Tuning for

YAMAHA RD/RZ 350 YPVS

(All Models from 1983 to present)

A Guide for beginners and advanced

from

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(mechanical engineer)

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Foreword

When you read this, it's already the second impression you get from this book and I want to take this opportunity to apologize for my English. As I’m not a native speaker it will sometimes sound a little funny to you.
Thanks to Steven Jago who corrected special bike related vocabulary and Jill Becker who was in charge for the grammar it should be partly “very British”. Unfortunately in my job I usually deal with US guys, so you're gonna find both mixed up.
Despite the fact that modern Software offers fairly good proofing assistance, you will certainly find many, many mistakes. Please don't mind the ttyping errohrs, I'm schure all of you Couldd heve done it better.

Since May '87 I own an RD 350 YPVS (German Model-Code: 31K) and up to now I've driven about 215.000 km with this wonderful bike. As I used it the way it was designed to be used, almost every single part was exchanged or rebuilt at least once.
Almost 25 years ago - in December 1991 - I started to publish my first tuning-manual which proved to meet exactly the demands of German RD riders. This first version just contained the adaptation of different Books where I added the concrete statements for the RD (which I tried on my own).
In the meantime I got an engineer degree, which helped people to trust my methods a little bit more. But I don't claim to know everything; all that's written is not a must but a can. If you know better, do it your way, but let me know.

This resulted in many contacts to RD freaks all over Germany and Europe – especially since the Internet makes global networking so easy.
In contrary to the past where everybody seemed to take his secrets down to his grave noways people tend to share and spread their knowledge as the enthusiast group shrinks from year to year.
Also the popularity of the banshee quad gives positives influence on available spare and tuning parts & services.

Because I want to improve engine performance and reliability I'd like to point out that you should keep your bike in a fairly good condition. Keep an extra eye on carburetor setting, oil-pump setting and the cooling system. Pistons, cylinders and cranks shouldn't be too old or badly worn.
If you think you don't need to follow this you will find the weakest point of your engine very quickly.

You can imagine that I must dismiss any liability for any damage which might occur as a result of methods or modifications suggested in this book. I must stress that most of the stuff described subsequently is only legal for race use on a closed circuit. If things are described to be legal for road use, I can only promise that for Germany.

Contents

Introduction

Objectives of work

Most of the subsequent methods do not result in an astonishing rise of engine performance.
My personal objectives were:

- To reach at least 100% of the promised stock engine performance (59 HP for 31K and 63HP for 1WW).
- To gain 10 - 15% performance without outstanding engine rpm or noise.
- To minimize costs by mostly using stock parts.
- Not to lose too much reliability.
- To be convenient for everyday riding (that means no gas/oil mixing, no changes in jetting when weather changes, ...).
- To show methods which can be used by total "greenhorns".

Due to frequent requests I have included modifications for high performance and high revs which decrease significantly the reliability of your engine. If you don't have the required expertise just leave these out.
At the end of the modifications chapter I have listed my suggestions for different tuning stages which you can use as an orientation (If you're unsure what to do).

Tools and other useful stuff

For tuning and maintenance you will need such common tools as:

- Drilling machine with flexible shaft
- High speed mini-drill (Drehmel, Proxxon)
- Grinders (parabolic or conic, tungsten-carbide or HSS)
- Files Flat (3 x 15)
  Square (ca. 10 x 10)
  Round (∅ ca. 8)
  rather coarse, not too fine (must be suitable for Aluminum)
- A set of small files
- Impact driver
- Several wrenches from 6 to 32 mm size
- Set of hexagon socket-screw wrenches ("allen key")
- Torque wrench 0 ... 100 Nm

For engine assembly and disassembly (consider having this done at your local dealer):

- Rotor mounting tool
- Clutch holding tool

Other helpful stuff:

- Small mirror (ca. 150 x 150)
- Silicone based sealing compound (Dirko / Dirko HT from Elring)
- Alcohol, Aceton or brake cleaner for degreasing
- Sandpaper 60 ... 1000
- Fine steel wool

If you are about to do some heavy porting work I'd advise to using some conic or parabolic tungsten carbide grinders (don't use the cheap HSS, they wear quickly when grinding cast iron). You can do it with a file, too , but it will take much more time.

For the exact finishing and deburring of the port shapes at the sleeve you have to use the file set.

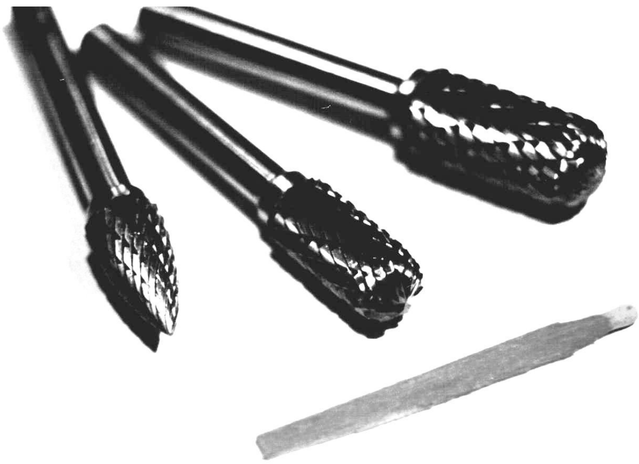


Figure 1: Several grinders

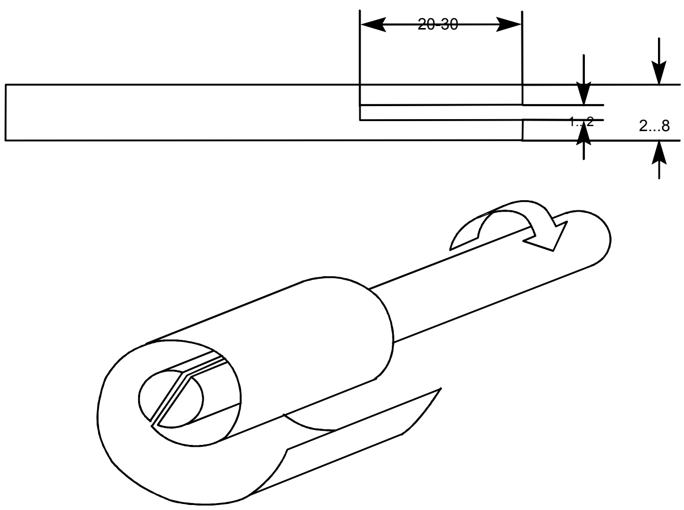


Figure 2: Polishing shaft

For polishing I've used a self made shaft in a high speed mini drill. You just have to make a 20 mm slot at one end and roll up some sandpaper with the grinding surface at the outer shape. With this tool polishing is really fun; begin with #60 to #100 and then increase in steps to #1000 (from #600 on you should grind with some water).

At the intake and transfer ports it's enough to use #200.

I use to mount almost everything that needs a gasket with the silicone based sealing compound Dirko.

- Clutch cover
- Lower cylinder gasket
- Power-Valve-bushes
- Hoses for cooling liquid
- Intake manifold
- Everything which comes in contact with oil/water and doesn't get too hot

Dirko HT is more resistant against heat and I use it only for the head gasket. First degrease the surfaces very carefully and put a thin film of Dirko HT on the head and cylinder mating surfaces. After inserting the gasket tighten the head screws in 2 or 3 steps to 28 – 33 Nm. If you have used a brand new gasket retorque the head the next day after having warmed up and cooled down the engine. Repeat the procedure after a few hundred kilometers.
Meanwhile I use head gaskets more than once, because they are quite expensive and Dirko HT enables you to use them 2 or 3 times.

Do not use gaskets from top end or engine sets. The company Vesrah has silver colored head gaskets which are of very low quality. They don't even seal a stock engine, never mind a tuned one. So if you're offered a silver one, take another or change your dealer
The Prox gaskets seem to be a good choice in stock engines. I only heard of failures in tuned engines.

Marco Böhmer can modify the heads to contain a groove for O-ring usage. In this case you can use cheap but high-quality industrial Viton O-rings.
I have used the low-cost version with just one ring around the cylinder sleeve. The rest of sealing is done with Dirko.

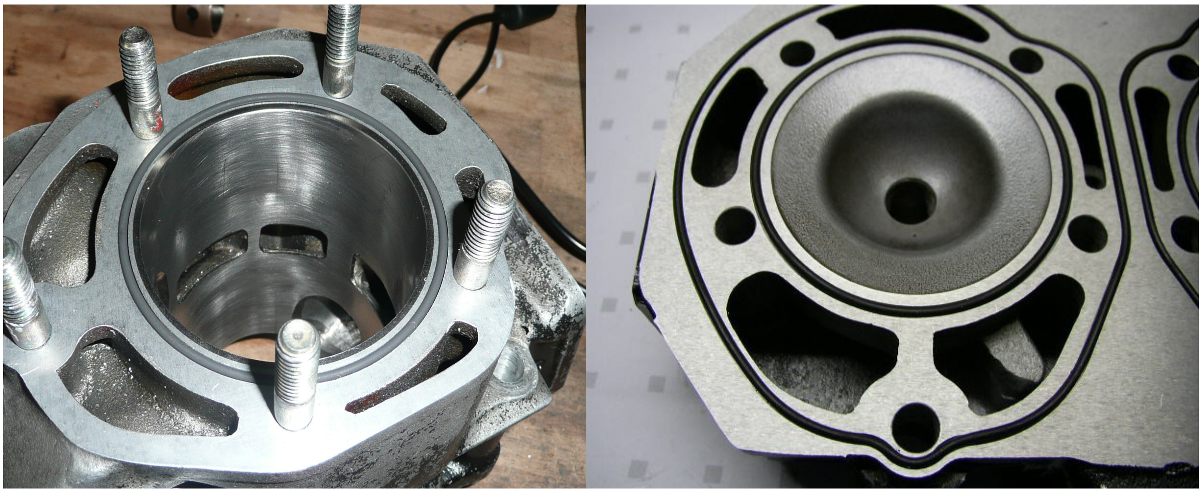


Figure 3: O-Ring conversions (Left: single ring in cylinder, Right: dual rings in head)

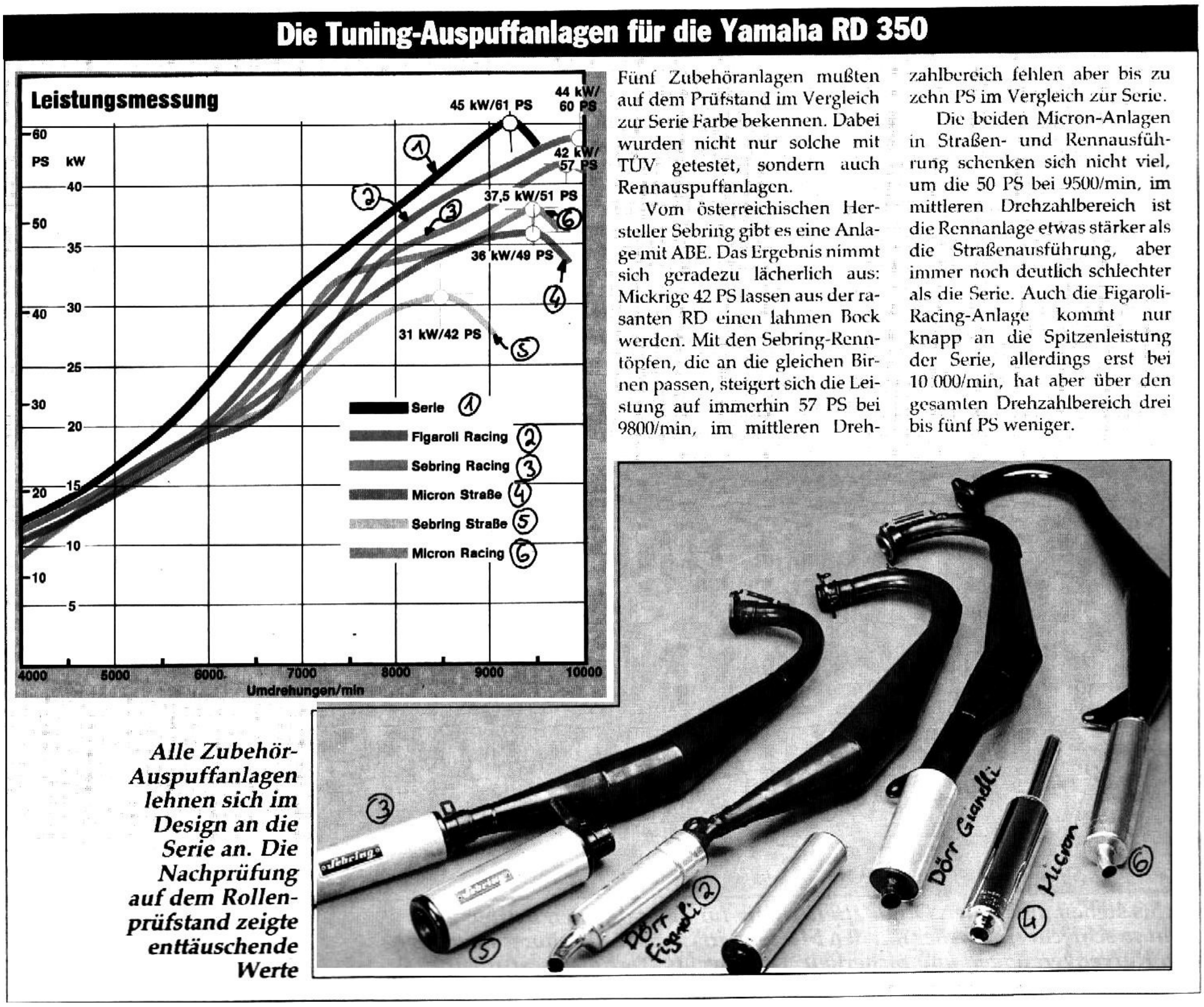
Mods

General

Most people mistake noise with performance which leads to a myriad supply of so called "race pipes". Compared to the very good 1WW stock pipes most of them are junk. I would strongly recommend these to every RD because they deserve the name "silencer" and they've the YAMAHA logo!
My (quite cheap) Dörr pipes had the following disadvantages:

- Every four weeks the silencers fell off due to the bad quality.
- Significant loss of power accompanied with a significant increase of noise.
- Nasty vibrations in the most used middle rev range.
- Pipes come in contact with tarmac far too early.

