

Synchronizing the Cylinder Vacuum

Motorcycle cylinders work quite independently compared to automobiles. Separate carburation, intake manifolds, exhaust pipes and sometimes even independent air filters allow the cylinders to be tuned so that one may be making more power than another. This can be due to differences in air flow, temperature, injection, or valve adjustment between the cylinders. Periodically, the cylinders should be synchronized. This is usually done by comparing intake manifold vacuum beneath each throttle and trimming the mixture until balanced.

Some old-timers will tell you it can be done by ear, listening to the air flow in each carb throat through a tube stuck in your ear. Most modern tuners have switched to mercury sticks. Rigid tubes stuck in a bath of mercury are attached to the vacuum source. The vacuum draws the mercury up the sticks in proportion to pressure difference between the manifold and the atmosphere. In order to smooth out the individual vacuum pulses, a damping device is needed. This is nothing more than a small orifice (pin hole) restriction in the lines, placed close to the manifold with an air reservoir (length of tube) behind it. Because there is no real air flow in the gauges, there is no pressure drop across the orifice. But when the manifold vacuum drops there is a delay before the gauge pressure can bleed off and it appears steady and readable. Other types of vacuum gauges include mercury-less versions (that draw metal rods), or traditional needle, or "clock" gauges. The clock gauges are very fast acting (they are designed that way so you can see engine problems such as sticking valves). You will definitely need a damper if you choose a clock gauge. I would recommend using two side by side gauges for checking cylinder synch. The reason is, the cylinders are not perfectly independent. As one cylinder drops strength, the idle drops, and this will change the vacuum in the second cylinder's manifold. It takes a bit of fooling around to get a cause-and-effect feel when you are turning the screws. Swapping gauges would make this difficult.



A cheap set of carb sticks. Marked in centimeters of mercury, these are very sensitive. Most manufacturers request balance less than 2 cm Hg. Up to four cylinders can be viewed side-by-side.

The Falco control unit uses manifold pressure as one of its primary map variables (especially at idle). You would like to synch the cylinders with this control "open loop" so you will need to unplug the electrical connector from the manifold pressure sensor. This sensor is clipped to the lower left side of the airbox. Attached to this are two very small vacuum lines, connected between a "tee" connector and each of the manifolds below the throttle body. These should be unplugged from the tee. You can use them as a vacuum source, or you can plug them. You will need very small adapters to attach these hoses to most vacuum gauges. I found suitable conical shaped adapters in

my Mitivac vacuum test kit.

On the left side of the airbox, unplug the electrical connector to the manifold pressure sensor. Also, remove the two vacuum hoses from the "tee". Test vacuum may be taken off of these. Or plug them.



On the right side of the intake manifolds, there are larger vacuum ports. The front port is plugged. The rear is attached to the clutch diaphragm. You can use these for test vacuum and they will fit most gauges easily. The clutch line uses Aprilia's favored clic-clamp. You may not be able to reuse this clamp if you remove it. Plan on having a 1/4-in worm clamp on hand.



Larger vacuum ports are on the right side of the intake manifolds. The rear line feeds the slipper clutch. Depending on how you remove the clamp, you may not be able to reuse it.

Attaching the gauges to the left-side vacuum lines. Note the adapters and damper orifices in the lines.



You'll want to adjust the cylinders while warmed up, but if you plan on idling for an extended time, you may want to put a fan in front of the bike. You can start the bike up and idle it with the gauges in place, but remember never to rev the throttle on or off quickly with the sticks attached. It is possible to suck mercury out of the gauges and into your engine. Before starting your bike, though, locate the brass air bleed screws on the left side of the

throttle body. Mark the slot location, then turn the screws lightly all the way in, counting the turns. Turn them back out to their original location. Record the number of turns so if you get messed up you can get back to where you were.



The mixture is trimmed with air bleed screws. Clockwise closes off the orifice, making the mixture richer. Count the number of turns to seat the screws before you start working. From the factory, these screws are usually set an equal number of turns out (approximately 1-1/4).

