Number 2 in a Series of Papers on RD tweeking by Geoff "Shoeman" Battick

Cylinder Porting

This is the real magic to most people, and the most difficult to attempt if you have never done it before.

READ THIS WARNING FIRST

A word of warning: If you make a mistake here it can be either very costly or often impossible to correct. Whenever you are removing metal from something, bear in mind that you cannot put it back. ***Always measure twice, & cut once !*** think about it, and be sure to have the correct tools for the cut you are attempting. I have many hundreds of dollars worth of special tools just to do this stuff. A Dremel or some old files will not yield good results. If you cannot reach all of the port you are attempting to work on, then forget it or find someone who can. !!!

You should also be sure of the size of the cuts you make, as removing too much metal from any port can render the cylinder useless. There, that's the end of the warning.

If you've read this far, I assume you are already familiar with the basic operating principles of the 2 cycle engine. If not, go find a book or article that explains it and study it until you firmly understand it. It's too much of a subject for me to go into here. I'll also not go into a thorough treatise on all the theory of port timing and flow control, instead I'll give some good advice for a beginner who wants to build a moderately fast but dependable street bike or entry level racer.

The most common port and maybe the easiest to modify is the Exhaust. It will also yield the most immediate boost in perceived output by "the seat of your pants". A stock RD350 (according to the factory manual) has an exhaust port height of 29.5mm. That is measured from the gasket surface at the top of the cylinder down to the peak of the exhaust port. Always measure the cylinder you are working on to see if it has been previously modified!! A slight variance (up to 0.5mm) is average and common.

Note that the ports top surface is curved, rather than straight.This is important to ring life, and must be maintained in any modified port. You can raise the exhaust height to 28mm and suffer no ill effects in regards to a rideable powerband. Some people raise the exhaust even higher(the TR3 and TZ350 had a height of 26mm) but the transfer ports must also be raised or you will have a real hard to ride and ultimately slower machine.

Stock exhaust port width of the RD350 is 38mm(60% of 64mm). This can be widened to up to 70% of the cylinders bore (example: 64mm X .70 = 44.8mm) BUT!! never go immediately to the maximum!! Ring and piston life are shortened immensely at that figure, and max port width combined with a high exhaust port height can yield too much exhaust area for your cylinders transfer port area, which result in a **VERY** narrow powerband. I'll digress here for a moment on powerband characteristics.

This may sound boring, and you may feel you need real GP racer (actually modern GP bike are easier (!?) to ride than the air-cooled racers of old due to things like PowerValves, improved port layouts, electronically controlled carbs or fuel injection and digital ignitions that read rpm/throttle position and whatever other secret stuff being used) power, but bear in mind that we are usually dealing with the RD's standard street oriented Transmission.

Do the math and calculate the RPM drops between each gear for an RD versus an old TZ. You'll see that the separations between the RD's gear ratios are such that if you build an engine with an output like that of a TZ each time you shift (say, at 10K) you will fall out of the power rpm-wise and you will then have to wait until your mighty engine waahs its way up to 8k where the power starts once again, only to repeat again on the next shift, and so on. The reason old GP bikes got away with 2000 rpm wide powerbands was because they had transmissions that always kept the revs up where the power was (aka. a close-ratio gearbox) and good riders could keep it "on the boil". Lesser talented guys where left bogging out of the corners waiting for the Hit while the fast (talented) guys whipped past them and on to victory. So for these reasons the transmission you are using must be kept in mind when building an engine. More on that later.

Now, back to exhaust port mods. It will do you no good to just raise or widen the cylinder liner, you must also enlarge the entire exhaust "duct" out to the exhaust gasket/pipe surface. You need to have straight (meaning not wavy) walls, with no steps or lumps or ridges that taper down to the outlet side, which you can match to the exhaust gasket or pipe mount stub's I.D. Any steps or differences in the diameter here will cause reflections in the sonic waves that cause the pipe to do it's magic and will be bad for power output.

The Intake port is the next easiest to play with, and it also can yield good power boosts. When you examine a stock 350 cylinder you will see a lip and ridge at the bottom of the inlet at the liner. This should be removed. The factory says the bottom of the intake is 91.5mm below the top of gasket surface. This (once again, with CAUTION!) can be lowered to 100mm, but most people stay in the mid 90's. You need to put a large radius on the bottom of the port,and a big chamfer there as well or you will have piston breakage problems, especially with radically deepened (97-100mm) ports.

You can also raise the top of the intake port, up to 1mm below the bottom piston ring at BDC. This is approx. 66-67mm below the deck, but it is best to use a piston with rings that you slide into the cylinder and bring to BDC and then you can eyeball through the boost port where the rings end up and work from there. As this is a pretty small amount we're talking about removing, it's probably best for a novice to leave it alone and concentrate on getting a good port shape at the bottom, since that part of the port has a much greater effect on mass air-flow into the cases.

