really is, but the knowledgeable pilot will not retreat from use of carburetor heat. Carburetor heat should remain in the hot position until power returns.

In conditions where carburetor ice is likely to form, the pilot may use heat during cruise to prevent the formation of ice in the carburetor. It is also appropriate to use full carburetor heat, if needed, to prevent icing when operating at low power for instrument approaches, or for flight in the traffic pattern. Unless the aircraft is equipped with a carburetor air temperature (CAT) gage, and very few general aviation aircraft are, use of full carburetor heat is recommended. An unknown amount of partial heat can actually cause induction ice in the float type carburetor. This may occur when moisture in crystal form in the incoming air that would ordinarily pass through the induction system without any problem is melted by the partial heat. This moisture then freezes when it comes in contact with the cold metal of the throttle plate.

Whenever carburetor heat is used in the landing configuration, and a go-around or touch-and-go takes place, there are some important steps for the pilot to remember. The throttle must be advanced and the carburetor heat lever placed in the cold position. The order in which these steps are accomplished is not too important, but both must be done. Leaving the carburetor heat on during a go-around will result in a loss of power that could be critical at low altitude and low airspeed. Do not use carburetor heat for takeoff or climb with a Lycoming engine as it is not necessary, and it may bring on detonation and possible engine damage. An exception to this rule might be justified in extremely cold weather conditions such as those found in the Arctic, and these conditions require a special knowledge to accommodate operation under such extreme conditions. A review of the material discussed in this article should help pilots to cope with reduction of engine power when it is caused by loss of intake air for combustion. A thorough understanding of the air intake system and the knowledge to competently deal with induction icing are essential to safe flight in general aviation aircraft. Pilots are encouraged to enhance the safety of their flying by knowing what to expect and what steps to take when the air flow to the engine is cut off for any reason.

Excerpt from

Leaning Textron Lycoming Engines

A. GENERAL RULES

1. Without exception, observe the red-line temperature limits during takeoff climb and high performance cruise power operation.

(a) Cylinder head temperature - maximum limit listed in the Textron Lycoming Operator's Manual.

(b) Oil temperature limit - maximum limit listed in the Textron Lycoming Operator's Manual.

(c) TIT - maximum allowable limit specified in the Textron Lycoming Operator's Manual.

2. Whenever mixture is adjusted, rich or lean, it should be done slowly.

3. ALWAYS RETURN MIXTURE SLOWLY TO FULL RICH BEFORE INCREASING POWER SETTING.

4. At all times, caution must be taken not to shock cool the cylinders. The maximum recommended temperature change should not exceed 50oF per minute.

B. LEANING THE NORMALLY ASPIRATED ENGINES

1. Use full rich mixture during takeoff or climb. Careful observation of engine temperature instruments should be practiced to ensure limits specified in Textron Lycoming operator's manual are never exceeded. Refer to the aircraft POH (pilot's operating handbook) or AFM (aircraft flight manual) for more specific instructions.

2. For 5000 feet density altitude and above, or high ambient temperatures, roughness or reduction of power may occur at full rich mixture. The mixture may be adjusted to obtain smooth engine operation. For fixed pitch propeller, lean to maximum RPM at full throttle prior to takeoff where airports are 5000 feet density altitude or higher. Limit operation at full throttle on the ground to a minimum. For direct-drive, normally aspirated engines with a prop governor, but without fuel flow or EGT, set throttle at full power and lean mixture at maximum RPM with smooth operation of the engine as a deciding factor.

3. For cruise powers where best power mixture is allowed, slowly lean the mixture from full rich to maximum power. Best power mixture operation provides the most miles per hour for a given power setting. For engines equipped with fixed pitch propellers, gradually lean the mixture until either the tachometer or the airspeed indicator reading peaks. For engines equipped with controllable pitch propellers, lean until a slight increase of airspeed is noted.