If you are working for the EPA, you'll want to see how lean you can possibly set these screws and still have the bike idle without overheating or stalling. For the rest of us, the tuning theory is to richen these screws (turn clockwise) until doing so no longer results in a better idle. Better idle, loosely defined, is a faster idle speed and a steadier vacuum. Your secondary objective is to balance the vacuum in the manifolds for each cylinder. While you do this, you will want to keep the idle speed around 1,300 - 1,500 rpm. Balancing at too high an rpm accentuates differences in port flow. Adjust the idle speed with the thumbscrew on the right side frame. Note that the thumbscrew and idle screws do the same thing: control the amount of air in the mixture. So, many different "solutions" of air screw settings and idle screw settings are possible (not to mention the CO adjust screws in the ECU box). Driveability will dictate the best settings. Normally, that is around 1 to 1-1/4 turns out on the air screws and the idle adjust thumbscrew near its lowest possible setting (it will stop reducing the idle when the throttle plates hit the second idle stop). If you are running a Factory Pro or other aftermarket chip, you may find that lower air screw settings and more throttle plate opening are necessary for good off-idle throttle response. See the [idle adjustment](#) page for hints in this case.

I can only suggest a tuning procedure here, as I haven't read the manual on this. I ended up with the front screw out 1-3/4 turns and the rear screw out 1-1/4 turns. So a good starting place would probably be with both screws 2 turns out. Richen up a quarter turn at a time until the idle drops. Eventually, it will drop noticeably. When it does, back the screws out 1/4 turn. Balance the cylinders from there, by turning the strong cylinder's screw out. Watch the vacuum gauges. If the vacuum is erratic, as if searching for an idle speed, try leaning out another 1/4 turn. My bike never did have a really steady vacuum when balanced, but seemed to run better with the front cylinder slightly stronger. I've been told this is not abnormal.

When you are done, reset the idle speed and reconnect the vacuum lines and electrical connector.

Update: August 2001. A Mille owner from Australia was good enough to send me a copy of the Mille service manual for the cylinder synchronization procedure. In summary:

- They did not synchronize vacuum, they synchronized %CO emissions, setting them to between 0.8% and 1.3% CO at 1250 rpm (plus or minus 100 rpm). This is quite lean, of course. Coolant temperature during

this test is 80-100 C (176-212 F), and air temp is 20-30 C (68-86 F).

- Vacuum was checked, and targeted at 300 mbar plus or minus 30 mbar (22.5 cm Hg plus or minus 2.25 cm). The manual warned that small differences in vacuum were acceptable only if the CO% was in range. They did not disconnect the pressure sensor (but my dealer told me they did this at Aprilia training).

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Tuning the Idle Mixture with Factory Pro Chip

Marc Salvisberg at [Factory Pro](#) tuning has put a lot of time and experience into a new chip for the Falco/Mille. It pulls very hard midrange to top, but I especially appreciate the time he put into making the low cruise rpms smooth. The first thing most people notice if you use this chip is that the idle speed comes up significantly. There is usually not enough range in the idle adjustment thumbscrew to bring the idle down! As Marc says, funny things happen when you give an engine the right amount of fuel for the throttle settings.

On the right side of the frame rail is a thumbscrew for adjusting the idle stop. This idle stop determines how far the throttle plates are open when they are in their closed position. Turning the thumbscrew counterclockwise will reduce the idle until a the throttle linkage hits a second idle stop, hidden under the airbox and set by the factory. You can remove the airbox and adjust this factory stop to lower the idle further, but driveability will suffer. As the throttle plates approach a sealed position, the off-closed throttle response gets jerky. If you have moved this factory stop, it can be reset by turning it out until the throttle plates are just completely closed, then turn it in between 1/2 and 3/4 turns. Tighten the M5 locknut when you are done.

The lower throttle stop screw is connected via flexible shaft to a thumbscrew on the frame rail. A spring holds tension on it. The upper throttle stop is set at the factory, 1/2 to 3/4 turns in from the position where the throttle plates are completely closed. A locknut holds it in place.