Finally we get around to the transfers and boost port. These are the toughest ports to modify, requiring special tools and lots of practice and a thorough understanding of the flow patterns involved. Suffice it to say that if you mess the transfers up, the cylinder will most likely be junk. Even though they are small, they take the most time to modify correctly. They also have a huge effect on the engines power characteristics. There is a very important relationship between the transfers and the exhaust, and the two must be kept in balance. The theories are more than I want to get into here, so I will give some very basic advice that anyone, with some research, can flesh out and take to the next level. The concept I'll use here is that of "Blowdown time"(BD), which is the time, in degrees of piston travel, between the time of exhaust ort opening and transfer port opening.

A typical race engine has a BD interval of 35deg. A street engine will usually have a BD of 25-30deg.

Surprisingly, the RD350 has 35degBD on stock form, pretty zoomy for a streeter, but that is part of the reason for it's signature power delivery. This is why you get into trouble if you raise the RD's exhaust port too much without raising the transfers as well. I shall explain...A long blowdown period is needed to clear the cylinder at high rpms, where the time allowed for scavenging the burnt gasses out the exhaust port is short. (I must add that port area is a significant factor in this process, and really must be taken into consideration in designing a cylinders port configuration, but I want to keep this at a basic level so we will conveniently ignore it.) But...the longer the exhaust is open, especially at lower rpm, the more chance, actually a certainty, there is of the fresh charge simply "short-circuiting" and instead of staying in the cylinder to burn, it heads right out the open exhaust port and you lose power.

So..if you raise the exhaust by much, even up to the 28mm I recommended, you get about 39.5deg. of BD, which will certainly hurt low to mid rpm performance. That is why I said that simple mod **"feels"** faster. Yes, it does make more power at a higher rpm now, but the real reason it feels like it hits so hard at 7.5-8K is because it is making less power below those rpms than it did before. So once again **"balance"** is needed to get truly superior power. You could simply raise the transfers to maintain the original 35deg BD and you will preserve the power curves original shape, just moved up the rev range a bit, yielding a wider powerband and better high rpm power as well. That assumes, of course that you can maintain the engines breathing capabilities to keep up.

Generally, an engine of this design is limited typically to a 2500rpm wide spread of maximum power, so if you make it rev effectively to 10500rpm, for example, it will still make less power below 8000rpm. So here is a classic compromise, make it rev to the moon for the big numbers HP-wise, or keep the revs lower and go for a easier to use spread of power. This explains why the Power Valve was (and is) such a great invention. All it really does is give you a "variable blowdown " engine.

A great example is the RZ350, which introduced the powervalve to the street bike world. An RZ has a very high exhaust port height of 26mm (opening at 82degATDC, real racer stuff!) but the transfers open are down at 43mm (120degATDC) which gives a BD of 38 deg, more than most " peaky " race engines use. If this exhaust height was fixed at that number, the engines mid rpm power would really suffer. But..the powervalve takes care of this, by lowering itself at lower rpms so trolling around at traffic speeds or exiting slower corners, the BD becomes only 27deg, nice and friendly to ride, and it also helps pass emission tests by blowing less short circuited unburned charge out the pipes.

A nice side effect is also the fact that the valve raises compression at lower revs, boosting torque there, and lowers the compression as it rises, allowing better upper rpm rev capabilities. When you open the throttle on a YPVS equipped bike at lowish revs, the engine actually responds and accelerates for you, demonstrating the proper powercurve it promotes. This must have been a huge revelation for TZ pilots when they got ahold of the TZ250H with its' then new YPVS system.

Now they had peak power and some useable midrange as well. Back to the transfers,higher ports also give the cylinder more time to fill at high rpm, boosting power by giving more time and area (oops, I said I was not going to talk about that) which is needed in the shortened time period that occurs at high rpm. Too low a transfer height and there is not enough time left for complete cylinder filling after the scavenge phase is complete, which also limits power.

So I hope I have driven home the need to have exhaust and transfer ports in proportion to each other in order to make the best power possible for your application. The directional flow of the transfer ports is also very important. This is controlled by the shape and angle of entry, both horizontally and vertically,and the boost port adds to this as well. This is the real tricky part, because it is fairly straightforward (but hugely time consuming) to simply raise the transfers heights, but preserving or improving the directions that they discharge in is difficult.

That is why that job is best left to an experienced and steady hand.Without a right-angle handpiece you'll not be able to do any of this work at all. One of the latest trends in transfer flow is to use flat domed pistons and transfer ports aimed straight across the cylinder at each other, instead of the "old school" upward pointing streams. This new think simply fills the cylinder from the bottom up with a colliding swirl of gas that purges the cylinder of spent gasses as it rises with the piston. It also cuts down on the amount of charge that can in some cases simply blow right out the exhaust port by making the two (or more) transfer flows "stall" when they collide instead of swirling around in front of the exhaust port.

The theory is that this gives greater cylinder filling. Modern MX'ers are a good place to see where cylinder design has progressed to,and they are easier to come across than an NSR500 and an OW Yamaha is, and both are now sadly extinct. As I said earlier,this is not a complete treatise on port design, but if you understand this you have a very good basis to take it a step further yourself if you are still interested. Either way, you now know more than I did the first time I took a grinder (actually a file!) to a cylinder way back when.

Next in the series:- reeds and cages

 Prepared for the Web & PDF Format by Geo. of K.G.B. of T & T.