4. For a given power setting, best economy mixture provides the most miles per gallon. Slowly lean the mixture until engine operation becomes rough or until engine power rapidly diminishes as noted by an undesirable decrease in airspeed & when either condition occurs, enrich the mixture sufficiently to obtain an evenly firing engine or to regain most of the lost airspeed or engine RPM.

Some engine power and airspeed must be sacrificed to gain a best economy mixture setting.

NOTE
When leaned, engine roughness is caused by misfiring due to a lean fuel-air mixture which will not support combustion. Roughness is eliminated by enriching slightly until the engine is smooth.

5. The exhaust gas temperature (EGT) offers little improvement in leaning the float-type carburetor over the procedures outlined above because of imperfect mixture distribution. However, if the EGT probe is installed, lean the mixture to 100oF on the rich side of peak EGT for best power operation. For best economy cruise, operate at peak EGT. If roughness is encountered, enrich the mixture slightly for smooth engine operation.

6. When installing an EGT probe, the probe must be installed in the leanest cylinder. Contact the airframe or kit manufacturer for the correct location. In experimental or custom applications, multiple probe instrumentation is required and several power settings should be checked in order to determine the leanest cylinder for the specific application.

7. During normal operation, maintain the following recommended temperature limits:
(a) Cylinder head temperature - limit listed in the Textron Lycoming Operator’s Manual.
(b) Oil temperature - limit listed in the Textron Lycoming Operator’s Manual.

8. For maximum service life, maintain the following recommended limits for continuous cruise operation:
(a) Engine power setting - 65% of rated or less.
(b) Cylinder head temperatures - 400oF. or below.
(c) Oil temperature - 165oF. - 220oF.

Fuel Injector or Carburetor

From time to time, there is a question about the advantages of a fuel injection system over a carburetor. That is probably the wrong way to approach the matter when there is a choice to be made. Each of these methods of fuel metering has its own unique set of characteristics. It may be helpful to consider the advantages or disadvantages of each system.

First, consider why we need a carburetor or fuel injector as a part of any engine. Both devices provide a means of delivering a metered amount of fuel to be mixed with a measured volume of air. This is necessary because combustion can only occur when the air/fuel mixture falls within a given range. The extreme outside limits of this range are approximately 20:1 at the lean end and 8:1 on the rich end. For practical purposes, the operational air/fuel mixture range for most air cooled Lycoming engines will fall between 16:1 at lean and 10:1 when operating at full rich. Obviously, both the fuel injector and the carburetor are capable of metering within these limits.

The float type carburetor is a device which mixes fuel with air and has been used for many years. It has the advantage of being relatively simple. There is no diaphragm or springs - in general, very few moving parts. Installation on the engine is simple. All of this adds up to the significant advantage of being the least costly method of fuel metering. One additional item should also be considered. The fuel lines to a carburetor are large enough that there is little chance of them becoming clogged by the very tiny particles of foreign matter that may be found in the fuel.

Along with these advantages, the disadvantage frequently attributed to the carburetor is its inherent capability for developing ice in the vicinity of the throttle plate. For the pilot who understands and recognizes carburetor icing, this disadvantage is of little consequence since all certified aircraft are required to have a carburetor air heating system which will prevent or eliminate icing.

Since the fuel injector is more complex and expensive than a carburetor, why should it be considered? Because the fuel injector has its own set of advantages which in some cases are worth the additional cost.

First, the fuel injector causes air and fuel to be mixed at the cylinder intake port. Therefore, the refrigeration type icing that occurs in a carburetor venturi when fuel vaporizes in moist air cannot happen when a fuel injector is used for fuel metering. Many pilots consider this to be a significant advantage.

The primary characteristic of the fuel injector is improved fuel distribution to each cylinder. This feature reduces the possibility of one cylinder operating at a very lean air/fuel mixture while another may be operating near the rich end of the mixture scale. The improved distribution allows leaning that results in slightly lower overall fuel consumption. This is of particular value in the higher horsepower engines where saving a small percentage of the fuel being burned may result in a significant dollar savings.

