Beginners Guide to Two Stroke Jetting

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The following is a post I wrote on another forum; I thought there may be some here that might find something useful within it...

I'm writing this brief overview because it seems that there are still quite a few people not sure about how to go about jetting their bikes. Now, before all the experts chime in to tell me how you've been tuning record breakers for the last six decades and that this method leaves 2% of horsepower on the table just let me say that I don't claim this to be the ultimate tune - it's just a simple method that anyone can use to get a bike running nicely. There are multiple ways to successfully remove the skin from a cat.

What's our objective? To end up with a bike that runs cleanly throughout the range of rpms and throttle openings that doesn't seize, overheat or foul plugs. This is generally achievable with most engines but just be aware that as the state of tune increases beyond a certain point (with wide chamber cone angles and large port timing/areas) then it isn't reasonable to expect to be able to jet for good running both on and off the pipe. But for any reasonable street engine it'll be achievable.

What's a good, safe tune? One that's runs cleanly yet is rich enough to prevent detonation and piston seizure. Actually a very lean mixture is quite safe too - the engine simply won't run or it'll run so poorly that it'll be obvious to the rider that something is wrong. The riskiest condition is one that's just slightly lean - the engine will still run smoothly (so the rider will probably stay on the throttle) but it'll be susceptible to detonating and seizing or holing the piston.

Given the risk of lean mixtures, the first step in tuning is this - to find a setting that is unmistakably too rich. At every stage of throttle opening we first find a setting that is definitely, obviously, unmistakably too-rich and then back off from there. Notice I mentioned stages of throttle opening? The fueling of different openings (eg. idle, off-idle, 1/4 open, 1/2 open etc. etc.) is controlled by different carb components, and we set these individually and in a certain

sequence.

What do we need to get started? Most important is a notebook so we can record the changes and their effects. THIS IS IMPORTANT - GET A NOTEBOOK AND USE IT. You'll avoid duplicating tests and after you've made a few runs you can read back through your notes and look for patterns.

You'll need some marks on your throttle to show 1/4, 1/2 and 3/4 throttle openings. Guessing isn't good enough.

You'll need initial jet settings that are at least close enough to let the engine run and the bike be ridden. If it's a stock engine and carb this is easy - go with the factory settings. If it's an off the shelf replacement carb from Mikuni or Keihin for example then their as-supplied settings are generally close if the carb is appropriately sized and used on a reed valve engine. If the carb is a little bigger than normal (for a given cylinder size) you'll want bigger jets, and vice versa. Piston ported engines will want less jet. Sometimes you'll find the same carb used on a similar engine from another manufacturer and in this case their factory jets will be a good starting point.

But if you're running some oddball combination you can just run whatever you have and go from there.

You'll need a selection of jets to test, but you may want to carry out some runs with the existing jets before buying these. This way you'll have some idea of what sizes to get - after all if the existing jets turns out to be way too small there's no point in buying even more that are too small.

Your carburetor(s) needs to be clean and every orifice clear, including things like air bleeds that aren't always obvious. Float level should be at least in the ballpark and things like slides, needles and needle jets should be unworn.

You'll need an ignition that's in good shape that's properly timed. This is important - it's not at all unusual to waste time chasing a carburetion problem that later turned out to be ignition-related. You'll also need an engine that's in good mechanical shape with good ring seal and no air leaks or leaky crank seals.

You need some fresh fuel of an appropriate octane level, the same as you'll be using in regular riding. And a decent flow of that fuel through the petcock and any filters or strainers that might be fitted. If it's just a weak dribble fix it now.

You also need to be able to recognize the symptoms of lean running and rich running. We'll cover this in a minute. I'm not even going to go into plug reading - once you're familiar with the sound and feel of rich and lean conditions you won't need to even look at the plug. Plus there are other factors that affect the plug appearance that just confuse the beginner.

OK, we're nearly ready to get started. What we are going to do is jet the carburetor in a certain sequence starting at idle and with the throttle barely cracked, then onto wide open throttle, then finally we'll do that big bit in between. Then once we've done that we might even do it all over again to try to get as close as possible to the ideal settings.

Why the odd sequence? Mainly because the pilot jet and the main jet - the ones that control low throttle openings and full throttle respectively - have a big influence on the mixture strength at around 1/4 to 3/4 throttle. Much more influence than the mid-throttle settings have on the low and high openings. And we do the low throttle setting first simply because it's easier to work with a bike that starts and idles easily.