To prove that this is not a subjective opinion I have enclosed a copy of an article from the German magazine PS where they had measured some race pipes on a 1WW. The conclusion was: None of the tested pipes increased performance at any revs.



Die Tuning-Auspuffanlagen für die Yamaha RD 350

Fünf Zubehöranlagen mußten auf dem Prüfstand im Vergleich zur Serie Farbe bekennen. Dabei wurden nicht nur solche mit TÜV getestet, sondern auch Rennauspuffanlagen.

Vom österreichischen Hersteller Sebring gibt es eine Anlage mit ABE. Das Ergebnis nimmt sich geradezu lächerlich aus: Mickrige 42 PS lassen aus der rasanten RD einen lahmen Bock werden. Mit den Sebring-Renntöpfen, die an die gleichen Birnen passen, steigert sich die Leistung auf immerhin 57 PS bei 9800/min, im mittleren Drehzahlbereich fehlen aber bis zu zehn PS im Vergleich zur Serie.

Die beiden Micron-Anlagen in Straßen- und Rennausführung schenken sich nicht viel, um die 50 PS bei 9500/min, im mittleren Drehzahlbereich ist die Rennanlage etwas stärker als die Straßenausführung, aber immer noch deutlich schlechter als die Serie. Auch die Figaroli-Racing-Anlage kommt nur knapp an die Spitzenleistung der Serie, allerdings erst bei 10 000/min, hat aber über den gesamten Drehzahlbereich drei bis fünf PS weniger.

Alle Zubehör-Auspuffanlagen lehnen sich im Design an die Serie an. Die Nachprüfung auf dem Rollenprüfstand zeigte enttäuschende Werte

Figure 4: Dyno test race pipes

Dyno Testing

To make a realistic picture of your tuning efforts it's best to use the same dyno on the same day with identical adjustments. I know that this is difficult so try to use at least the same dyno for testing.
A good example is the following from the company WIWA. They claimed to have measured the performance at the rear wheel which makes it difficult to compare with the measurements from Figure 3, because they measured "clutch" performance.
Fact is that WIWA reached a bunch of 7 extra horses at the cost of a thousand extra revs (If we believe that they tested the same bike ...).
One thing is not quite clear: Yamaha claims to build engines (31K) with 59HP at 9200 Rpm. This bike had maximum performance at 8600 Rpm. Either they chose a rather weak bike or the dyno tachometer was not adjusted properly.

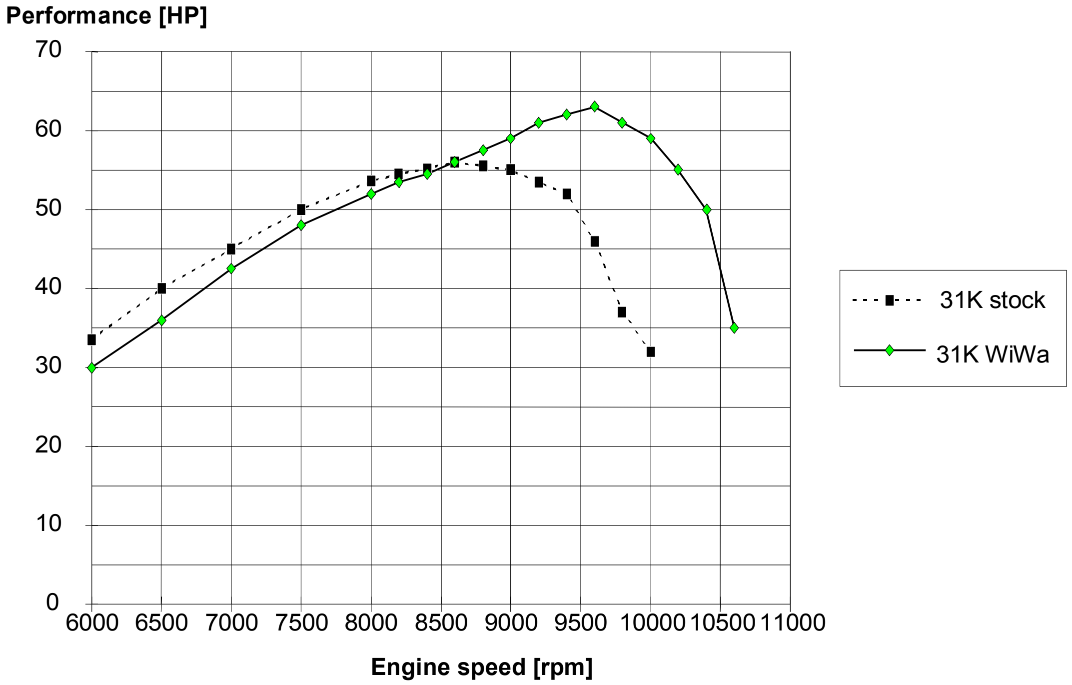
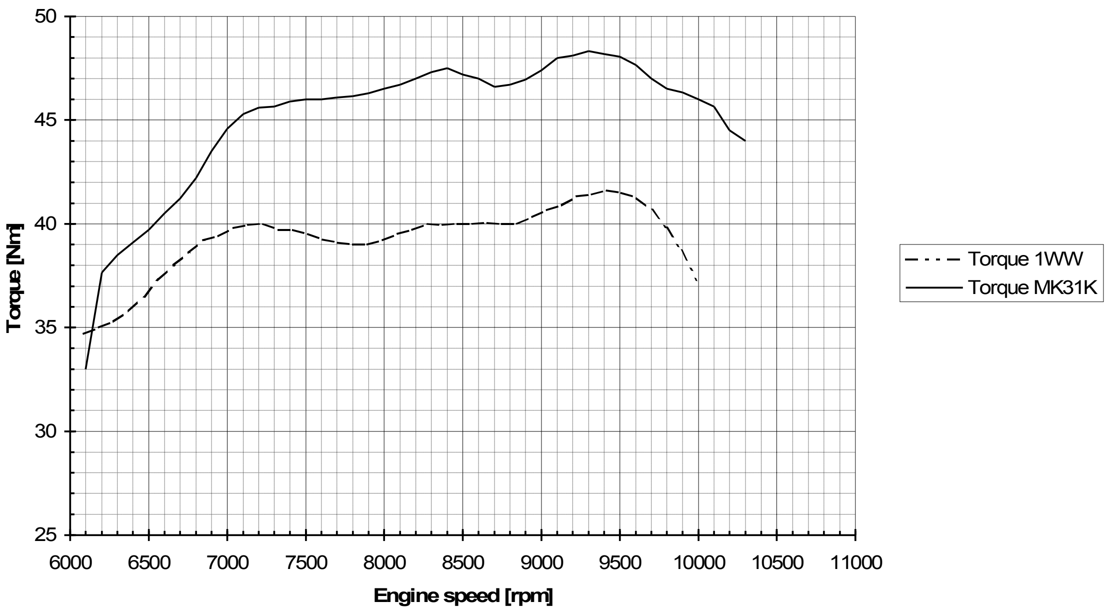


Figure 5: Dyno test WIWA catalogue

Most common dynos measure the angular acceleration of a heavy barrel with a known mass inertia. The rear wheel torque is calculated with inertia and acceleration. After the acceleration part you can also measure your gearbox losses by letting the engine roll out. The deceleration of the barrel gives you the gearbox torque losses. If you add both curves you will get the "clutch" torque.
Up to this all dynos differ only a few percent, because no engine Rpm was measured.

To calculate engine performance the computer needs information about the actual engine revs. To get the angular acceleration all dynos have their own tachometer at the barrel. The difficulty is to synchronise it to the bike's tacho properly.
Some mechanics do that quick and dirty by just performing a short ride with let's say 4000 Rpm. If the dyno's tacho shows 2000 Rpm you just type in a conversion factor of 2 and afterwards the dyno shows the same (inaccurate) value rather than your tachometer. This leads to somewhat higher "measured" performance than there really is, because the torque is assigned to a too high Rpm value.



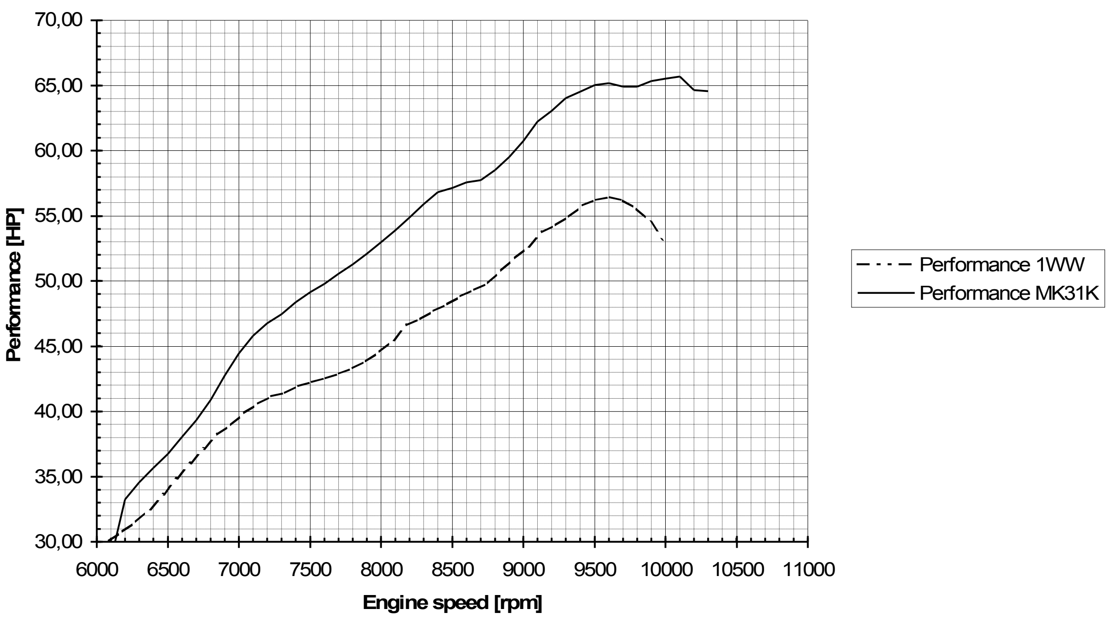


Figure 6: Dyno test with 31K and reference 1WW 2/3.2.95

Remember: Dyno owners are salesmen, and you won't come back if you were disappointed by an honest dyno test, so they will always use a conversion factor that leads to a higher performance! A proper dyno has an inductive coil to measure engine Rpm directly using a clamp on the ignition cables!

In February 1995 I made a test with a stock 1WW on the same dyno with the same settings (conversion factor for engine/dyno Rpm). The result was what I already knew: The tuning was fairly successful; In this case my bike had 9HP extra at the same Rpm level. Don’t worry about the quite low values of clutch performance and torque, we tried to be realistic.

One disadvantage of "clutch" values is that you can't compare them directly to other measurements. To get this possibility you must change engine revs with rear wheel velocity. The performance is now calculated with the "right" dyno Rpm and the diagram shows rear wheel performance about vehicle velocity. This is what you really get out of your bike.
This example quoted 52HP at 9100 Rpm (Revs calculated with tire radius and gear ratios). This bike was even mildly tuned; imagine the disappointment of the owner. In fact stock RZ's have some 45 – 50 rear wheel HP, so this dyno curve was not too bad