Finally, the fuel injector will meter fuel regardless of its attitude while a float type carburetor can only operate in an upright position. This advantage, of operating in any attitude, makes the fuel injector an ideal fuel metering device for the engine that is designed for aerobatics.

Operating the direct drive, fixed pitch Lycoming engine

Some pilots have demonstrated a lack of understanding with regard to the operation of the direct drive, fixed pitch, normally aspirated powerplants. When a power chart is provided, it will indicate that as the airplane is flown at different altitudes above sea level, it is necessary to use a higher RPM for adequate cruise performance with an increase in altitude. A typical example might be the O-360, 180 HP Lycoming powerplant. The power chart by the airframe manufacturer for this fixed landing gear aircraft lists 75% power at 7500 feet at 2675 RPM (no manifold pressure gage in their airplane). The pilot who does not understand the principles of operation in the thin air at altitude may observe that red line takeoff RPM is 2700 RPM, and is then reluctant to lean either for cruise or climb despite the altitude because he is pulling almost the same RPM as at takeoff..

However, he can and should lean the engine at these altitudes despite the high RPM, for the horsepower is down to 75% because of the thinner air. On the other hand, with any direct drive normally aspirated Lycoming engine, he can and should lean the mixture at any altitude as long as he is in cruise configuration at 75% power or less.

Let ’s take a look at the airframe manufacturer’s power chart for the O-360, 180 HP engine and observe the gradual increase in RPM required with the increase in altitude, but maintaining 75% for cruise at each altitude. What the chart will not show here is that for flight above 7500 feet, it is not possible to achieve 75% power with a normally aspirated engine (meaning not turbocharged or supercharged).

POWER CHART

Altitude	**RPM**	**Percent of H. P**	**Endurance on 59 gals. Fuel**
2500	2550	75%	4.8 hours
3500	2575	75%	4.8 hours
4500	2600	75%	4.8 hours
5500	2625	75%	4.8 hours
6500	2650	75%	4.8 hours
7500	2675	75%	4.8 hours

Your Engine and the fixed pitch propeller

The effect the propeller has on engine operation and on aircraft performance is quite significant. Based on questions which have been asked by aircraft owners and from experience gained at the Textron Lycoming service hangar, there are several areas of propeller related information which may be of interest.

Aircraft equipped with a fixed pitch propeller will usually have static RPM (full throttle with aircraft standing still) limitations and full power in flight RPM limitations spelled out in the Pilot ’ s Operating Handbook. If static RPM is below the minimum specified, the engine could be low in power. However, experience has shown that this is not always true. Faulty induction air systems and/or faulty exhaust systems have been shown to contribute to indications of low power. A propeller which is ever so slightly less than perfect may cause the static RPM to be outside the designated full throttle static RPM zone. In addition to these other factors, it is not unusual to find a tachometer which is inaccurate. If an incorrect static RPM reading is observed during the engine check, any one or all of these components could be at fault. The tachometer may be the easiest to check as there are hand-held devices that quickly give an RPM reading that will verify the accuracy of the standard aircraft instrument. Knowing the accuracy limits of the aircraft tachometer may eliminate the need for further examination of the engine and propeller, or it may confirm the need for further troubleshooting. In any case, consider each component of the system before blaming low static RPM reading on one of them.

Another aspect of operation with a fixed pitch propeller came in the form of a question from a Lycoming engine owner. He indicated that the propeller provided by the airframe manufacturer had been exchanged for a cruise propeller. (This exchange should only be done with FAA approval.) With the new cruise propeller is use, an increase in fuel usage was soon apparent. Operating costs increased and an explanation was requested.

It is well known that the amount of horsepower taken from an engine will have a direct relationship to the amount of fuel used. Therefore, it can be deduced that use of the cruise propeller increased the horsepower requirement. This deduction deserves some additional explanation.

As an example, the standard propeller supplied with an aircraft may allow the engine to develop 180 horsepower at 2700 RPM at full throttle, in flight at sea level, with a standard temperature. The Lycoming 0- 360-A Series normally aspirated engine illustrates this example.