Before we start the engine though, lets talk about rich and lean conditions:

Rich is like this:

Tends to get worse as the engine gets hotter
Has a regular misfire, like a stutter. Mildly rich will fire every second cycle (four stroking), very rich every third or fourth cycle (six or eight stroking). Extremely rich mixtures will load the engine up to the point where it won't rev (the classic ba-pa-ba-baaaaaa sound of a loaded up engine with an open throttle and no load) or even die. Usually the quickest way to clear a loaded up engine is to back the throttle off to just above idle.
At idle a rich engine will tend to load up, get slower and slower and die.
Will usually respond OK to opening the throttle
Exhaust will be smelly, smoky and drooly, header pipe not very hot
Engine will run cooler than normal
Plug will look wet and black

Lean is like this:

Tends to improve as the engine heats up - wants the enrichment device left open for longer after a cold start
Runs weakly on a steady throttle opening and hesitates on further opening

Extremely weak mixtures simply won't fire at all
Exhaust and plug will be hot and dry, not much smoke, maybe none at all
Will need more throttle opening than usual to maintain idle
May buck and pop on the over-run and may be a bit slow to return to idle

Rookie tuners sometimes get confused - they know the engine isn't running right but aren't sure if it's rich or lean. This is where the temperature indicators are very useful, so we'll take a quick look at this now.

The way a bike runs from cold gives us a good idea of its mixture strength. A bike in good tune, started and ridden from cold (and by cold I mean anywhere from 50 to 70 odd degrees F, not freezing) will hesitate and maybe misfire a little for the first few seconds; it may take anywhere from 5 to 20 seconds before it runs cleanly and a further minute or two before it responds really well. Remember, cold engines like rich mixtures, hot engines like leaner. So if the bike runs relatively well from a cold start but gets worse with time then it's too rich. Or if it takes an unusually long time to warm up and run cleanly then it's likely too lean. Colder weather will dictate a longer warmup; if it's very hot it may run cleanly right from the start.

But what do you do if you simply can't tell which way to go? That's easy, just go richer and see if it gets better or worse. If you still don't know go richer again. You'll soon see which way to go. And if it doesn't run any better regardless of what jet you use then perhaps it's time to take another look at areas like the ignition or the crank seals.

Keep in mind that when we say "too rich" or "too lean" what we really mean is too rich or lean at a specific throttle opening. It's entirely possible that an engine runs too lean for example at just off idle and be too rich at mid throttle. We need to specifically check each of these openings, so if a rider says to you "It feels rich" the correct response is "Rich where exactly? Full throttle? Half?" As the engine is warming up see what it "feels" like at different throttle openings and make sure your notes record these details.

Here's an example of a tuning notebook entry:

Run# 1 - 220 main, 04 needle jet, 5df needle clip in 3rd groove from top, 45 pilot, 2 turns out, timing at 17deg. Warm day, hesitated badly off idle from cold, not so bad when warmed up but still baulky. Idles OK. Feels lean off idle, will try 55 pilot next.

Get the idea? Once you're more comfortable with tuning and making notes you might abbreviate them to look more like this:

#1 - 220/04/5df-3/45/2/17 - warm, very lean off idle

Let’s say our bike is running rich or lean at a particular throttle setting. How do we know how much more or less jet to give it? If it's obviously grossly rich or lean make your initial changes in big steps - say 30%. If it's not so bad but still obviously off then use smaller steps of around 15%, and if it's very close but just not quite perfect change it in 5% steps. Jetting in very small steps in the early stages just makes the job take longer to do, so make your changes progressively smaller as you get closer to the target. Jets are generally numbered according to flow, so a 220 will be 10% richer than a 200 for example.

Enough talk, let's get started with tuning. We'll begin with simply getting the thing to idle - this means we'll be working with the idle speed screw, pilot jet and air screw adjustment. So we'll get it started and running at some sort of idle, even if we are only keeping it running by holding the throttle. While it's running turn the idle air adjustment screw to achieve the best idle with the lowest possible throttle opening. Keep in mind that the screw adjusts the amount of air in the idle mixture, so turning the screw out makes it leaner. If you can't get decent a idle with the screw being somewhere between 1 and 3 turns out from bottom then we may need to change the pilot jet. If the screw ends up being bottomed out or almost bottomed out you need a larger jet; if it ends up being screwed out more than say 2-1/2 turns you need a smaller pilot. Once the engine has warmed up you should be able to snap the throttle open quickly to about 1/4 open without hesitation. If it hesitates, you need to go bigger on the pilot jet.

Don't be surprised if you have to compromise slightly with the pilot and airscrew setting - the one that gives the best idle with the lowest idle speed screw setting more often than not turns out to be a bit lean for the best off idle response. But usually you can richen it up enough to fix the response without affecting the idle quality too badly.

While you're adjusting the air screw take your time - move the screw say 1/4 turn and wait for 10 seconds or so to see what happens. There's a lag or delay in the engine response to screw adjustments, especially small ones.

You might find that there are two or three pilot jet/airscrew combinations that will give a good idle - for example 30 jet and 2-1/2 turns, a 35 jet and 2 turns or a 40 jet and 1-1/2 turns might all idle fine. In these cases use the combination that gives the best response when the throttle is suddenly opened from idle to 1/4 - 1/3 open. The different jet and screw combos can also provide options when trying to eliminate any popping or bucking on the overrun; normally a sign of a temporary lean condition.

Now that it idles and will take small throttle openings we'll head to the other end - full throttle and the main jet - before working our way towards the middle ranges. We do it like this because the main jet has a significant effect on mid-throttle mixture strength, but the mid-throttle settings (needle and needle jet) have no effect on full throttle running. In other words we are trying to avoid doing anything that will change what we achieved in the previous step.

