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Section 1 Symptoms

1. Engine Quits

1.1 Without Warning, High Power

In most cases, if an engine quits without warning, the cause is fuel related. To get an idea why the engine quit, first evaluate the flight condition. In climb or cruise, if no change to the engine controls has been made, most likely the **fuel supply was interrupted** (blocked or disconnected fuel hose). Fly and land the airplane first and later read the chapter on fuel systems in the Systems section for likely reasons.

If the engine quits and possibly restarts when the nose of the airplane is lowered and/or the throttle is pulled back, the fuel supply may be very low or a major **fuel leak** has developed. If switching to a fuller tank does not change the situation, suspect a fuel leak (hose fitting loose for example). This presents a significant fire hazard if the leak is in the engine compartment and if a suitable landing site is available, it may be best to turn the fuel selector valve off and land. If the leak is in the cabin area, there may be a strong fuel smell.

If the airplane has come out of maintenance, there may be **air in a fuel line** (for example if the fuel was drained for a weight and balance). The engine will quit when you switch to a the tank you have not used before, but if the boost pump is turned on, it will eventually draw fuel through the lines and the engine should restart on its own after a few seconds if the prop is windmilling. If not, use the starter.

An engine driven **fuel pump failure** will cause the engine to quit due to fuel starvation. This is quite rare though. You should be able to get it restarted with the boost bump turned ON if you have enough altitude to troubleshoot. Your first priority must be to fly the airplane.

The **magnetos may be grounded,** which is equivalent to turning the ignition switch off. While it is unlikely that this would happen at the same time with two magnetos, a faulty ignition switch could potentially cause this. If you have electronic ignition, the engine will quit if electrical power is lost to the ignition system. To reduce the chance of a single point failure, it is an advantage to use two different ignition systems, for example one magneto, which is a completely self-contained ignition device in addition to an electronic ignition.

If you are **side-slipping** an airplane with wing tanks for a prolonged time and the fuel selector is on the low wing, eventually the fuel supply will be interrupted and the engine will quit because the fuel flows away from the pickup at the wing root. Terminate the sideslip or switch to the other tank.

Most mechanical problems with the engine will give you some sort of warning before you lose power completely. Typical symptoms are loss of oil pressure, roughness or vibrations. Depending on the nature of the problem, there may not be much time before the first indication that something is wrong and the loss of power. At low altitude, your first priority must be to maneuver the airplane into a position from which a safe landing can be accomplished. Troubleshooting must wait. If you still have some power, use the following chapters to determine possible causes.

1.2 Without Warning, Low Power or Idle

There can be several reasons for the engine to quit when you pull the power to idle, especially if you have operated it for a while at low power during a descent.

One reason the engine may quit is badly **fouled spark plugs** after running the engine at low idle with a rich mixture**.** To minimize the chance of this happening, lean the mixture during the descent or when taxiing. Do not forget to enrichen it before applying full power, or the engine may quit then. If the engine does not have a mixture control, periodically apply higher power (cruise power) for about 30 seconds to clear the spark plugs. Do not let the engine temperatures drop below the minimum for full power operation (green arc on gauges – normal operating range). Avoid running an engine at idle in flight for any longer than necessary.
If the problem is recurring and depending on the type of deposit formed on the spark plugs, selecting a colder plug from the approved list may help. Depending on the lead content of the fuel and the type of operation, more frequent cleaning of-the

spark plugs may be necessary. Where the majority of engine operation is at low power, a hotter plug can be advantageous. If the majority of operation is at high cruise power, a colder plug is recommended.

An **overrich mixture** can cause the engine to quit, especially in combination with a low idle rpm setting. This can especially happen on a warm day, with the mixture full rich, on approach or on final, if the carburetor heat is turned on. Supplying the engine with unnecessary additional hot air will reduce the density of the air in the intake further and enrichen the mixture to a point where the engine will not run anymore.

On engines where fuel flow is regulated by fuel pressure such as the Continental IO-360 and IO-550 series, turning the **high boost on** (>10 psi additional pressure) with the mixture control rich will flood and stop the engine. Low boost (<5 psi) will only slightly enrichen the mixture and not interrupt the engine operation.

1.3 With Preceding Warning

In most cases an engine will give you a warning before it quits. The time between the first symptom and the power loss is often only a few seconds. Pay attention to what exactly precedes the power loss, this can point you in the right direction for troubleshooting afterwards.