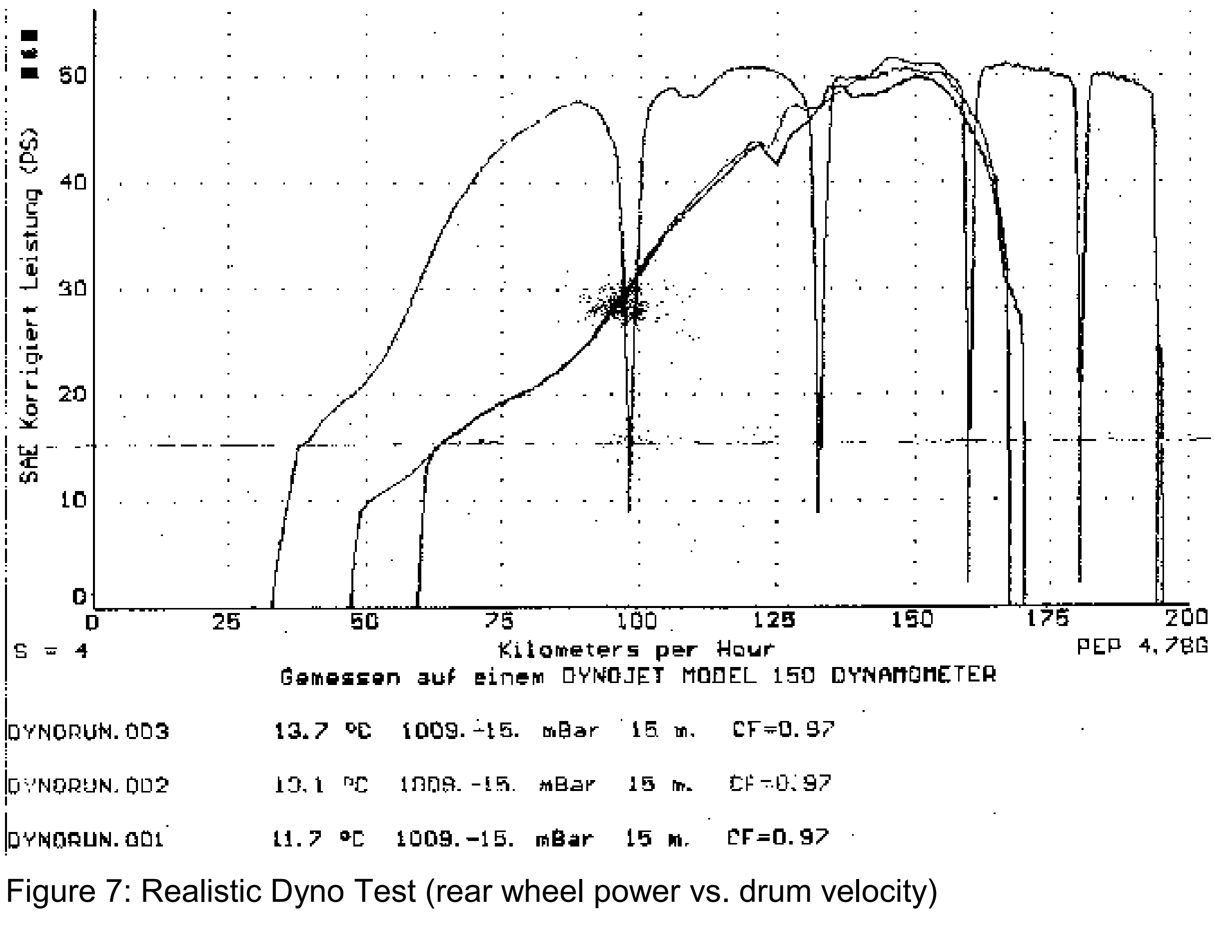


Figure 7: Realistic Dyno Test (rear wheel power vs. drum velocity)

Maintain optimum stock performance

It was already mentioned before: The German model codes for the RD350 YPVS are 31K (1983-85) and 1WW (since 1986). The most significant difference is in the pipe shape, the 1WW has silver coloured silencers and the 31K has a tapered ending and it's all in black. The second thing is the number on the side of the intake area: The 1WW is labelled 1UA, the 31K has a 31K. The RD250/350LC (1980-82) without power valve had the model codes 4L1 and 4L0. Later on I will use the model codes rather than the full name.

All German RD's were restricted in quite a simple way. The 31K was available in three different performance steps. Due to the former German driving license system there was a 27HP version (Nowadays there is a 34HP version instead). The insurance system was responsible for the 50HP version and full performance was 59HP.

You can enjoy full engine performance just by removing the exhaust inlet and checking the main jet size.

	Main Jet	Bush ∅	Bush length
27 HP	#200	18 mm	60 mm
50 HP	#240	26 mm	60 mm
59 HP	#240	remove	bush

Table 1: Jetting for different stock performance stages (31K)

It's fairly tricky to remove the inlet, because mostly it's welded. Use a drill, a grinder or other force. The needle position is 4'th groove from top for all versions.

The 1WW had some more carburetor modifications in addition to the exhaust inlet.
The 27HP version had it's own model code 1WX (carb label 1XE00). If you find that on your bike this means red alert, because you ought to check the power jet system.

	Main Jet	Power jet	Idle Jet	Nozzles	Bush ∅	Bush length
27 HP	#180	#20/25	#25	N-8 (8 bores)	18,5 mm	60 mm
50 HP	#185	#60/65	#27,5	N-8 (4 bores)	26 mm	60 mm
63 HP	#185	#60/65	#27,5	N-8 (4 bores) Prt.Nr.: 1XA-14141-28	remove	bush

Table 2: Jetting for different stock performance stages (1WW)

As you can see the 1WW has a modified carb system, which enables the YAMAHA engineers to use a very lean main jet for good throttle response. The power jet adds the extra fuel during full throttle operation.

The jet is located at the lower end of the black tube which connects upper and lower part of the carb. If you are not sure about the actual jet size (or if you want to find a new setup) you can drill out the stock jet and tap in an M4 thread. After that you can use stock Mikuni jets (N100606) with a broad range of available numbers.

Stock carbs

The right carburetor setting is very important for two strokes. Stock RD's require the following setup:

	31K	1WW
Main Jet	#240	#185
Idle Jet	#22,5	#27,5
Needle Jet	P-0 (345)	N-8 (532) (4 vents)
Tapered Needle	5K1 (4. pos. From top)	5L20 (2. pos. from top)
Slide Cutaway	2,0	2,0
Float Height	21 mm ±0,5 mm	21 mm ±0,5 mm
Power Jet	---	R: #60 ; L: #65

Table 3: Stock carb setups

For warm weather in summer you can go down to #220 - #230. A Friend of mine used to ride with #200, but his engine seized as soon as he fitted the 1WW pipes!
On a stock 31K you can clip the needle one or two steps lower. That would be position 2 in summer and 3 in winter.

The 1WW models don't need any rejetting, the stock setup is very good.

After fitting the carbs onto the inlet rubbers, you must synchronise the left and right carb slide. This means that you use the cable adjustment screw to adjust both slides to the same height.
This is extremely important, because if you leave this maintenance work, it is possible that one slide hangs lower than the other. The result would be a seizure caused by the leaner mixture on one cylinder.
To perform the synchronisation properly it's insufficient to use the YAMAHA workshop method. It's better to remove the air filter cover and the upper part of the filter box (You will have to remove the battery and the oil tank, too).
Now you can use a mirror to have a look at the carburetors from the back. Adjust the cables so that both slides begin to vanish at the same throttle position behind the upper edge of the carb bore. Take care that you pull and release the throttle a few times before and after adjustment. Check your work at least twice.

Wash the filter element in a solvent (I prefer fuel), pour a little motor oil on it and squeeze out before reinstalling. For Moto-Cross purposes there are special air filter oils, but you can also use any regular motor oil (for example 15-W40).

The second most important work to do is to clean the needle jets at least once a season. If some vents are sealed with dirt the engine is rough at middle rpm's and fuel consumption rises.
Replace the main jet with a screw M5x50 or longer. You can now push out the needle jet (towards the slide) by tapping on the screw without damaging it.
After cleaning reverse the steps to mount it. Align the pin in the carb housing and the groove in the needle jets.

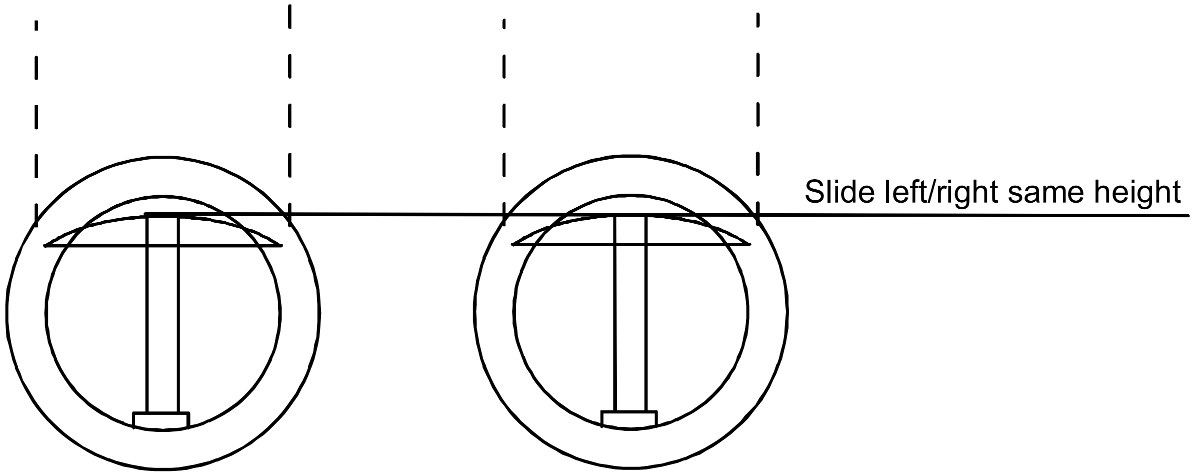


Figure 8: Carb synchronisation

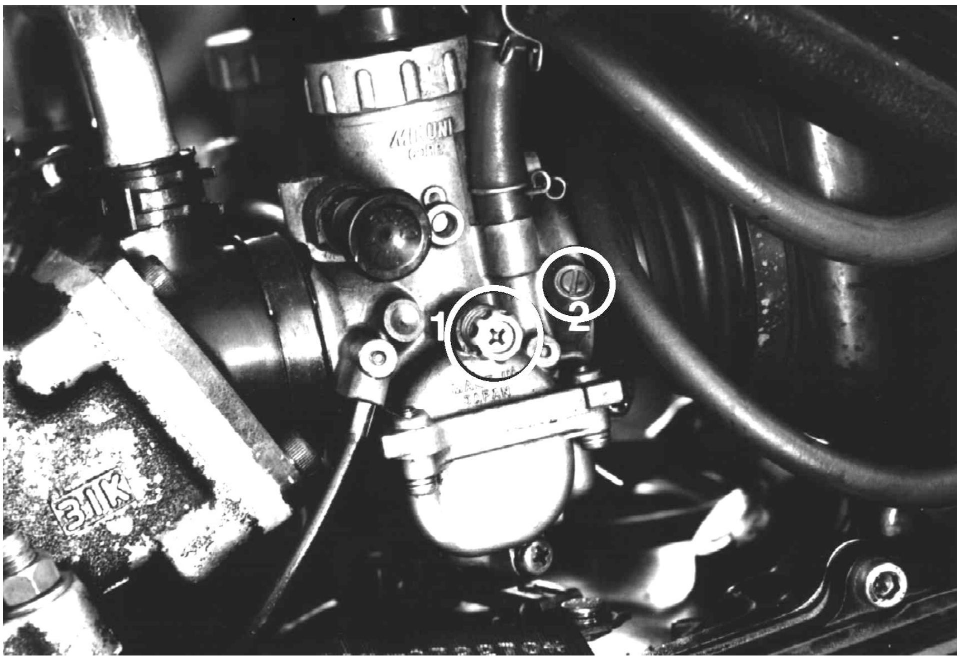


Figure 9: carburetor 31K (1. Idle speed adjustment screw; 2. Idle mixture screw)

If you use the 1WW pipes on the 31K you must slightly re-jet the engine. Due to the increased volume and changed pipe layout mixture weakens in middle and low revs.
You can compensate this by the idle air screw or via a larger idle jet. Stock screw position is 1 to 1 1/4 revolutions out from the end position. I found about 1/2 to 3/4 revolution out to be the optimum with the #22,5 idle jet (Turn the screw clockwise: richer mixture; turn counterclockwise: weaker mixture). When you use the #27,5 idle jet from the 1WW the screw position can stay in stock position.
The main jet can also stay at #230 but you should raise needle position to 3 or 4.
This will increase mid range power at the possible sacrifice of a reduced max. engine Rpm.

In this section a short summary about spark plugs:
The right spark plug has a great influence on the combustion temperature. If you use a higher number, the plug can drain a bigger amount of heat out of the combustion chamber which keeps the temperatures low. The main disadvantage is the danger of plug fouling and a loss of crisp throttle response. If you use a too warm plug it can overheat and melt the piston.
Anyway, always try to use the lowest possible number.

NGK BR8ES : Standard plug for stock 31K.
NGK BR9ES : Standard plug for stock 1WW and mildly tuned 31K.
NGK BR9EIX : High quality product with Iridium electrode, replaces BR9ES
NGK BR10ES : Plugs for extensive motorway speeding, race use, ...
NGK BR10EIX : Price as BR9EIX, Specifications same as BR10ES.

You can also use all plugs without the R (Resistor type) option. This will reduce significantly the number of fouled plugs, but it may influence the power valve system by electromagnetic radiation.

Intake Kit

If you read the ads in the old magazines you will know the Ledar Intake Kits.
They were developed to increase power by increasing air and fuel supply. The Kit consists of filter elements (K&N style), filter spacers and nozzle type needle jets.
Re jetting is strongly recommended, otherwise mixture weakens dramatically. A test with a stock 31K equipped only with the nozzle type needle jets ended in a seizure.

If you use the complete kit in a 31K a #280/290 main jet is required. The needle has to be altered to the 5'th position. Air screw position around 1/2 out.