Next, let us assume that this same engine/propeller combination is operated at 75% power with a "best economy" fuel air mixture setting. Again, assume sea level and standard temperature to simplify and standardize the discussion. Seventy-five percent power will require about 2450 RPM with a brake specific fuel consumption of .435 pounds per brake horsepower hour. Also, 75% of the 180 rated horsepower is equal to 135 horsepower. Fuel usage at this power and mixture setting will be 58.7 pounds per hour or 9.8 gallons per hour. The mathematics to arrive at this fuel usage are simple:

180 HP X 75% of power = 135 HP

135 HP X .435 BSFC = 58.7 lbs. of fuel

58.7 lbs. of fuel / 6 lbs. per gal. = 9.8 gal. per hour

Having made some assessments about what can happen with a standard propeller, now we will try to see what happens when a cruise propeller is installed in place of the original. The first thing we must know about the cruise propeller is that it has more pitch than the standard propeller. This means it will take a bigger "bite" of air than the original propeller with each revolution. This bigger bite of air will have an effect on aircraft performance and on how the engine may be operated.

Taking a bigger bite of air increases the resistance to the turning propeller. Perhaps it may be easiest to imagine what happens by considering your hand when held in the air stream outside a moving automobile with the palm forward as compared to having the side of the hand forward. Because of this increased resistance, the static RPM will be lower than with the original propeller. The same thing will be true when full throttle, in flight RPM, is compared to that of the standard propeller at a similar altitude and temperature. This will reduce takeoff performance of any aircraft. Using the earlier example, the engine was rated at 180 horsepower at full throttle and 2700 RPM.

Now, in spite of applying full throttle, the increased resistance reduces the maximum attainable RPM to something less than 2700. As a result of not developing the rated 2700 RPM, the engine also will not develop the power for which it was rated. Since maximum power is less than full rated, aircraft performance will suffer. This should be considered before a fixed pitch propeller is chosen or exchanged for a different model.

At this point we must return to the original question. Why does the engine require more fuel with the cruise propeller? It is an accepted fact that the cruise propeller is more efficient for cruise operation, so it would not be unusual to follow this line of thinking. Seventy-five percent of rated power, using the original propeller at sea level and standard temperature, required a throttle setting to achieve 2450 RPM. Therefore, without more thoughtful consideration, it seems logical that the cruise propeller might also be set for 2450 RPM when 75% power is desired. Of course there is an increase in performance, but this can be attributed to the more efficient cruise propeller. Next comes the realization that the improved cruise performance isn't all efficiency. Instead of 9.8 gallons of fuel, the engine is now using a greater amount of fuel per hour. For purposes of this illustration, let us assume that the number is 11 GPH. By reversing the mathematics used earlier, it is possible to estimate the horsepower and percentage of power actually being used as a result of operating the cruise prop at 2450 RPM with a best economy fuel air mixture.

11 GPH X 6 lbs. per gallon = 66 pounds

66 pounds / .435 BSFC = 151.7 horsepower

151.7 HP / 180 rated HP = 84.3% of power

Assuming a fuel usage of 11 gallons per hour for this problem provides a reasonably realistic example of the change that a different fixed pitch propeller might create. It also illustrates the need for pilots to change their habits when a propeller is changed. In addition to the change of habits, the discussion shows a real need to reevaluate the takeoff, climb, and cruise performance of an aircraft if the fixed pitch propeller is changed for a different model.

Another very important point concerns leaning. Remember that Lycoming recommends leaning to best economy only at 75% of rated horsepower or less. It is very possible that leaning to roughness or to peak on the EGT gage could cause serious damage if the engine is actually producing more than 75% of rated horsepower as shown in this illustration.