1.3.1 Engine Cuts Out and Restarts

You are **out of fuel or have restricted fuel flow**. If you have another tank containing fuel, switch to it and turn the boost pump on. There may or may not be a warning before the engine quits. This depends on the flight condition it may briefly lose power, quit and restart several times. If your fuel gauge is functioning, its reading (zero) should confirm the cause for the problem.
If the engine is running full rich and the power loss is due to fuel starvation, rpm may briefly increase before it decreases. If you have a constant speed propeller, this will not happen and the slight increase in power before it drops is unlikely to be noticeable.
The reason for the rpm increase is the brief leaning of the engine towards best power, then as it leans further, the power is reduced and the engine runs smoothly lean of peak until the mixture is leaned beyond what is needed for combustion. Depending on where you start out (rich or lean of peak), a change in power and EGT (rise or drop) can be observed. Read the chapter on fuel systems in the Systems section for likely reasons.

There may be **water in the fuel**. The engine may continue running roughly or quit completely depending on the amount of water it receives.

1.3.2. Rising CHT before Power Loss, Engine Smooth

There can be several reasons for the fuel starvation. One is the formation of vapor in the fuel, leading to **vapor lock**. This is likely the case if the fuel was very hot, for example if the airplane was parked in the sun in hot weather for some time. A rapid climb to high altitude can also cause this. High altitude in this case means above 10,000 ft. Vapor lock is possible with Avgas, but more likely with auto gas (mogas).
Fuel starvation due to vapor in flight usually happens slowly, and you will have a chance to observe the symptoms (rising CHT, changing EGT) and do something about it. A typical symptom is smooth engine operation until just prior to quitting. Enrichen the mixture and turn the boost pump on, that should fix it. Reduce the power and increase the airspeed if necessary and wait for the fuel to cool.
Vapor lock can also happen on the ground, especially at high ambient temperature and high elevation. If the engine was shut down for a short time, then restarted, it may run for a short time while you are taxiing, then quit without warning. In the worst case you may have to wait until things cool down.

1.3.3. Low Oil Pressure Before Power Loss

The most likely cause for the engine failure is **oil starvation**, either from loss of oil or a restriction at the oil pickup location. Unapproved additions to the engine can have unexpected results. One owner added a magnetic pickup to the engine oil drain plug which restricted oil flow to the oil suction screen, causing oil starvation to the engine, resulting in a failure.

1.3.4 Engine Roughness before Power Loss

If the engine quits with preceding roughness, it can often be traced to **fuel system contamination**, which lowers the fuel pressure and fuel flow to a point where the mixture is too lean for the engine to run. Depending on the severity of the contamination, the engine may continue to run with some roughness or quit completely. The roughness may happen all of a sudden, but a complete power loss may take a while.
Reducing power and turning the boost pump on often smoothes out the engine operation but does not fix the basic problem. Read the chapter on fuel systems in the Systems section for likely reasons and be prepared to clean the entire fuel system before the next flight.

A different cause for the symptoms described above can be a small **fuel leak** in the lines which increases over time. If the leak is small, the mixture will initially lean out because the pump is drawing air into the lines, with the same symptoms as you would see them if you manually lean the mixture. If the leak is aft of the firewall, you should be able to smell the fuel in the cabin. If that is the case before a flight, do not fly the airplane until you have determined the reason for the fuel smell. It may be acceptable to fly if the leak is very small, but it is recommended to fix it before flight.
If the leak is larger and has developed in flight, the engine will start to run rough, which can be intermittent, or even quit completely. Although it may restart if the throttle is pulled back, the boost pump is turned on or the mixture is set to rich, land as soon as possible because a fuel leak always poses a fire hazard. Read the chapter on fuel systems in the Systems section for amplified explanations.

Carburetor ice will cause a power loss, and if no action is taken by the pilot, the engine may run rough and quit. If you have a constant speed propeller, which keeps rpm from dropping, the power loss may first become apparent as a drop in indicated airspeed and manifold pressure. The whole process takes some time which should be sufficient for you to think about what is happening and turn the carburetor heat on. Factors promoting carburetor ice are high humidity, low OAT's or the use of fuel with ethanol which can contain more water than Avgas, which readily forms ice in the carburetor even if the air is dry.