If you have a 1WW (Power-Jet carburetors) you can close the Power-Jet system by gluing in a 6 mm plug with Dirko sealing compound. The main jet size can stay #280/290 but due to the fatter 5L20 needle the position should be 2 or 3; Air screw position stays at stock level (1 1/4).
Another possibility is to drill out the stock power jets and (after tapping in a 4 mm thread) to use Mikuni power jets (N100606).
The "old" main jet size is now divided to these two systems, the addition should equal the #280/290 level. The setups that I know use #210 to #225 main jets and a power jet around #75 (#215 + #75 = #290)

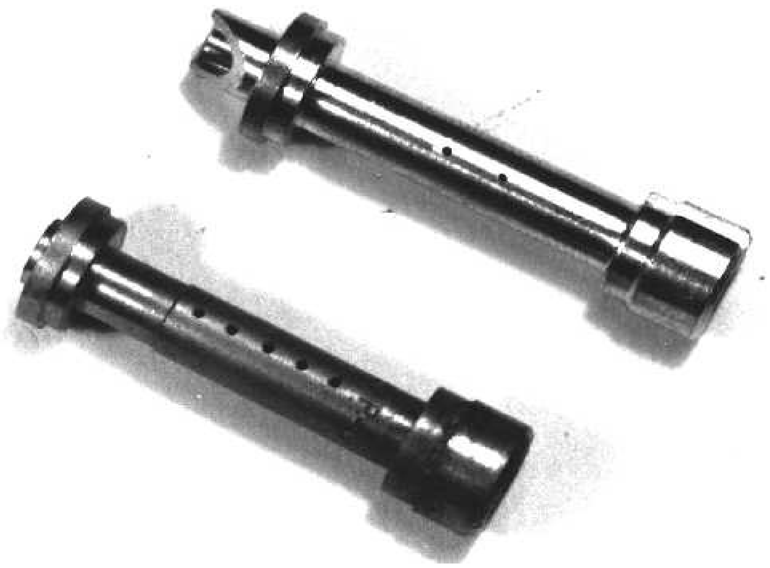


Figure 10: front: stock nozzle; rear: Ledar nozzle

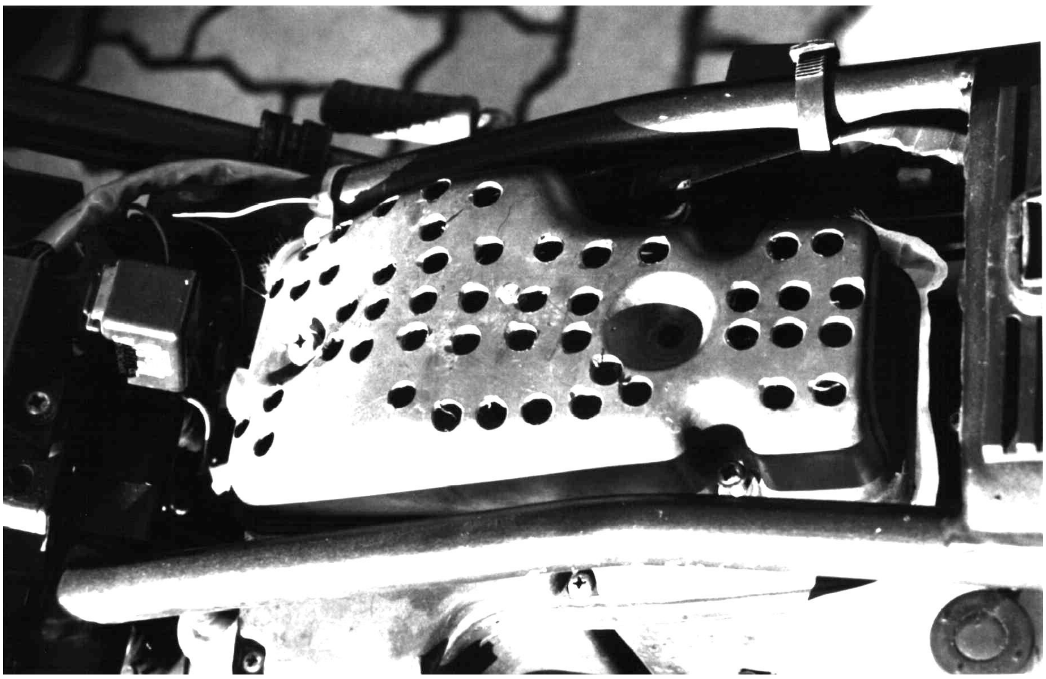


Figure 11: perforated air filter cover

People who prefer a lower noise level and a stock look should use the stock air filter box. The lower (hard) inlet must stay in the box and the upper cover can be perforated with 10 mm holes. The stock air filter element is substituted by a piece of gauze or similar material to keep Insects and other bigger particles out of the engine.
The setup is the same, but the engine noise is lower compared to the K&N solution.
If you leave out the lower inlet, noise increases dramatically and the given setup is too lean. In this case you have to increase the main jet size and possibly richen the idle and mid-range mixture.

This modification increases performance in any rev range. Fuel consumption is also increased to 7 - 7.5 litres per 100 km. I recognised a significant decrease of engine reliability during full throttle operation. Take care that your main jets have a rather too big than too small size.

Other (i.e. bigger) Carbs

Before you attempt to install larger carburetors onto your RD engine I must warn you that this is no one-weekend-job! Finding a complete new carb setup is an extremely difficult thing and what you need over and over is expertise. Even if you are experienced enough some engine failures and increased maintenance will follow the conversion.
The every-day-behavior of a bike gets worse if you use race carbs, because most of them have neither an idle adjustment screw nor a starting system (choke).

What eases the whole thing is if you get data from other RD's with bigger carbs.

Problem number 1: What carburetor type and size should I take? VM 34 with round slide or rather a big TM 38 PowerJet with flat slide?
Answer: Either you buy a complete kit from someone who managed to run it with his RD or you try to purchase exactly the carbs from one of the following setups. The second way is to try your own setup with cheap carbs you already own.
The bigger the carb bore the more unreliable and the less convenient the whole engine will get. The performance optimum for an extremely tuned RD engine is around 34 to 38 mm. But beware: These big ones live and die with the gas velocity in the venturi bore. You must at least mount some race pipes and somewhat bigger reeds to increase gas flow. Otherwise they will not work! I would only recommend such big carbs for race use on tracks where you have much full throttle operation, because mid range power is reduced substantially.

In my opinion the optimum for street use is 30 or 32 mm because you can install these onto a stock engine and it works. I tried the Mikuni TM30-6 slingshot (around 500,- DM) and the 32 mm RGV Carbs (‘89-’91).
A catalogue from the USA (Spec II) claimed a 12% top end (9000 Rpm) and 16% mid range (5000 Rpm) power increase on an air cooled and race-pipe equipped RD350. The same test-bike proved that the 34 mm carbs only had advantages above 9000 Rpm. With a TZ reed conversion they obtained "terrific power increases from 6500 Rpm up". (*Authors comment: Only with this conversion the gas velocity was sufficient for the 34mm carb size*)
On the RZ350 (31K or 1WW) they claimed a 13% performance increase.
Their recommendation was 32 mm for riding around town and short race tracks, and 34 mm for high-speed race tracks where maximum power is required.

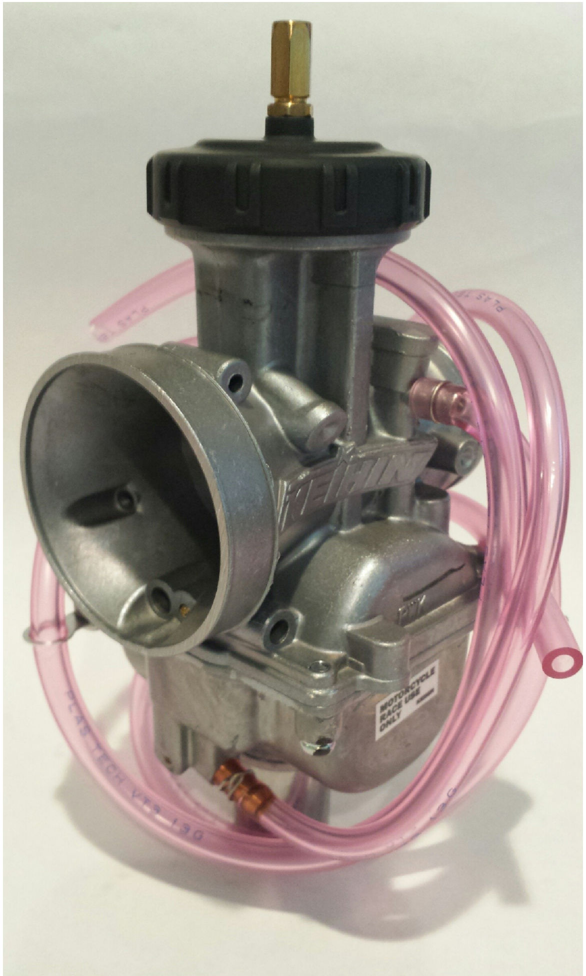
Problem number 2: How the hell do the greater carbs fit to my engine?
Answer: If you don't manage to slip them on with warming and oiling the flange you have to think about other flanges.
The TZ750 ones should fit the 31K/1WW, but they are expensive (200,- DM each) and rare. From Mikuni you can get universal flanges, but to fit them to the RD engine you have to make an auxiliary plate which connects the rubber flange and the cylinder (drawing within appendix). If you can’t make them on your own you can purchase the Trinity Racing Stage IV manifolds, which are quite similar to my adaptor plate solution without changing the carb angle (Info: http:\\www.trinityracing.com).
Due to the greater outer dimensions of most 34 mm carbs it can be necessary to change the carb angle about 20°. This won't do the function any harm but it gives you more clearance between the carb and the clutch lever in the crankcase.

Problem number 3: How do I keep stock cables (gas petcock, oil pump, throttle cables) in use?
Answer: Because the stock carb bore is only 26 mm the stock throttle cable is limited to this stroke via the cable distributor (2 carburetor + oil pump). To increase the max. stroke you have to make an extension for the cable distributor which adds the needed length (stock 26 mm stroke, now 35 mm => 9 mm extension; drawing within appendix).
You must change the cables as well because most carbs will need longer inner cables due to different carb design.
The vacuum line to actuate the gas petcock and the oil supply can be attached in the auxiliary plate as well. Otherwise you have to "open" and "close" the petcock by using "PRI" and "ON". If you remove the oil pump I'd recommend gas oil mixtures from 1:30 to 1:50 with synthetic or racing two stroke oil (Castrol TTS/XTS/747, Bel-Ray Si-7/H1-R, Motul 600/800).

Most of the banshee carb kits come with a cable but you need to check that it's not for the thumb operated throttle.

In the US the Keihin PWK carbs are very popular and they're highly recommended for anything with more than 400 ccm. Most people report that they're easier to handle than the Mikuni TM's which I tend to believe (have a look at the motocross bikes that almost 100% use Keihin)

Figure 12: Keihin PWK carb



In Germany Keihin copys are sold under the brand name Koso where I heard different opinions. Some reported them working just fine others were dissatisfied.
If you think about it logically you'll find that a carb must meter air and fuel in an extremely precise way.
To do this you need extremely precise mechanical parts which are expensive to build. If you want it cheaper, you use larger tolerances, have less waste and this yields in higher deviations, i.e. a pair of carbs can behave different.

A Pacco carb that I had a commercial sample was such a crap that I directly send it back. The cast was rough, machined surfaces had scores and there were burrs.

Finding a Setup

After fitting the carbs onto the cylinders somehow you should use some big K&N filter elements with filter spacers to clean up the incoming air. If you completed your setup you can think of using the stock airbox instead.

The balancing pipe between the flanges can be left out, because it is said to make it difficult to find a clean setup with big carbs. An auxiliary plate is even easier to manufacture if you don’t use a balancing pipe.

When you’ve finished all the fitting work the great moment is there: The first time you let the engine run. The normal case will be great disappointment, because it will not run as good as you expected it to run. There might be weak throttle response, reduced max. rpm, engine runs like choke is out, ...

With the Colortune spark plugs you can tune the idle and low end mixture by observing the combustion colour. You should first have a look at some good running stock engines to judge the right colours. The ideal mixture between gas and air which is around 1:14 (mass proportions) leads to Lambda-values around one. A weak mixture increases the Lambda value, a fat mixture decreases it.
Two stroke engines need a Lambda of around 0.9 (slightly fat) for optimum performance but in the mid-range a leaner mixture (Lambda around 1+) gives better throttle response.
A fat combustion is followed by a bright orange colour, a lean by a light blue. With this indicator you can pre-set the idle and the needle jet.
If you’ve got plenty of money you can use a Lambda tester instead. The Bosch LSM 11 gives you the measured value on a digital display. As it uses a heated UEGO sensor, it can be used even for twostrokes. Info: Marco Böhmer (Tel.: +49/9256/953344 16:00 to 21:30 CET).

Now it's time to have a short ride to prove or change the pre-sets and to find a temporary needle position.
My favorite order of finding a setup is: Idle mixture screw, idle jet, and a temporary needle position for the low end. After that do the full throttle test to find a temporary main jet.

Then try to optimise mid range behavior and finally check your setup again because the single systems influence each other and it could be necessary to correct one of the "temporary".

The idle system should be adapted to the mostly used circumstances. In race use with gas/oil mixture you must have a quite big idle jet of #60 to #90. If you want to ride around town a maximum of #40 is required to avoid plug fouling during low-throttle operation. Use the idle mixture screw to fine-tune the idle mixture.

For the purpose of finding the main jet you are in the need to read the plugs. At the beginning you must look out for an appropriate test area. It should be an at least one kilometre straight which has a slight uphill slope. The result is when you were riding with full throttle the engine is fully loaded at max. Rpm. The second possibility is to perform the same on a dyno.

Put in a set of plugs which are suitable for your tuning stage (i.e. NGK BR9ES or B10ES). Take care that you are not running short of fuel. If you want to reproduce the tests later you should also note weather conditions (like: sunny, dry, 25°C, 1025 mbar).
Then warm up the engine and ride at least one kilometer with full throttle condition at max. Rpm with max. possible speed. At the end of the straight, simultaneously press the kill switch and release the throttle to zero condition. Notice the achieved revs and speed to compare with the other runs.
Then screw out the plugs and look at the porcelain. It should be a quite dark brown with a black ring around at the end of the plug thread. if you haven't the desired color try to get it rather darker than too light.
The ideal jet size is one number fatter than the jet with maximum speed.

In the internet I found a jetting instruction which was a little different from mine, but it made sense. It was recommended to warm up the engine for 10 minutes (blipping the throttle) with an old pair of plugs to remove oil out of the lower crankcase. If you do the test without warming up the old oil will darken the plugs and make things look richer than they really are.
Then screw in a brand new pair of plugs and warm up the plugs again by not giving full throttle to the engine for at least 2 minutes. This is very important because if you push a full throttle load of fuel onto a cold plug it will foul or at least get too dark due to that fuel overload. Start with 1/3 throttle with no more than 6000 Rpm. Then steadily move up the throttle and rpm until the first straight (about 1 minute after starting). When the straight comes up, roll the throttle on very slowly, 6500 shift to 4th, 7500 shift to 5th, 8500 shift to 6th and then bring the throttle up to full slowly. This should ensure that all residual oil has come out of the crankcase and that the plugs will see a somewhat representative mixture.