With this information as background, it is easy to see that setting a desired power with a fixed pitch propeller can only be accomplished if the pilot has a chart that applies to the specific aircraft/engine/propeller combination. Although the power chart for a new aircraft may come from data obtained by test flying with a calibrated torque meter, a fairly accurate chart can be derived for any fixed pitch propeller and engine combination. Briefly, this is done by finding the maximum available RPM at any particular altitude and applying data from the propeller load curve.

To conclude, the purpose of this article is to make readers more aware of some operational aspects of the fixed pitch propeller. Usually it is only necessary to accept the material provided by the airframe manufacturer and to use the engine/propeller as directed. If a propeller change is made, or on those rare occasions when we question the power available to the propeller, the material presented here could prove to be helpful.

Spark plug fouling

Spark plug fouling in your aircraft engine may be a problem. It is desirable to reduce the problem as much as possible. Textron Lycoming Service Letter L192 provides information that may be very helpful in reducing spark plug fouling. To aid our readers, the entire text of the latest revision to Service Letter L192 is printed here:

"In many cases spark plug fouling resulting from the tetraethyl lead (TEL) in aviation fuels can be reduced or eliminated by proper operating techniques.

"The problem of lead fouling arises when low engine operating temperatures coupled with a rich mixture prevent the complete vaporization of the TEL. Under these conditions, lead deposits can form in the spark plug electrodes, causing misfiring. By establishing and maintaining proper engine operating temperatures, the TEL can be kept properly vaporized and pass out the exhaust system.

"However, the Champion Spark Plug Company has designed a spark plug which will reduce or eliminate the effects of lead fouling. The spark plug REM-37-BY can be used in the following engines: O-235; O-320; IO- 320-B, -F, AIO-320; LIO-320-B; IO-320-A, -D, -E; AEIO-320; HIO-360-B; HO-360; O-360-A, -C, -E, -F; IO- 360-B, -E, -F; AEIO-360-B, -H; O-360-B, -D; IVO-360; VO-360-A, B.

"For operators experiencing lead fouling, the following operating recommendations are made:

1. By use of the spark plug recommendation charts, be certain the proper plugs are installed. Do not simply replace the same part number of those removed. A previous mechanic may have installed the wrong plugs. Reference latest edition of Service Instruction No. 1042.

2. Rotate top and bottom spark plugs every 25 to 50 hours. Top plugs scavenge better than the bottom ones.

3. Proper adjustment of the idle speed (600 to 650 RPM) fuel mixture, and maintenance of the induction air system, will ensure smooth engine operation and eliminate excessively rich fuel/air mixtures at idle speeds. This will minimize the separation of the non-volatile components of the high leaded aviation fuels greatly retarding the deposition rate.

4. The engine should be operated at engine speeds between 1000 and 1200 RPM after starting and during the initial warm-up period. Avoid prolonged closed throttle idle engine speed operation (when possible). At engine speeds from 1000 to 1200 RPM, the spark plug core temperatures are hot enough to activate the lead scavenging agents contained in the fuel which retards the formation of the lead salt deposits on the spark plugs and exhaust valve stems. Avoid rapid engine speed changes after start-up and use only the power settings required to taxi.

5. After a flooded start, slowly run the engine to high power to burn off harmful lead deposits, then return the engine to normal power.

6. Keep engine operating temperatures in the normal operating range. Too many people think the lower the temperatures the better. Keep cylinder head temperatures in normal operating range by use of normal power and proper leaning. Use oil cooler baffles to keep oil temperature up in winter.

7. Use normal recommended leaning techniques at cruise conditions regardless of altitude and re-lean the mixture with application of alternate air or carburetor heat. If aircraft is used as a trainer, schedule cross country operation whenever possible.

8. Rapid engine cool down from low power altitude changes, low power landing approach and/or engine shut- down too soon after landing or ground runs should be avoided.

9. Prior to engine shut-down the engine speed should be maintained between 1000 and 1200 RPM until the operating temperatures have stabilized. At this time the engine speed should be increased to approximately 1800 RPM for 15 to 20 seconds, then reduced to 1000 to 1200 RPM and shut-down immediately using the mixture control."