1.3.5 Engine Roughness when advancing Throttle

If the engine runs rough, quits or fails to produce high power when the throttle is advanced, it can be due to an **excessively lean mixture**. If you have a mixture control, make sure it is full rich before you push the throttle forward.
If the mixture control is all the way forward, consider that it may be misrigged or has become disconnected, especially if the airplane has just come out of maintenance. There can be other factors which are influencing the mixture. Use EGT and fuel flow readings to troubleshoot the problem. The EGT's of all cylinders will be higher than normal and the fuel flow will be lower than normal if the mixture is too lean.
Run the engine at a power setting where it still is smooth with the mixture control full forward. Slowly lean the mixture and observe the EGT readings. They should rise continuously, peak and drop 50ºF to 100ºF, depending on the engine, before the engine starts misfiring. If this is not what is happening, something is wrong with the mixture. This can be a restriction in the fuel system due to debris (if the problem started gradually) or a wrong fuel system setup (after maintenance).

Clogged injectors on a fuel injected engine will cause the affected cylinders to run too lean, with the symptoms as described above. If the fuel flow to one cylinder is significantly blocked, the EGT and CHT will be much lower than for all other cylinders.
Note that a partially clogged nozzle (injector), in an aircraft that has a pressure operated fuel flow indicator, will cause that indicator to display a higher than normal fuel flow. Leaning in an attempt to correct the high indicated fuel flow will result in an even leaner mixture in the affected cylinder.

2. Engine Runs Rough

My definition of "rough" or "misfiring" means that the engine is power output has become irregular. This is opposed to "vibrations", where the engine shakes evenly with the same frequency and amplitude, which is discussed in a separate chapter. A rough running engine is probably the most common issue a pilot will encounter. There are many reasons why an engine runs rough, so for troubleshooting it is important to consider any other symptoms, conditions or contributing factors.

2.1 At High Power Settings (Throttle Far Forward)

Is there also a power loss? Does the engine run smoother when you pull the throttle back? If so, the first suspect should be the ignition system. A worn magneto or worn or fouled spark plug is less likely to produce strong sparks if the pressure in the cylinder is high.

2.1.1 Intermittent, Brief

If the engine sounds like it is cutting out briefly and keeps returning to smooth operation, but is not quite producing full power, suspect **fouled spark plugs**.
If fouled spark plugs are the problem (in flight) and the roughness is light, keep the throttle wide open to increase the temperature at the spark plug and burn off the deposits. If you have a prop control, increase the rpm. This should help the engine run smoother because it reduces the load on it. If you have a mixture control, lean it as far as practical but keep an eye on the engine temperatures. Wait a few minutes to give the deposits a chance to burn off. The engine should smooth out and you should also have full power available. If the roughness becomes worse when leaning, reduce power first.

Another reason for brief, intermittent misses can be **fuel contamination** with water, especially in fuel injected engines. Water droplets can remain suspended in the fuel for a while after refueling, especially if mogas is used. Once at cruise altitude, at lower temperatures, the water collects at the lowest point in the tank and is drawn to the engine where it may cause brief or longer power interruptions, depending on the quantity. This can happen with carbureted and fuel-injected engines. In-flight roughness can also be caused by trouble with one or more fuel injection nozzles. The engine may run rough intermittently, indicating that dirt or water has passed through a nozzle. If the engine runs rough continuously, it indicates that a nozzle is plugged. The EGT and CHT on that cylinder will be lower than the rest. Read the chapter on fuel systems in the Systems section for possible locations for airframe fuel system contamination.

Sticking valves will cause scattered or intermittent misfire or roughness. This roughness will be present at all throttle settings but be worst at high power. Reduce power as much as possible if the problem persists. In some cases it will improve once the engine warms up.

Some engines like Rotax may show some roughness in cold weather when the **engine temperature is too low**. Since the temperature sensor is usually on the hottest cylinder, it may show proper operating temperature even though the other cylinders may not be warm enough. Reduce the airflow through the engine compartment (winterization kit) or simply cover part of the radiators with duct tape (experimental airplanes only, please).