For the needle type and position you can use the criteria “best acceleration” similar to finding the idle mixture.
But don't worry, most carb kits which you can purchase have a quite usable setup so there's "only" main jet, idle mixture and needle position left

If you are very ambitious to optimize part load mixture perform acceleration and speed testing with different bushes which shorten max. slide stroke. This makes the slide position reproducible and you can have a look at the mixture at different slide positions.
You can influence the quality of your setup by using more or less steps in slide position. Normally three levels should be sufficient; this would arrest the slide at 10, 18 and 24 mm for a 36 mm carb.

The needle and the needle jet bear a marking which contains letters and numbers.
For the needle jet a "higher" letter (“G” is higher than “F”) and a higher number represent a richer mixture (Main influence at 15% - 50% throttle opening). Take care that you have the same series number to compare these markings. The 31K have a needle jet P-0 (345) and the 1WW a N-8 (457). Despite identical geometric shape (both nozzles are suitable for both carb types) there are differences in mixture relevant details like number, position and diameter of cross bores.

lean fat
P-6 > P-8 > Q-0 > Q-2 > Q-4 > Q-6 > Q-8 > R-0

Needle marking is quite similar. The main influence lies at 15% - 75% throttle opening, so needle type and position is a substantial part of your mid-range setup.

The first number represents the needle length and therefore the mixture above half throttle. The second letter denotes the needle diameter and therefore it influences the mixture below half throttle. The last digit is a code for other features such as cone angle or other geometric features.

A needle 8L1 would enrich the mixture above half throttle compared to a needle 6L1.
A needle 6P1 would enrich the mixture below half throttle compared to a needle 6D1.
You can judge for yourself what component to change

As a guide to which component has an influence in which range you can use the following figure.

- 0 to 1/8 - throttle (0 to 4,5 mm) idle jet, idle mixture screw
- 1/8 to 1/4 - throttle (4,5 to 9 mm) idle jet, slide cutaway, nozzle
- 1/4 to 3/4 - throttle (9 to 27 mm) nozzle, needle
- 3/4 to full throttle (27 to 36 mm) main jet

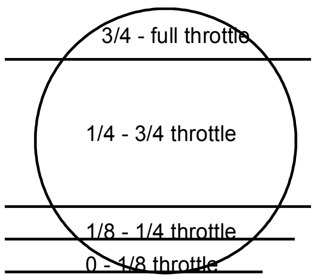


Figure 13: Range of influence for carb components

This can only be a guide because the different circuits influence each other. If you have a lean idle mixture you can use either the idle mixture screw or the idle jet. If you change the main jet to a very different value it can be necessary to rejet the lower end circuits, too.

TM30-6 Slingshot Carbs

In August '96 I tried the 30 mm Mikuni slingshot carbs (That means the slide is round with a flat back side). The result was very convincing:
Already at the first trial I reckoned a noticeable power increase. Low and mid-range was quite ok after short testing. I guessed a 3 to 5 HP boost at the top end.
The "guess" is based on a better high speed acceleration (above 100 kph) and the plus 5 kph top speed.
The carbs are suitable for the stock rubber flanges and at the air box. The outer carb dimensions leave a small clearance to the clutch actuator.
Unfortunately there are no fittings for oil- and vacuum-lines (gas petcock), so you'll need to manufacture them on your own.
For finding the setup I used a 1:40 mixture and operated the petcock on "PRI". Later I used the oil injectors from old RD500 flanges (you can also use fittings from an old oil pump)
The vacuum line can be fitted to the balancing pipe between the stock flanges. I used a tube with appropriate diameter and glued it to the connecting tube with a two component adhesive.

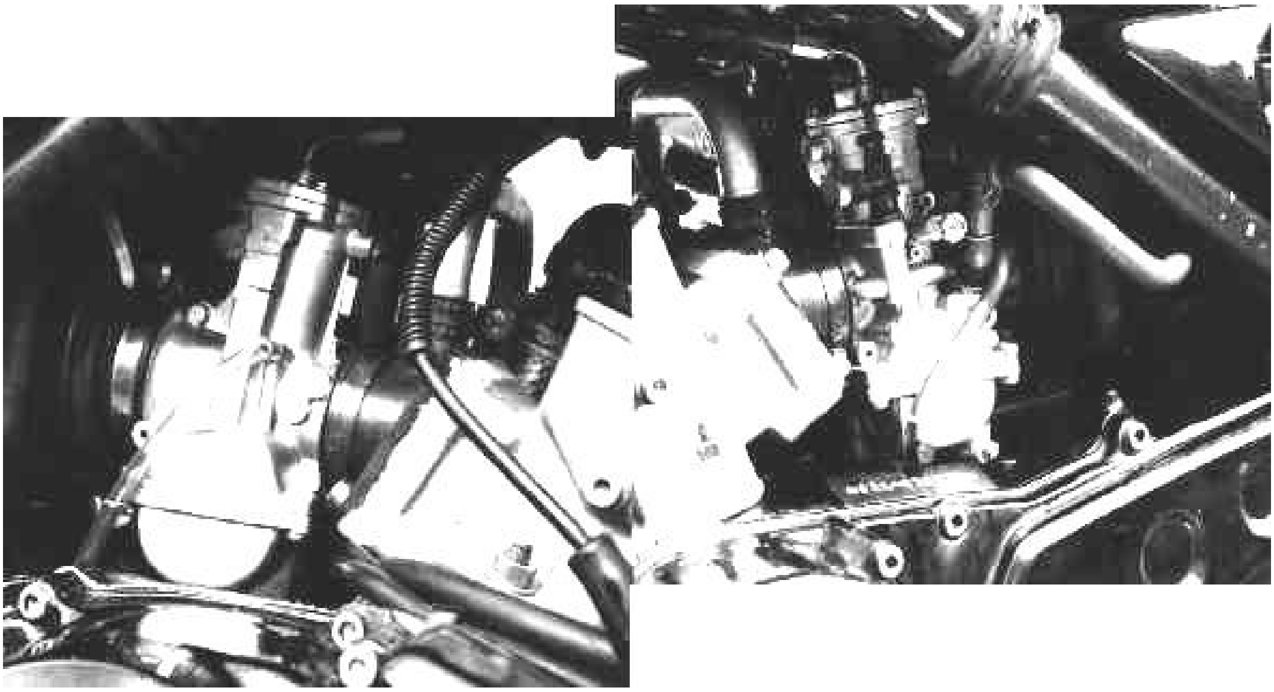


Figure 14: Mikuni TM30-6 slingshot carbs

The distributor for the stock throttle cables allows almost full stroke for the TM30 carbs. There is only half a millimeter lacking to open the bore completely.
Only the outer throttle cables have to be shortened about 20 mm and the cable guidance tube at the top of the carb housing has to be bent slightly to avoid contact with the frame tube above.

Later on I changed the choke buttons on the carbs to a cable based solution with a choke lever at the handlebar. Very comfortable to use is the RD500, TZR250 or TZR125 stock Choke lever with self-made cables from a bicycle equipment shop. The ultimate solution would be a complete choke actuator for the handlebar like you can find it on a MuZ Skorpion or a Cagiva Mito.

After testing the TM30 carbs for more than one year on my own bike I can recommend it for everyday use around town and race tracks. I even found two other guys who found similar setups and quite similar results without knowing my setup. Both were riding with Jolly-Moto pipes which required a slightly fatter main jet.
You should take these setups as starting values and refine them for your individual engine.

Carbs	TM30-6 (Mikuni delivery state)	TM30-6 (31K modified, stock pipes)	TM30-6 (31K modified, Jolly's)
Main Jet	#195	#150	#165 - #190
Power-Jet	#70	#55	#50 - #60
Needle	5EL68, Pos. 3	5EL68, Pos. 3	5EL68, Pos. 2
Needle Jet	N-9	N-9	N-9
Idle Jet	#40	#27,5	#27,5
Idle Mixture Screw	2 $^1/_4$ turns	1 $^3/_4$ turns	1 $^1/_2$ turns

Table 4: Setup Mikuni TM30-6

TM 34 Flat Slide Carbs

In 1995 I had the opportunity to fit Mikuni TM34 flat slide carbs onto my RD engine. They were said to have already been running on an RD and they had a modified bore (about 36 mm).

To get the full possible carb slide stroke I had the cable distributor modified and made new cables for the carbs (Outer length about 180 - 200 mm, inner cable 24 mm longer)
The carbs didn't fit the stock flanges, so I manufactured an auxiliary plate with standard Mikuni flanges.

As it was meant to be used only for racing I got rid of the vacuum and oil connectors. Neither did I use any kind of balancing pipe between the flanges.

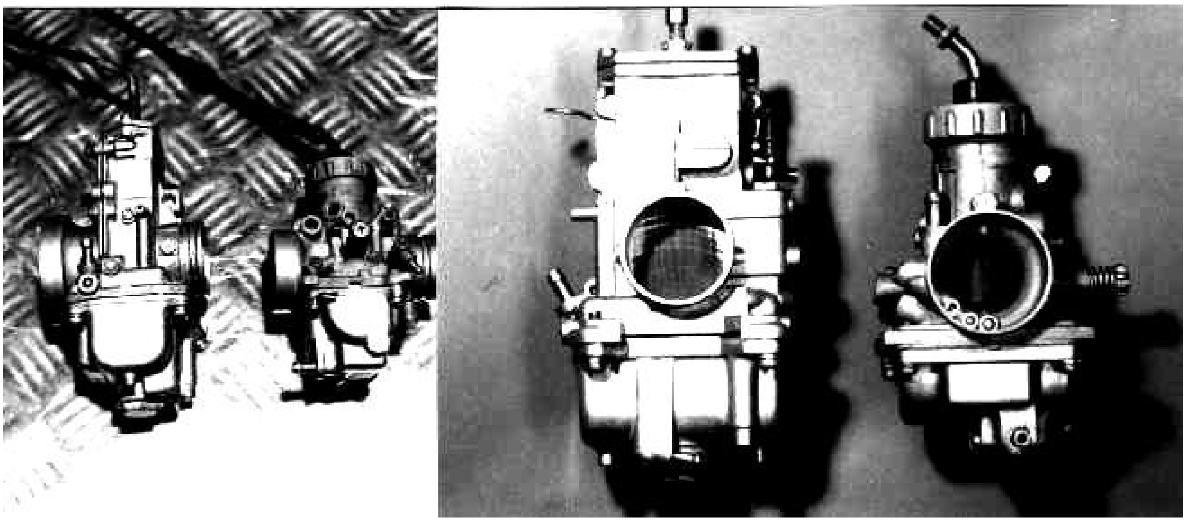


Figure 15: Comparison carburetor TM34 and VM26

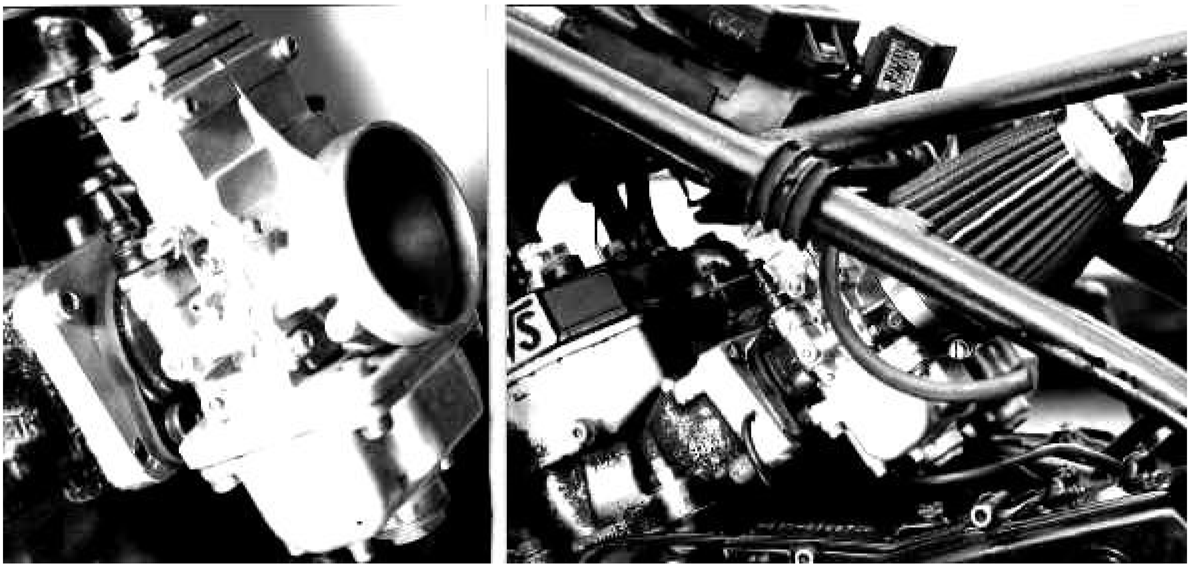


Figure 16: carburetor TM34 screwed to the cylinder via adapter plate

With the initial setup the engine behavior was very poor (as expected) at all Rpm's. The idle mixture was so fat that the motor started cold without any choke actuation. Guess how the motor ran when it was warm? With stock pipes it was pure horror to ride; so I tried some Jolly Moto pipes.
This gave the engine a terrific boost in top end power, but low and mid-range was as bad as before. A dyno test proved a plus 5 HP top end performance at 12000 Rpm but below 10000 there was a 5 to 10 HP loss!