From the factory, the throttle position sensor (TPS) is zero'd to the value of this secondary throttle stop. If you have lowered the throttle stop, the TPS adjuster will now have a negative offset, but this is a small problem as the primary map at low throttle openings is vacuum axis and not throttle position. You can verify the correct setting of the TPS removing the seat and removing the rubber cover on the ECU protection box. There will be two mating barrel connectors, unplugged in the rubber box. Plug these together, then turn on the key *without* starting the bike. When the throttle plates are closed against the throttle stop, the computer should be reading the TPS potentiometer as "0" (look at the right-hand dash display for a "-1", "0", or "1" indicator). If the dash display reads "-1", your TPS has a slight negative offset, and you should pick up the idle stop a bit until it reads "0". If it reads "1", your TPS is not adjusted properly. It is likely that your idle stop is a hair too high. Try readjusting it lower, but staying in the 1/2 to 3/4 turn range. If the TPS display will not come down to "0" in this range, the TPS can be reset by loosening the mounting screws and rotating the potentiometer. This is very unusual, however, so be sure you've not made a mistake before moving your TPS from the factory position. Turn off the bike and unplug the diagnostic connector when you are done.



The diagnostic connector is located in the rubber ECU box. Plug the two connector halves together with the engine off. Turn on the key (without starting the bike) and the computer will enter diagnostic mode.

Unlike many other bikes, you don't need an ohmmeter to set up the TPS. In diagnostic mode, the computer will tell you where it thinks "zero" throttle position is.



With your throttle plates set and TPS verified, you can now set the idle mixture for the desired idle. There are two inputs left, the air bleed screws and the CO trim pots. The air bleed screws control the amount of air bypassing the throttle plates. There are two of them so they may be used for synchronizing the cylinders. These are the large brass screws in the base of the throttle bodies, visible from the clutch lever side of the bike. The goal is going to be adjusting the idle speed by moving these screws. Stock, they are approximately 1-1/4 turns counterclockwise from fully seated. With the Factory Pro chip, they will need to be approximately 1/2 turn out to get good driveability.



The mixture is trimmed with air bleed screws. Clockwise closes off the orifice, making the mixture richer. The stock setting is about 1-1/4 turns out from fully seated, but the Factory Pro chip will require that these be closer to 1/2 turn out.

Lightly seat the air bleed screws (clockwise), then turn them out one turn counterclockwise. Start and warm the bike above 176 F (80 C). Turn the screws clockwise equal amounts until the idle drops to your desired range, but the idle is still smooth. The factory idle setting is 1150 - 1350 rpm, but I have not been able to get my bike to idle smoothly below 1500 rpm. If the idle drops off sharply, you are probably too rich and should back the screws a bit.

With the Factory chip (and some other aftermarket chips), the CO pots are enabled. These are located in the metal ECU box, and can be accessed through holes in the front next to the connectors. These are 1 turn potentiometers, nominally centered in the middle of the range. With USA stock chips, these pots are disabled in software. With the Factory Pro chip, they are enabled, and should be adjusted for best idle.

Starting with the pots in the center position, turn each pot in 1/8th turn increments, waiting a few seconds after turning them for the idle to catch up to the input. The goal is to get the "best" idle. "Best" idle is a bit subjective, but generally highest idle with steady vacuum produces a good running engine. The pots most likely won't be in matching positions when you are finished. If you end up increasing the idle too much, readjust the air bleed screws again. The process is a bit iterative, but that's "tuning". When you are done, you will have found a good baseline setting for the air screws, and have trimmed the CO pots so that the idle is a strong and steady as possible.

If you like, you can also synchronize the cylinders at this point. The more I fiddle with this bike, the less important I think exact cylinder synchronization is. In fact, the service manual emphasizes trimming the screws to synchronize CO emissions, and verifying vacuum only to see that it is in the correct range (22.5 cm Hg, plus or minus ten percent). I have found the bike runs a bit smoother with a "stronger" front cylinder. See the procedure for setting up the vacuum gauges and [synchronizing cylinders](#) if you wish to verify your vacuum balance.

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