2.1.2 Continuous Roughness

If the roughness is such that the engine does not want to run smoothly unless you reduce power considerably, and you have used the procedure for fouled spark plugs with no or little improvement (2.1.1), you should suspect that the **plugs are also worn** (gaps too large) and need to be adjusted or replaced. If the roughness or the power loss is considerable or persists, reduce power to minimize the roughness, land and get the spark plugs cleaned or replaced.
The voltage required to jump a spark gap increases with the pressure of the charge between the electrodes and is approximately proportional to the size of the gap. If the gap is too large and the pressure in the cylinder is too high, the voltage may be insufficient to cause a spark. This is why the roughness due to worn spark plugs is worst at full throttle. How long the spark plugs will last depends on the type of engine, fuel used, how the engine is operated and the type of spark plugs. You should monitor their condition so that you know what their life expectancy is in your case. Keep in mind that spark plugs may wear faster than normal if the engine is often run hot and at high power settings.

Roughness can also be traced to a **worn magneto**. It may cause brief or continuous misfiring and power loss. This is most obvious if the engine has a single ignition and worst at high power. The engine most likely runs smooth at low power and idle. With dual ignition systems, a problem with one ignition is often only spotted during the ignition system test (preflight). The roughness is generally worse at high power settings. A magneto with more than 500 hours on it is a likely suspect. If the engine has dual ignition, the engine should run smooth if switched to the good magneto and rough when switched to the bad magneto. If the engine runs smooth when switched to both, it can be excluded that the bad magneto had a distributor gear failure.

A typical magneto failure which can cause severe and continuous roughness is the **magneto's distributor gear failure.** If it sheds teeth, the magneto can start firing spark plugs at random. Although throttling back may reduce the roughness, there is only one thing you should do. Turn the bad magneto off, this restores smooth engine operation by using only the good ignition!

If the roughness is accompanied by high or rapidly rising CHT on one or more cylinders, the cause could be **preignition**. Reduce power, land, and investigate the cause. Preignition is caused by something in the cylinder which is so hot that it ignites the fuel prematurely by acting as a glow plug. This results in very high stresses and temperatures on that cylinder and causes damage. Improperly torqued spark plugs have been identified as a cause for preignition. Once a spark plug backs out, it loses its normal heat conduction path though the cylinder head. It can then become so hot that it glows red and triggers preignition. An overheated exhaust valve can also cause preignition.

A **damaged distributor** (ignition) will cause continuous roughness or misses. This failure is not limited to magnetos but can affect any ignition system which uses a distributor. If you have dual ignition, identify which one is working well and operate on this ignition only until the problem can be fixed.

A worn or **damaged ignition harness** which allows the high voltage to bleed off can also cause the same symptoms, but is easy to diagnose visually when the cables are inspected. An obvious candidate for roughness and power loss are loose or **disconnected ignition leads**. If your ignition harness uses automotive spark plugs and connectors, check that the stay on tight. If the connectors are worn out, the cooling airflow may cause them to loose contact intermittently.

On a fuel injected engine, **blocked air reference lines**, or a blocked fuel manifold valve vent, can cause some roughness. The symptoms are similar to a clogged injector nozzle by not allowing the fuel to atomize properly. The affected cylinder(s) will have low or unusual EGT readings. Inspect the air reference tubes, the injector shrouds, and the manifold vent for blockages or leaks.

On many airplanes, it is recommended that the boost pump be in the "low" position for take off, landing and as required. It may happen at higher altitudes, when the pump is in the "off" position that the engine will hesitate, run rough or die. This condition is related to a **low head pressure** at the inlet of the engine driven fuel pump. Once the auxiliary pump is turned off, gravity and the weight of the fuel are the main factors that influence the head pressure to the engine driven pump.
Low head pressure is also influenced by the design of the airplane (low wing), low fuel level in the tank and possible deterioration of the fuel system. Low head pressure can be the result of restrictions. Fuel lines of the wrong size (diameter too small) will limit the fuel flow at high power. Having many 90º and 45º fittings in the fuel system also restricts fuel flow. Very long fuel lines also add up to flow restrictions. Particles may accumulate in fuel lines with little slope over time, leading to a reduced cross section and restrict flow. Debris in the fuel filter or gascolator will have the same effect.
Leave the boost pump on or operate the airplane at a lower altitude or lower power setting. If the engine is running rough, or dies, power can be regained by reducing the manifold pressure to a point where the engine smoothes out or resumes running.
Low head pressure can also lead to the following scenario. The engine initially runs smooth at full throttle, but after a minute or so runs rough and loses power because it is getting insufficient fuel. Check that turning the boost pump on restores the power and smooth operation. Switching tanks may not have an effect unless the fuel line routing is significantly different for the other tank.