After some testing I found a suitable setup for my engine which was converted to TZR250-reeds and Jolly-Moto-pipes.

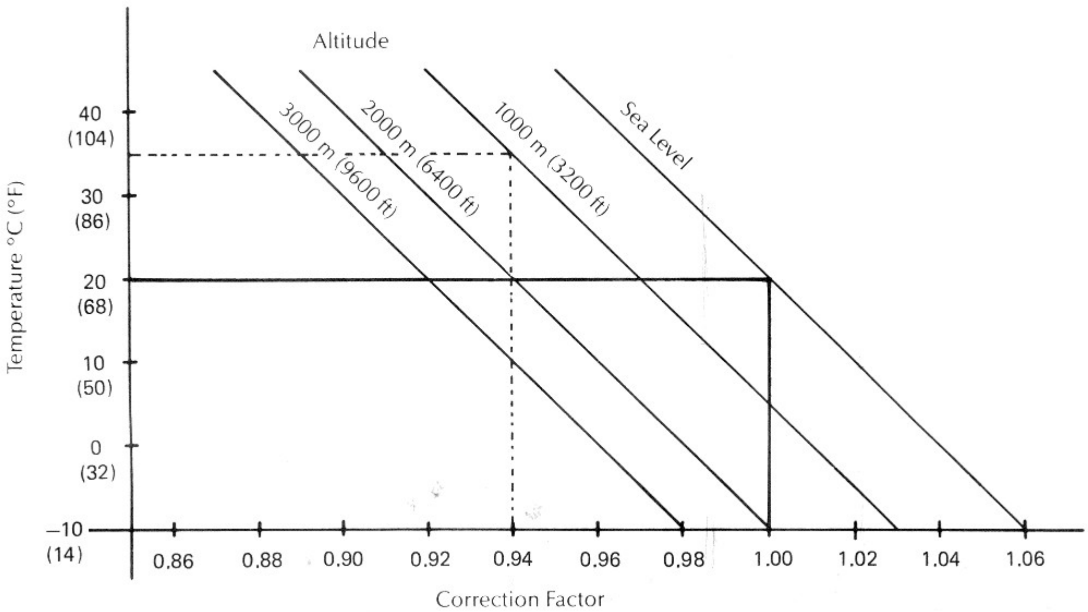
	Starting values	After optimisation
carbs	**TM34 bored to 36**	**TM34 bored to 36**
Main jet	**#340**	**#320**
Idle jet	**#35**	**#30**
nozzle	**R-0**	**Q-2**
needle	**6-FP 55, Pos 2.**	**6-FP 55, Pos 1.**
Slide cutaway	**4,0**	**4,0**
Idle mixture screw	**3/4**	**1**

Table 5: Setup for TM 34/36-Carbs

As a guide I have listed some other tested setups for other carbs on RD engines within the appendix.

Setup for altitude and temperature

If you found the right setup, you still have the weather changing the needs of your engine.
If the air is hotter, it's less dense (i.e. there's less oxygen in the same volume of air)
As your engine is metering volume and not mass, the engine now runs richer unless you adjust the jetting.
The same appliers if you go up the mountains. At high altitude the air pressure is less than at sea level, i.e. also less oxygen in the same volume of air.



Jet Needle/Air Screw Chart					
Correction factors	1.06 or above	1.06 – 1.02	1.02 – 0.98	0.98 – 0.94	0.94 or below
Jet needle setting	Lower clip one position	Same			Raise clip one position
Air screw opening	one turn in	½ turn in	Same	½ turn out	One turn out position

Figure 17: Jetting for altitude and temperature

In the Kawasaki KX500 manual there was a very nice jetting chart for temperature and altitude.
You read it as follows: You follow the temperature horizontally to the right until you intersect the altitude line. Then you go down and read the necessary correction factor.
The required jetting is the one you have at 20 deg C and sea level multiplied by the correction. In the example you start at 35 deg C and 1000 m altitude and read a correction of 0.94.
So if you have a #195 as a stock jetting you should try 0.94*195 = #185. For that correction Kawa recommends a change in the airscrew of about ½ turn out (i.e. 2 ¾ instead of a stock 2 ½)

If you found the base setup at different conditions, you need to reverse the method to get the 20 deg / sea level value.
Example: You found a #200 jet at 25 deg C and 500 m altitude. The correction for that case would be 0.98, so the 20 deg / sea level value would require a division by the correction (200 / 0.98 = 205).
If you do further calculations, you use the #205 as the base value and just multiply it with the correction.
In the above example with 35 deg C and 1000 m it would be #205 * 0.94 = #192.5
As there is no such jet, you need to test if the #190 or #195 would be better.
Or you have jets with intermediate sizes. Never heard of that ? Well read the next chapter ….

The jet size problem

A small problem in finding a setup for my RD500 following a reed conversion led me to a fundamental carburetor problem.

After rejetting from stock #195 main jets (stock YAMAHA with Mikuni marking) to #180 (Götz) with #22,5 power jets (using RD/RZ 350 idle jets with 4 mm thread) the engine was running very poorly. The mixture was far too fat in mid-range and top-end and I was wondering why, because the conversion would have required a slightly fatter jetting. Then I changed main jets to #170 (Mikuni) and it made no difference at all.
Just before going nuts I had the idea to measure my jet store – with some amazing results - .

The Mikuni jet number should indicate the fuel flow which is not the same scale for all measured jets.

Mikuni claims to deliver lots with a maximum variation of ± #10. This means if you buy a main jet labelled #180 it’s just sized in the range from #170 to #190.
The jet number is linear dependent on the fuel flow which means a #120 main jet has 20% more fuel flow compared to a #100 jet. Do not mistake fuel flow with jet bore diameter! This dependency is not linear!
I saw in an older jet chart that Mikuni also claims the jet number to represent the fuel flow in ccm per minute. This is only true for a special test combination of fuel, pressure and jet-type. As far as I know nowadays the jets are measured with air and the difference in pressure (before and after the jet venturi) leads to the jet number.
Obviously the method changed about one decade ago.

I found that some of my jets had differences between label and fuel flow of #30 numbers and more.

The stock RD500 #195 jets had all a fuel flow of about #165 (present Mikuni labeling). The #180 jets from Götz had almost the same flow rate as the #170 Mikuni (#173 and #171). What made it even worse was that the #22,5 idle jets had a bore which compared to Mikuni #60 power jets (Mikuni number N100606).
With that knowledge I dared reduce the jet size to stock #195 (= front #163, rear #168) combined with #30 power jets which lead to a usable engine behavior.

For this reason I’d advise anyone who is going to change jetting to make his own jet measurements. The values will be different but the intention is to compare “unknown” with “known” jets and to judge if the jet label is in a valuable range.

I used a rinsing bottle for battery acid (diameter about 70 mm, about 180 mm height) with an 80 mm hose with 5 mm inner diameter (to screw in the jets).
Pour in an exact amount of water (small bucket with scale or letter scales) and measure the time in which the whole amount has flowed out.
To avoid deviation in measuring you should follow exactly the following instructions.

- Clean the jet very carefully and pour in a full bottle charge of water before starting.
- Make about 5 to 10 measures for one single jet. (Typical values would be: 129s, 125s, 122s, 122s, 121s, 123s, 120s)
- Clean the values from obviously too high/low times (here 129 and 125), calculate the average time and standard deviation (mean-square error). See your math teacher or use a scientific calculator to perform that point. (Average = 121,6 ; standard deviation = 1,14 => The right time is between 120,459 s and 122,74 s with a likelihood of 68,3%)

- The flow rate in ccm per minute is calculated by: 125 [ccm] x 60 / flow time [s] = flow rate [ccm/s] (121,6 s lead to 61,67 ccm/s). Make the same calculation for the min/max values of the standard deviation to judge the accuracy of this single jet measurement.
- Make a diagram (scale paper or PC/EXCEL) where the x-axis is the jet size (labelled number) and the y-axis represents the flow rate.
- Connect the average points with a straight. This is your reference straight for future measurements with your special equipment (Here: Y=0.397*X).
- To calibrate your individual testrig to the statement flow rate = jet label you have to introduce a proportional factor k to convert the straight to Y=k*0.397*X. For our "good" jets (which are not too far away from our reference straight) this is calculated: k = Jet No. / Flow rate [ccm/s] (For the jet #170 with 110,4 s and 67,93 ccm/s the value for k is 2,5024). Calculate the k value for all jets and use the average k value (here 2,5188) for your converted reference straight.
- Now you can directly use the measured times to compare to the reference straight by calculating the corrected flow rate: y = 2.5188 x 125 x 60 / flow time [s].

My test setup had the disadvantage that you have to measure quite exactly. If you use a higher test volume (250 ccm) the measurement will be more accurate but it will double the time you need!

As an example I've listed my measurements (for 125 cc) below.

Jet-No. (Mikuni) #	Average 125 ccm [s]	Std. deviation [s]	Flow rate (calculated) [ccm/min]	k-factor [ ]	Jet-No. (calculated) #	Jet No. Max. #	Jet No. Min. #
150	122	1,211	61,48	2,4400	**155**	***156***	***153***
160	113,75	2,121	65,93	2,4267	**166**	***169***	***163***
165	111,857	2,2677	67,05	2,4609	**169**	***172***	***166***
170	110,4	1,91	67,93	2,5024	**171**	***174***	***168***
180	109,4	3,0956	68,56	2,6256	**173**	***178***	***168***
185	102,6	2,5099	73,10	2,5308	**184**	***189***	***180***
205	94,8	1,923	79,11	2,5912	**199**	***203***	***195***
215	89,2	0,836	84,08	2,5571	**212**	***214***	***210***
270	70,4	3,4	106,53	2,5344	**268**	***282***	***256***
			Average k=	**2,5188**			

Table 6: Jet size measurement part one

The conclusion from the whole thing is: Do not trust any jetting specifications without comparing it to own experience or at least two other independent origins. If you want to find a carb setup use a complete set of new jets purchased completely from one source.

Do not work with old jets unless you've measured them thoroughly.

Jet-No. (Mikuni) #	Average 125 ccm [s]	Std. deviation [s]	Flow rate (calculated) [ccm/min]	k-factor [ ]	Jet-No. (calculated) #	Jet No. Max. #	Jet No. Min. #
195	112,75	3,507	66,52	2,9315	**168**	***173***	***162***
195	116	2,16	64,66	3,0160	**163**	***166***	***160***
195	116	0,81	64,66	3,0160	**163**	***164***	***162***
195	114,8	1,3	65,33	2,9848	**165**	***166***	***163***
260	92,25	1,5	81,30	3,1980	**205**	***208***	***202***
280	73,75	1,8	101,69	2,7533	**256**	***263***	***250***
			Average k=	**2,9833**			

Table 7: Jet size measurement part two (out-of-range jets)

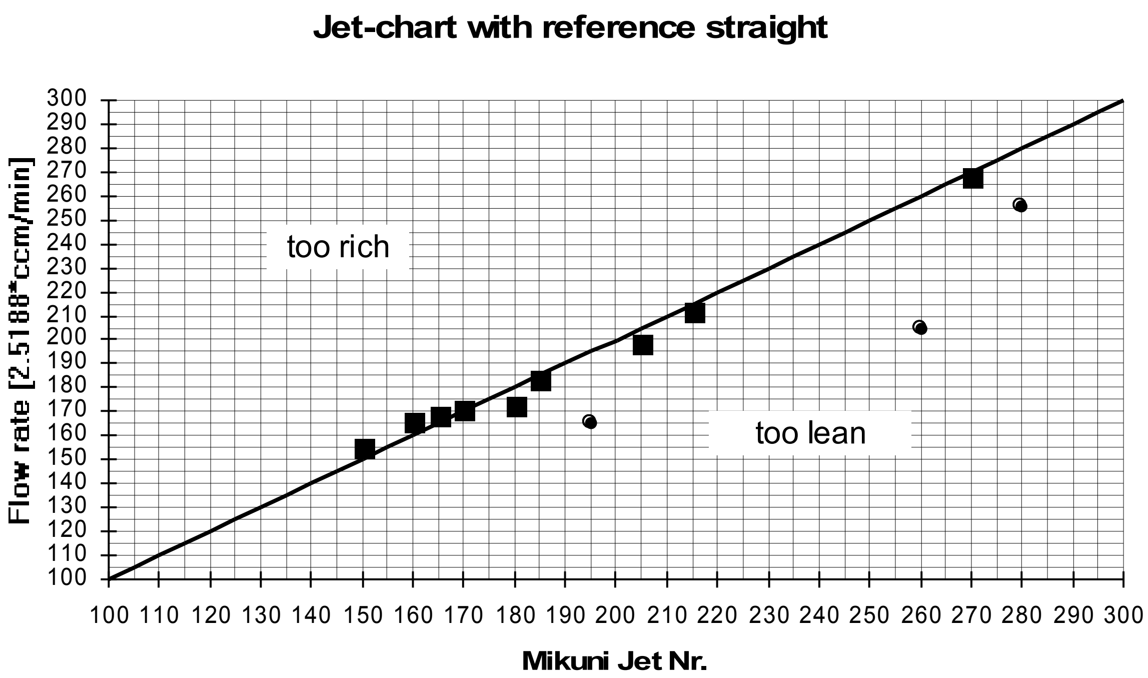


Figure 18: reference straight for the corrected flow rate

Fuel injected RZ350

In Winter 2006 I came in contact with Steve Murphree (aka smurph on the rzrd500.com forums), an US citizen who had successfully replaced the carbs on his 1985 RZ350 with a “shareware” EFI (Electronic Fuel Injection) system called MegaSquirt. He's a very kind guy and shares all of his experience on his Homepage (http://www.smcomp.com).