So get the engine warmed up and see how it responds to full throttle throughout the powerband. Don't worry too much about coughs or hesitations in the midrange; all we are after here is clean running at full throttle. Be especially wary of signs of leanness and if you suspect it's lean don't keep riding, pull it up and get a bigger main jet in it before it hurts itself. What we are looking for is a condition that's clearly, unmistakably rich - in other words a stutter at full throttle that gets worse as the engine heats up. When you get to that point then we can gradually reduce the jet size until the engine runs cleanly.

What do you do if you can't get the engine to run too-rich no matter how big a jet you throw at it? This isn't all that uncommon with high output engines and is particularly common with methanol. It nearly always indicates a fuel supply deficiency that could be anywhere in the system between tank and fuel bowl. Fix it before going any further. Occasionally (and again, particularly with methanol) you may find that the major restriction at WOT becomes the needle rather than the main jet - the solution here is to find a needle with a smaller diameter at its lower end. Some people suggest testing for this by running without any main jet fitted but I can't really recommend this - the main jet is usually the only thing that holds the needle jet in position for a start - so if it's a concern test with an old drilled-out main.

How much leaner do we go from the main jet that is just lean enough to avoid a slight rich stutter? That's a matter of opinion and will depend to some degree on the application. If safety is the prime consideration then just lean it til it stops stuttering. And if the bike is subject to prolonged periods at full load and throttle you should stick with this somewhat rich setting - the cooling effect of the extra fuel will compensate to a large degree. But if you're after the absolute maximum output and the bike only sees full throttle intermittently then there is a small amount of power to be had by going just a tad - no more than 3 or 4% - leaner than the just-short-of-stuttering jet. But if you're going to do this remember you don't have as much safety margin to cope with changes in weather and so on, so you need to stay on top of it.

Now that we have a bike that starts, idles and runs at full throttle, it's time for the most difficult part - that big in-between bit from about 1/4 throttle to around 3/4 throttle. The components that govern this are the needle, the needle clip position and the needle jet. Before you start put

some marks on the right hand grip and throttle housing to indicate 1/4, 1/2 and 3/4 throttle. It's very difficult to accurately judge these while riding so make the marks clear and easy to see.

You should have a pretty good feel by now for rich and lean conditions, so go for a ride and see what it feels and sounds like. Ideally, even if it's rich or lean throughout the range at least it will be consistent, and you'll be able to adjust it simply by raising or lowering the needle and/or using a different sized needle jet. Try the clip position first and if you run out of notches then go to the next size needle jet and try again. Changing one needle jet size will generally get you back to the middle notch of the needle, though it depends largely on the needle profile. Don't be too concerned if the fueling is consistent everywhere except the range between around 1/8 to 1/3 throttle - this bit can be tuned out by changing the slide cutaway. A higher cutaway makes the initial part of the midrange leaner; a lower cutaway runs richer. The number of the slide with Mikunis refers to the cutaway height in sixteenths of an inch; not mm as you'd expect. A change of one number is quite noticeable; slides are generally available in increments of 0.5.

Be aware that a lean-running two stroke is quite happy to seize even at part throttle, so don't persist in riding if it feels lean in the midrange.

The most difficult situation is the one where the engine runs lean in one part of the midrange, but is fine or even rich in others. This sort of thing often crops up with major engine mods or carburetor upgrades. About all you can do here is to try to get the engine running cleanly at one throttle opening. If you can accurately determine where the needle is sitting in the jet at this point then you can measure the needle diameter and then you can calculate the annulus area between needle and jet (the carb manufacturers have charts listing the jet diameters). This gives a sort of reference point from where you can start studying the alternative needle sizes and profiles. It's tedious work that usually requires some trial-and-error so you need patience but hopefully there'll be a needle profile available that gives consistent fueling. This is one area where street bikes and things like trials bikes can take a lot longer to tune than a full-on racer - because these bikes spend so much time at part throttle it's critical that the needle profile is appropriate. Another technique is to chuck a needle in a drill and fine tune it by pinching it in the appropriate place with some fine sandpaper as it spins. But be cautious - even .001" off the diameter makes quite a difference. Once you have a working profile you'll probably want to find an unmodified factory needle that's a close match; sanding removes the protective hard anodizing and a modified needle may wear very quickly.

As mentioned earlier you can use the slide cutaway to sort any remaining low throttle issues. By this stage you should have a bike that runs well right through the range. If the bike tends to pop

and bang a little on the overun this can usually be sorted with a larger pilot jet and an airscrew adjustment. Don't be afraid to experiment - especially in the rich direction - if you keep good notes you can always revert to the best previous combo.

Bear in mind that the weather conditions have a big impact on tuning, so try to avoid tuning on unusually hot or cold days. For a streetbike you probably won't want to rejet every time a cloud drifts over but a good compromise is to run "summer" and "winter" jetting that will ensure reasonably good running throughout the year.

Obviously I haven't covered things like synchronising multiple carbs or tuning powerjets; if there's interest we could cover these later.