If the engine starts running rough and threatens to cut out in cruise after running normally for a while, you may have a **plugged fuel tank vent**. Turning the boost pump on helps temporarily, switching tanks restores engine power if that tank is properly vented.

On fuel injected engines, **clogged fuel injector nozzle bleed air holes** can lead to rough operation. The reason is poor fuel atomization. Clean the nozzles.

Slight roughness or vibration can point towards **worn camshaft lobes** or valve lifters, because the valves do not open fully anymore. It is accompanied by a small loss of power. Another symptom would be lower than normal CHT and EGT on the affected cylinders. This condition is more common on Lycoming engines because the camshaft is above the crankshaft, making it more susceptible to corrosion, especially on airplanes which are not flown regularly or live in humid or corrosive (near sea shores) environments. In bad cases, metal is found in the oil filter and during oil analysis.

In very cold weather, the Continental O-470 (installed in Cessna 180/182s) can run rough in cruise and have a large rpm drop during ignition checks (>200 rpm). This is because of the very **poor fuel atomization in cold air**. Try turning the carburetor heat on to bring the induction air temperature up and leaning it as required. A carburetor air temperature gauge can point you in the right direction.

2.1.3 Intermittent Severe Roughness

If the roughness is intermittent and is reduced or eliminated at low power settings, suspect a **fuel leak or fuel system contamination**. In both cases the engine at times is not receiving enough fuel to run properly. Turn the boost pump on and be prepared for a total power loss if the problem becomes worse. Switching to a different tank may help if it contains cleaner fuel.

Magnetos are held on with two bolts. If the bolts are improperly torqued, the magneto may rotate and change **ignition timing**. Depending on how far it has moved, the roughness and power loss can be anything from light to severe. If you have dual ignition, switch one ignition off at a time. If the engine runs smooth on one circuit but not the other or both, continue to operate the engine on the good ignition and leave the other one off. If the ignition system is the culprit, moving the other engine controls is unlikely to have an effect on engine operation.

Preignition may be caused by high power operation at excessively leaned mixtures. Preignition is usually indicated in the cockpit by engine roughness, back firing, and by a sudden increase in cylinder head temperature. It may also be caused by a cracked valve or piston, or a broken spark plug insulator which creates a hot point and serves as a glow spot. Specifically, preignition is a condition similar to early timing of the spark. Preignition is a serious condition in the combustion chamber and will cause burnt pistons and tuliped (stretched) intake valves.
The best temporary in-flight methods for correcting preignition and detonation are to reduce the cylinder temperature by retarding the throttle, enriching the mixture, opening cowl flaps if available, or a combination of all of these.

Detonation can cause severe roughness and is very destructive to the engine. When operated within their limitations, engines are designed to have a good margin to detonation. The margin is reduced if the mixture is leaned at high power settings, leading to high temperatures, the octane rating of the fuel is less than what it should be or the power output of the engine is increased by increasing the compression ratio or increasing the manifold pressure. Carbon and lead compound deposits which accumulate on top of the piston, the inner cylinder head and cylinder surfaces increase the likelihood of detonation. The more time an engine has been in service with leaded fuel, the thicker will be the deposits.

Valve problems typically cause engine roughness, hick-ups, stutters, and vibration. The hick-ups and stutters can come from intake valves sticking.

If the severe roughness or backfiring happens during the ignition check (preflight), and it is the first engine operation after maintenance, there is a good chance that someone has **swapped ignition leads**. This is easy to verify visually since they are usually labeled with the cylinder number. See section 2 for typical cylinder numbers.

Improper fuel, for example if the airplane was fueled by mistake with Jet fuel instead of Avgas can cause very rough engine operation due to detonation from the reduced octane rating. Since this is damaging to the engine, shut it down immediately and remove the contaminated fuel from the whole system.