Because a) you can find a more detailed description there and b) very few would do such a conversion on their own I'll just give you an idea of what's required to repeat that project on your bike.

Anyway, I'd strongly suggest that you contact Steve for assistance, if you're interested.

The ECU (Electronic Control Unit) uses open source and can be modified by anyone who knows how to program in C. Only the PCB (Printed Circuit Board) has to be ordered from a few distributors (complete kit is around 200 $). You can assemble the kit on your own or get the box completed by the distributor; troubleshooting and help is done via an Internet community (http://www.megasquirt.info). Reading and understanding the documentation alone is a task for a few weeks!
There are also a couple of useful additions like ignition modules or the stimulator board or testing the ECU.

Next Problem is setting the parameters for the injection. For this purpose there's a Freeware called MegaTune from Eric Fahlgren which is running even on the oldest Laptop (DB9 Serial connector required). Here you can set lot's of stuff that also has to be read up and understood before you can start running your engine.
Usually you test carb's by riding and comparing to your memory or dyno charts. With the MegaSquirt you get a data-recording feature for free (Freeware called MegaLogViewer). You can even attach several O2-Sensors available on the market and have the AFR/Lambda value recorded.

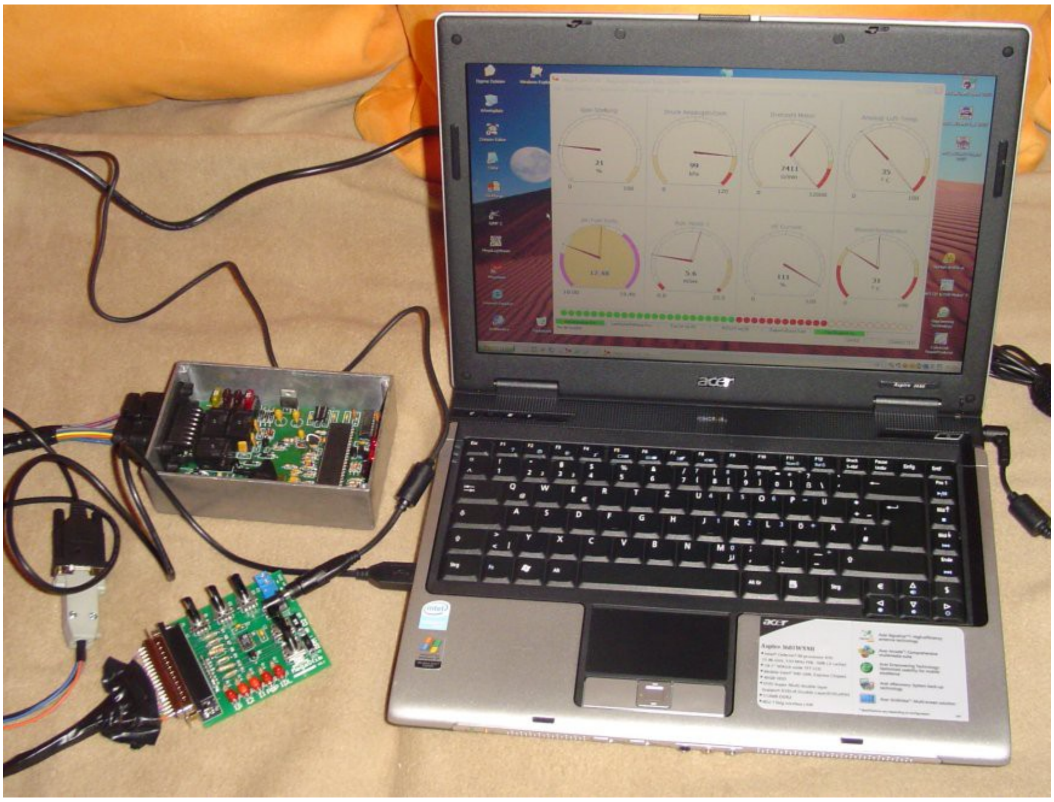


Figure 19: MiniMegaSquirt ECU (testing with stimulator board)

After having purchased the electronics-part you need some more hardware.

Every EFI system needs pressurized fuel to inject it to the engine. So he got an external & small high-pressure fuel pump from Walbro.
Then you need some injectors which have to be well chosen. Too big and you'll drown the RZ engine while idling; too small and you'll run too lean on WOT which will soon melt your pistons. Next point to look at would be availability and price. Steve ended up with using Yamaha R6 throttle bodies which are quite cheap to get (around 110 Euro for a set of 4). These have another advantage compared to “standard automotive stuff” - they have CV slides which keep the intake gas velocity in reasonable regions.
The Manifolds need to be angled to avoid the flat bar (over the carbs) on the RZ frame

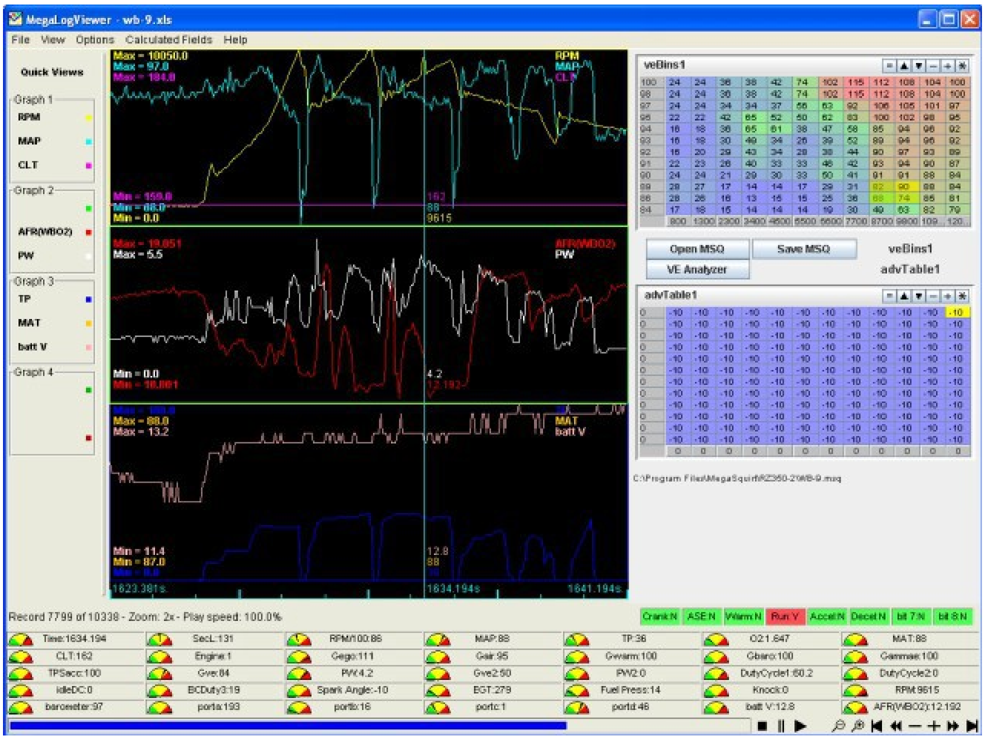


Figure 20: Screenshot from the data-recording Software MegaLogViewer

The main trick for the whole system is that it doesn't use a mass-flow sensor but calculates the mass of air from manifold pressure and intake air temperature. This saves the expensive and hard-to-tune heated wire sensor that you can find in most automotive injection systems.
If you know the “mass of air that got into the cylinder at the current working cycle” you can use an injector to get the exact required fuel for a desired Air/Fuel ratio. Ideally this is 14.7:1 for gasoline, but MegaTune can handle also alcohol-fuels.

The injector is nothing but an electronically controlled valve that sprays the atomized fuel info the manifold (up to now it woks almost as a carb).

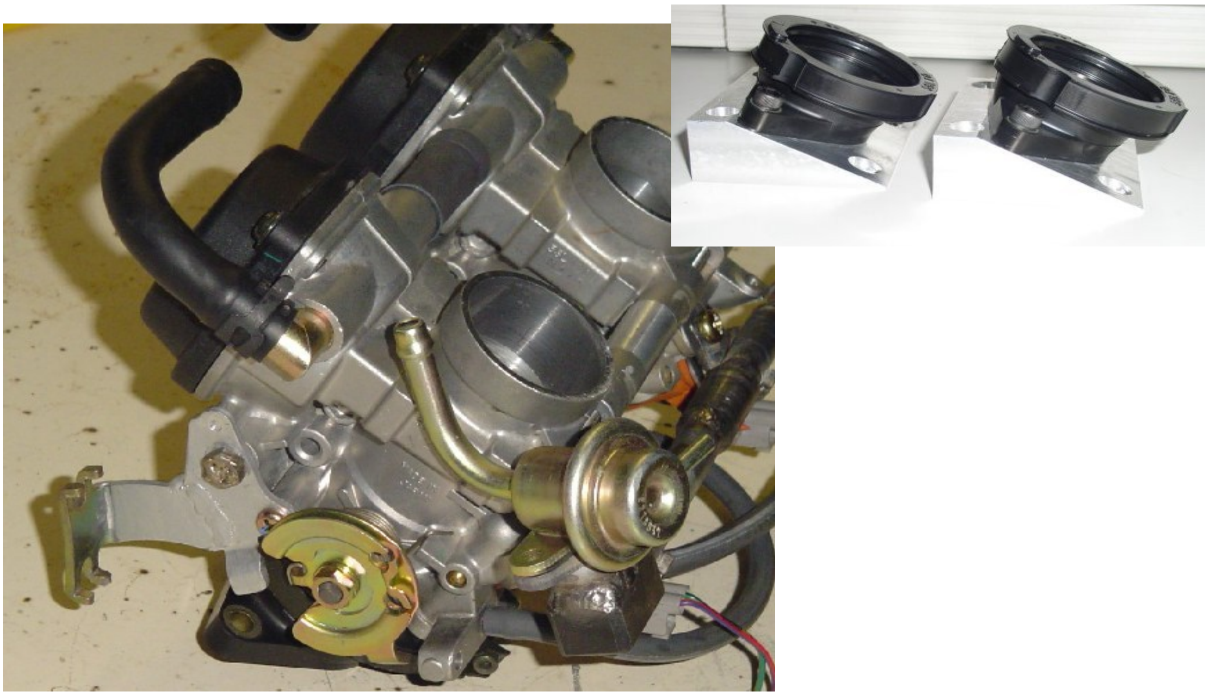


Figure 21: R6 Manifolds, throttle bodies & pressure regulator reworked to fit the RZ350.

At the beginning you assume that the VE (Volumetric Efficiency) is 100% at every state of the engine, which would mean that with every stroke the piston gets a 350 ccm of air into the engine and you inject the correct amount of fuel for a 14.7 ratio (that'd be a value of 100 in the table). This VE-table is the central tuning element in the FI system.

Finding a setup here means to determine how much your engine deviates from the “ideal” i.e. which correction you need to make the engine working well at every point of the Table (Manifold pressure vs. Rpm vs. VE value). A higher number means injecting more fuel, a lower number means a leaner setting.
I'll give you an example: If you find that at a point of the VE table and an “old” VE value of 60 the measured AFR is 15:1 but you'd rather like a 13:1 (better for max. performance) you need to set the value from 60 to 72 (60 * 15 / 13).
If it now comes to your mind “how the hell do I tune this without a O2 Wideband sensor and a dyno?” the answer is: Like you'd do it with your carb; it's a long try and error work, just that “changing jets” is now only hooking up the laptop and doing some mouse-clicks.

I'd compare the whole thing with convincing a Windows user to get Linux.

You'll have a lot of effort getting all needed drivers and setting up the system, but once it runs, it's stable and convenient.

VE Table 1

File Tools

TPS \ RPM (%)	1000	2300	3400	4500	5500	6300	6900	7500	8100	8800	9700	10800
206	56	74	90	100	116	131	132	131	128	128	128	128
175	56	74	90	100	113	118	121	126	121	124	124	124
144	56	74	90	100	113	119	120	122	120	119	119	119
117	54	74	90	101	107	108	107	107	107	107	107	107
97	53	74	82	82	89	90	84	86	88	88	88	88
89	51	70	67	64	73	70	70	70	70	70	70	70
81	52	60	55	45	59	61	60	60	60	60	60	60
73	46	47	44	33	50	51	51	50	50	50	50	50
66	41	39	37	29	39	42	45	44	44	44	44	44
59	39	35	35	26	35	36	36	37	37	37	37	37
55	32	31	29	23	30	29	30	31	31	32	32	32
50	29	26	20	14	17	16	17	17	17	17	18	18

Figure 22: My VE table (AlphaN)

The other main advantage of his EFI to a carb is that weather is compensated automatically. The ECU has sensors for air-pressure and temperature, so if you have found a good setup on one day in spring it'll automatically work summer & winter – another feature that you'll never have with a carburetor!

The only disadvantages were:

- 5 pounds more weight.
- more load on the battery / generator (fuel pump needs 48 W = 4A)
- Not as easy to install and tune as a set of carbs; Thus additional costs for assistance service.
- Manual wear compensation on the VE table for long time usage necessary.

I have contacted Steve and he sent me all the necessary stuff. My main focus was partial load optimization as it's being mounted on my road RD. I was always too lazy to do the clean carb setup for low load/rpm though I was always bothered how rough the engine was running around town.
This issue resolved very much with the EFI – especially in combination of fuel mapping and ignition.