2.1.4 Roughness Right after Startup

If the engine runs rough right after startup but smoothes out once it warms up, it could be caused by a **sticking exhaust valve** which is not closing fully. For troubleshooting, observe EGT and CHT readings of all cylinders during a ground run. On the affected cylinder, the EGT should be approximately normal, meaning the cylinder is getting fuel and is firing, while CHT is low because it is not producing much power. Further symptoms: the engine runs rough on either ignition. Perform the “poor man’s compression test” by pulling the prop through all the cylinders by hand and you will find that one of them is decidedly weak. Open the cowling, one cylinder should be cold. Remove the top spark plugs and put your finger over the holes while pulling the prop through. On the cylinders with the good valves, the piston will try to blow air out the hole on the compression stroke. If that is not the case, you have confirmed the problem in one particular cylinder. Next, pull the rocker box cover and visually check if one of the valves is stuck in the open position. If it were stuck in the closed position, which is fortunately much less common, the problem would be significantly worse and would involve a bent push rod and tube and would mean having to pull a cylinder.
Deposits on the valve guide or valve stem are causing valves to stick. Read the chapter on valve actuation and issues in the Systems section for more information.

The same symptoms (but usually shorter in duration) can also be caused by **air in the fuel lines**. This is common when the tank lies below the engine. Running the boost pump for a longer time before startup to purge the air from the lines can reduce or eliminate this problem.

A carbureted engine will run rough a short time after startup if you forgot to **open the choke** or if it is improperly rigged.

An **induction system leak** will cause the engine to run rough with the throttle at idle and low power. This problem persists even when the engine is warmed up. To verify this is the problem, open the throttle, the engine should run smooth then.

Some engines have a **fuel drain valve** which could be loose or defective, allowing air to be drawn into the intake (same symptoms as other induction system leaks).

2.1.5 Sudden Severe Vibration

If you have an engine with **dual carburetors** like the Rotax 912 and you experience sudden and severe engine vibration, roughness and power loss, the cause could be a problem with one of the carburetors. If the fuel supply to one of the carburetors is interrupted, the engine runs only on half the cylinders, which does not work well. The remaining power is most likely insufficient for level flight. If the power is reduced, the engine should run somewhat smoother. Examine the fuel supply to the engine (leaks) and check the carburetors for clogged orifices.

Sudden severe vibration is the result if a **piece of the propeller has broken off**. Reduce rpm as far as possible or shut the engine down to prevent damage.

2.1.6 Roughness at High Altitude

If you are flying a turbocharged airplane and are at high altitude when the roughness starts, it may be due to a **leak in the magneto pressurization**. Low air density reduces its insulating effect and can lead to internal arching of a magneto and therefore misfiring. If descending to lower altitude restores smooth engine operation, this diagnosis would be confirmed, unless the arching has caused permanent damage inside the magnetos.

A similar reason for a fuel injected, turbocharged engine to run rough at high altitude is a **leak in the nozzle pressurization**. This leads to uneven fuel atomization at the fuel injector nozzles.

The effects of a **cracked or burned coil** inside of the magneto will often show up at altitude as misses. Without an external damage indication, these can usually be best found by disassembly or bench test of the magneto.

2.2 Rough at Low Power or Idle

If the engine runs rough and misses at the first third of the throttle movement, but runs smooth and produces full power with the throttle further forward, you most likely have an **induction system leak**. Another symptom may be rising manifold pressure at a constant (low) throttle setting.
With the throttle closed, the pressure in the induction system (downstream of the throttle valve) is much lower than the outside (atmospheric) pressure. A faulty gasket, cracked hose or chafed tubing will let extra air into the engine intake. This air has not been mixed with fuel and therefore leans the mixture. Unwanted air may also enter the induction system through a primer system or leaky manifold pressure hose.
If the leak is large enough, the engine may quit from this excessively lean mixture. Another indication for an induction system leak may be higher engine temperatures, again due to the lean mixture.
In the case of a fuel injected engine, the metering unit will not account for the extra air and too little fuel is provided, again with the result that the engine runs too lean at low throttle settings.
One test is to enrichen the idle mixture, this should help the engine run smoother but of course does not fix the basic issue. Find the leak and fix it. Check that hose clamps on couplers are tight and the rubber is not cracked.

If the engine will not run with the boost pump on at idle (exceptions: fuel injected Continentals), and there is black smoke coming from the exhaust, the **idle mixture is too rich** and / or the boost pump pressure is too high. Lean the idle mixture at the injector or carburetor or adjust the boost pump pressure.

A fuel injected engine may have a **sticking valve in the flow divider**, which can be caused by debris. It will have to be disassembled and cleaned.

If the engine has run for an extended time on the ground at low rpm and rich mixture, the **spark plugs** will easily become fouled. An ignition check will show excessive rpm drops. If it is really bad, when the throttle is advanced, the engine may run rough, stumble or quit.
If the engine continues to run, lean the mixture, increase the power and wait for the deposits to burn off. Once the engine runs smooth and a check of left and right ignition shows an acceptable (small) difference and drop in rpm, you can take off. Keep in mind that there will still be deposits on the spark plugs and you may have a little less than full power available until the higher engine temperatures cause the rest to burn off.
If the engine quits when you try to advance the throttle, clean the spark plugs mechanically. Avoid long ground operation at low rpm (below 1000 rpm for direct drive engines) and lean the mixture.

Uneven or **wrong fuel pressure** on a fuel injected engine can lead to rough operation at idle. Check the fuel pressure reading against what it should be per the manual and adjust it if necessary.

The **exhaust valves may be warped** or burnt or a valve spring may be broken. If that is the case, rough operation will be persistent at all throttle and mixture settings.

If a valve has been sticking, a **bent pushrod** may be the result. In turn, this valve is not going to open properly anymore and will cause continuous rough operation and a power loss. With the engine off, turn it over by hand and the bent pushrod may be producing a scraping noise if it contacts the tube. Remove the valve cover to confirm that the valve is not opening.

3. Vibrations

Piston engine vibrate, that is normal. Every engine has a certain vibration level which cannot be reduced further. It is therefore easiest to spot abnormal vibrations if you are used to a certain engine and are familiar with what is normal for it. Read the chapter on engine vibrations in the Systems section to gain a better understanding on what causes vibrations to become worse.
The frequency of the vibration can be an indication of what the problem could be. Is it low <1000 rpm (like a mis-firing cylinder)...medium 1000-2500 rpm (prop speed)...high >3000 rpm (a buzz)?

3.1 At Certain RPM

If the vibration you experience in the cockpit becomes worse at certain rpm, most likely something has come **loose or is broken** and now resonates at certain frequencies. It does not need to be something attached to the engine, it can be anywhere on the airplane. A typical symptom is the occurrence of the abnormal vibrations at a multiple of the lowest rpm, for example at 1200 rpm and 2 x 1200 rpm = 2400 rpm.

Worn **torsional vibration damper** and counterweight pins or bushings on the crankshaft can lead to vibrations. Not all engines are equipped with torsional vibration dampers. The Lycoming IO-540 series and Continental IO-550 series engines are examples for engines which have those devices. A common misconception is that the torsional vibration dampers cause vibrations if the bushings or pins are worn. If there is a problem with those parts, the torsional vibrations they cause will not be noticeable to the pilot. They can be destructive to other engine components, such as gears and accessory drive shafts. A symptom for worn torsional vibration damper bushings would for example be a failed fuel pump drive shaft, with the consequence that the engine quits due to fuel starvation until the electric boost pump is turned on.

Check if the engine **shock mounts are sagging** excessively and the engine or baffling may be hitting something stationary (cowling, engine mount etc.).

Check the **propeller bolt torque**.

Check **propeller flange to crankshaft** attachment.

Check **engine mount bolts torque** at firewall.

Worn engine components like the **camshaft lobes** can be responsible for vibrations or some roughness at certain rpm. A quick check is to remove the valve covers and measure if all valves open exactly the same amount. A boroscope inspection of the camshaft can visually confirm wear or corrosion of the lobes. If any damage to the camshaft is found, the solution is to overhaul the engine and replace the camshaft. Lycoming engine are more susceptible to worn cams due to corrosion because the camshaft is above the crankshaft and receives less lubricating oil.

On engines with **hydraulic lifters**, a problem with these components can cause vibrations.

3.2 At High Power Settings

If the vibration is most severe at high power setting and rpm and has developed over time, it is likely that the **propeller** is causing them. Installing a different propeller is often a quick way to verify this.
Verify that all blades are at the same angle. Differences of >0.2º in **blade angle** can already cause noticeable vibrations. Compare the blade angles at different stations, not just one. A blade may be twisted, something that is more likely to happen with a wood propeller since wood has low torsional stiffness and moisture can cause it to deform.
Check the **tracking** at the tips, the propeller manufacturer should have specified a tolerance for this.