Finding a VE table wasn't as difficult as I thought it would, at least if you have some diagnostics at hand (WB O2 sensor, Datalog with Palm PDA)
In my project (Start 2/07) I have tried several things and currently (1/16) this is my setup:

- ECU: Microsquirt (MS II)
- Fuel map using AlphaN (Throttle position & engine speed) instead of speed density (manifold pressure and engine speed) due to issues with spiky MAP signal and a very narrow pressure range (only 80-100 kpa instead of 30-100 in a 4-stroke)
- Lambda coltroler TechEdge 2J1 + Bosch LSU 4.2 sensor
- Setup suitable for race track (tested in Lurcy-Levis and at the Harzring)
- On-the-road programming & data logging with Android App “MsDroid”
- Lambda-Controller TechEdge 2J1 and additionally the JAW (Just Another Wideband) with AFR display for „the other cylinder“
- 3D ignition map (Ignitech DC-CDI P2) to reduce advance in the low throttle range.
- Drove it around 10000 km on the road. Overall engine behavior was better than with the TM30 carbs (already sold them on eBay); smooth running, good acceleration. Fuel consumption around 6.3 l/100 km (44.8 mpg).
- Overall costs at 1100 Eur. , but you don't need all of that stuff. For about 5-600 Eur. the project can be reproduced.
- Still issues when opening the throttle after being closed from WOT at high rpm
- Dynoed the engine with 70 HP at the rear wheel
- Bike with EFI and DIY Exhaust approved road legal in Germany

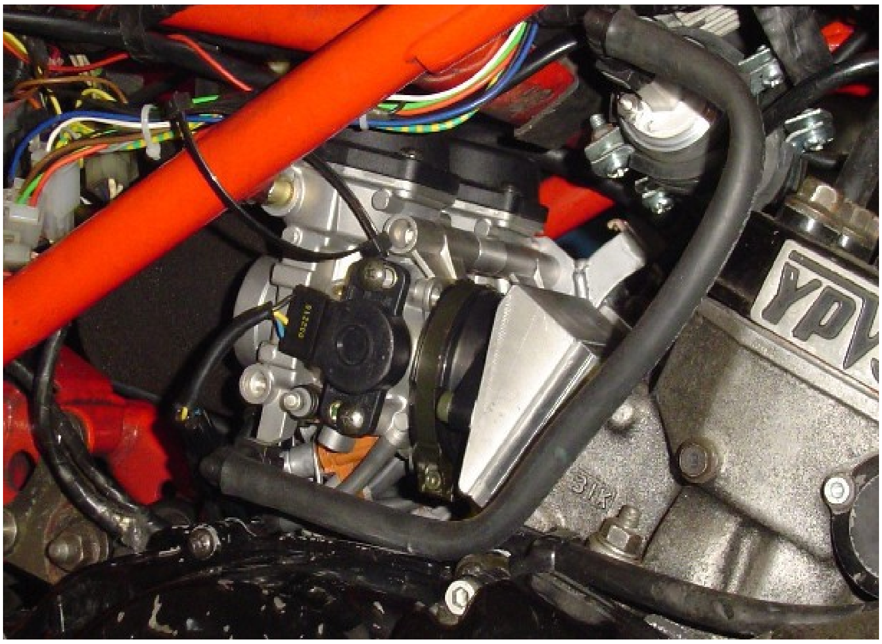


Figure 23: Throttle bodies on my RZ

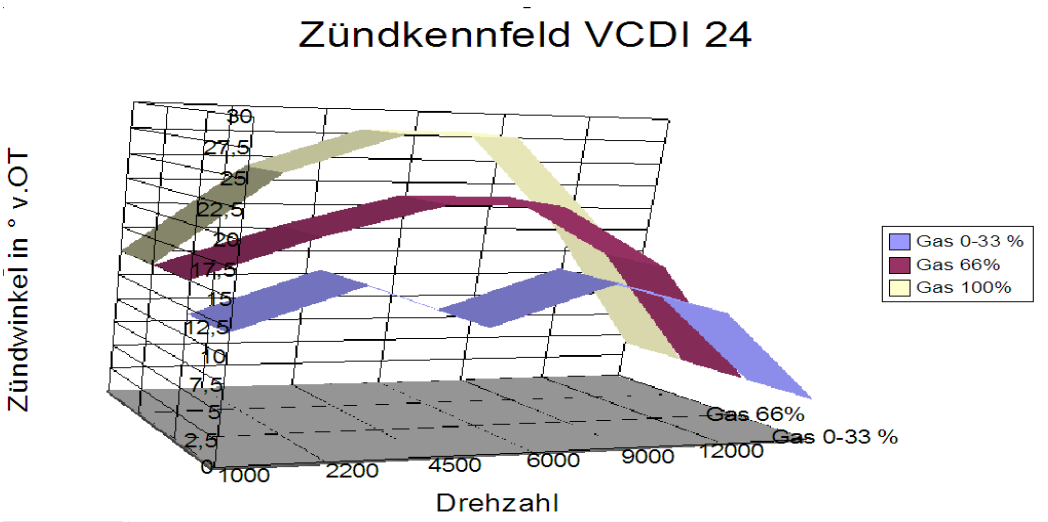


Figure 24: Optimized ignition map for smooth engine at partial load

Intake system

Reeds

There are different types of reeds available for the RD/RZ engines.
The reed-valves have the task to ensure that fresh gas/air mixture does not escape into the carburetor while the piston is going down. A slight disadvantage of this construction is the fact that the incoming gas has to open the reeds before entering the cylinder. This causes a slight pressure loss.
You can gain low- and mid-range power if you use “softer” (which mostly means thinner) reeds.
Now comes the second important thing about reeds: The natural resonance frequency of your reed assembly depends on weight and stiffness. It’s one of the factors that determine the redline of your engine because if you reached the max. rev-state the reeds come to a state of undefined oscillation which is not synchronised to the engine needs.
If you use lighter material, you can have a lower stiffness (gain in mid-range power) without changing this characteristic frequency. You can also use a thicker reed of the same material to gain more top end power, because this raises the resonance frequency.

Carbon fiber reeds are said to have a broadband effect: They should increase power especially in low and mid range but also at the top-end. The disadvantage is that these are not quite as reliable as fiber or steel reeds.

The following figure summarizes the effects of thickness and material on engine behavior.

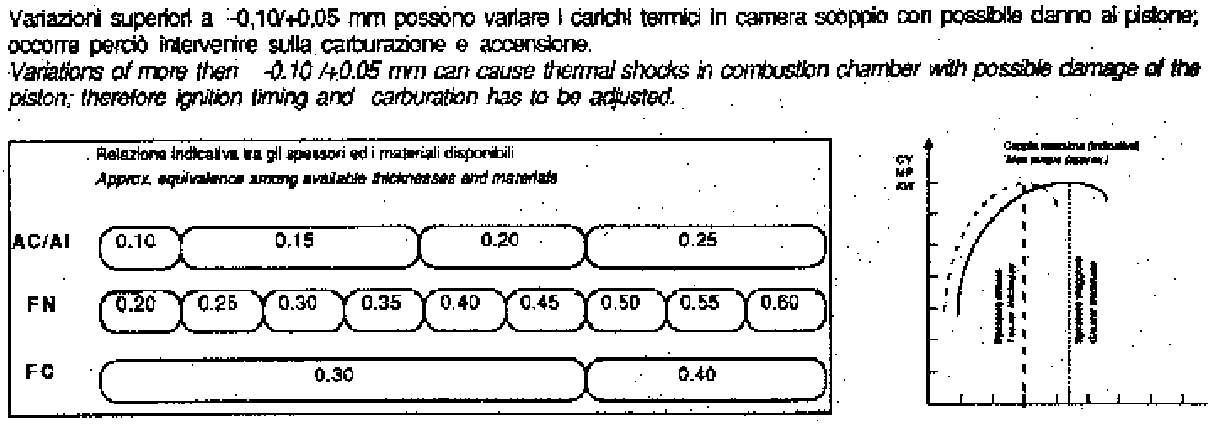


Figure 25: reed influence on engine performance (origin: Adige, Italian reed manufacturer)

Example 1: Instead of the 0,15 mm thick stock steel reeds you use fiber reeds of 0,4 mm thickness (Götz 69,-). These reeds are a little bit harder and lighter (weight -33%) which tunes the upper mid-range and the top end. You gain a better throttle response and a better acceleration.

Example 2: Instead of the stock reeds you use Boyesen-type reeds which have a so called “vented” or “dual stage” design. That means that there is one big reed petal with one or two holes in it which are covered by another thinner reed.
This has the effect of combining the advantages of having gains at mid-range (thin auxiliary reed) and at the top-end (thicker main reed).
In Germany they are available at Zupin for about 100,- DM a set.

Example 3: Instead of the stock steel reeds you use TZR250 0,4 mm thick fiber reeds and cages with a 6 pedal design. These are less stiff than the stock design and therefore they improve the flow rate in mid-range without having losses at the top-end due to increased flow area.

If you are not so familiar with a die grinder I’d recommend the solutions one and two, because the TZR reed-cages don’t fit straight into the RZ cylinders.

First you have to convert the flange bores to the RZ dimensions. If you haven’t got a milling machine in your cellar don’t worry: it’s possible to rasp them with a file too.
I was even too lazy for that and abused a drilling machine with a 6 mm drill to do that work for me.

Due to the narrow intake the cage must get fillets all around the outer shape near the sealing surface (see Figure 26).
Despite heavy milling work the longer reed cages require a 2 to 3 mm spacer to distance the cage away from the cylinder. Take good care that the opening angle of the reed is free of obstacles (see Figure 27).

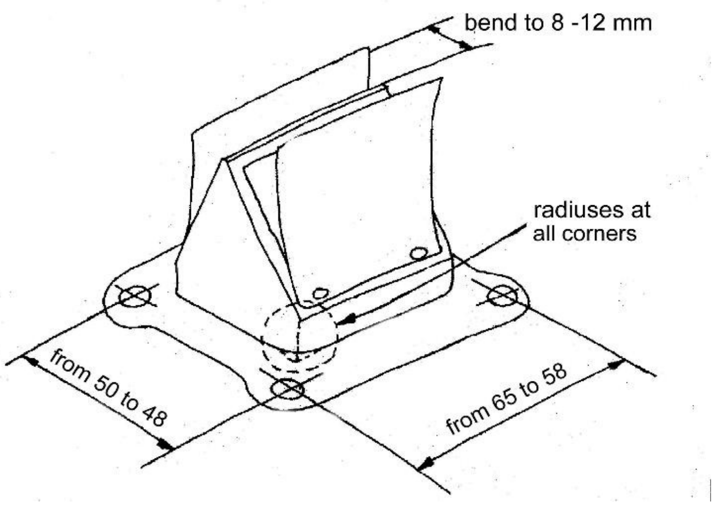


Figure 26: Outer shape of the TZR-reeds

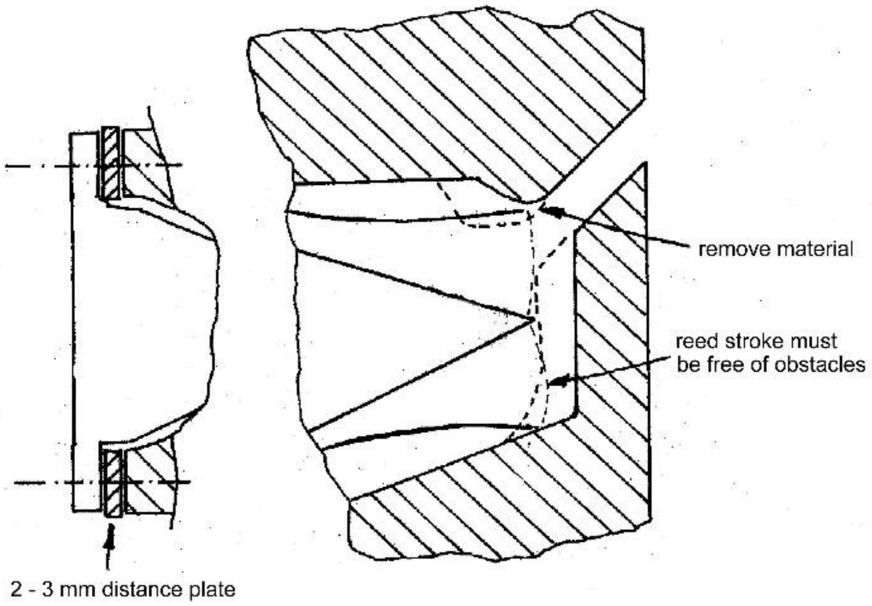


Figure 27: Cross section along the intake port with critical areas

Due to the variations in casting the left and right cylinder are not the same. You will have to tailor each reed cage to the corresponding cylinder.
At the end the required reed pedal area should be free from obstacles and the reed stops shouldn’t have contact to the cylinder (you may bend them slightly).

As a final step remove any burrs and round all sharp edges which are in the way of the flowing gas.

After assembling the reeds use plenty of DIRKO (silicone sealing compound) to mount them into the cylinder. After curing I put an extra sealing coat all around the outside of the visible reed cages.

In contrast to the catalog specifications the Götz fiber and carbon-reeds are not Boyesen type but standard two pedal reeds. They are packed in a set for both cylinders, so you only have to order one (and not two as stated in the catalog).

For the TZR 250 cages the TZR 125 carbon-reeds can be used. Here you have to order two sets (about 70,- DM each). Stock reed petals are available at YAMAHA for about 12,- DM each, complete cages are priced about 200,- for both.

In any case you will benefit from removing all the burrs in the stock cages and converting the backs of the bridges to a streamline profile. Be careful with your file and only work against the flow direction (rasp from rubber to metal). Otherwise the rubber can come loose and the cage becomes a neat deco object for your living room.
When using Boyesen or mono-pedal reeds you can narrow the bridges to let’s say 1 mm width. I would dissuade from removing the bridge for road use, because in this case the reed bends more which leads to early failure after a few thousand kilometers. This is only tolerable in drag race applications.

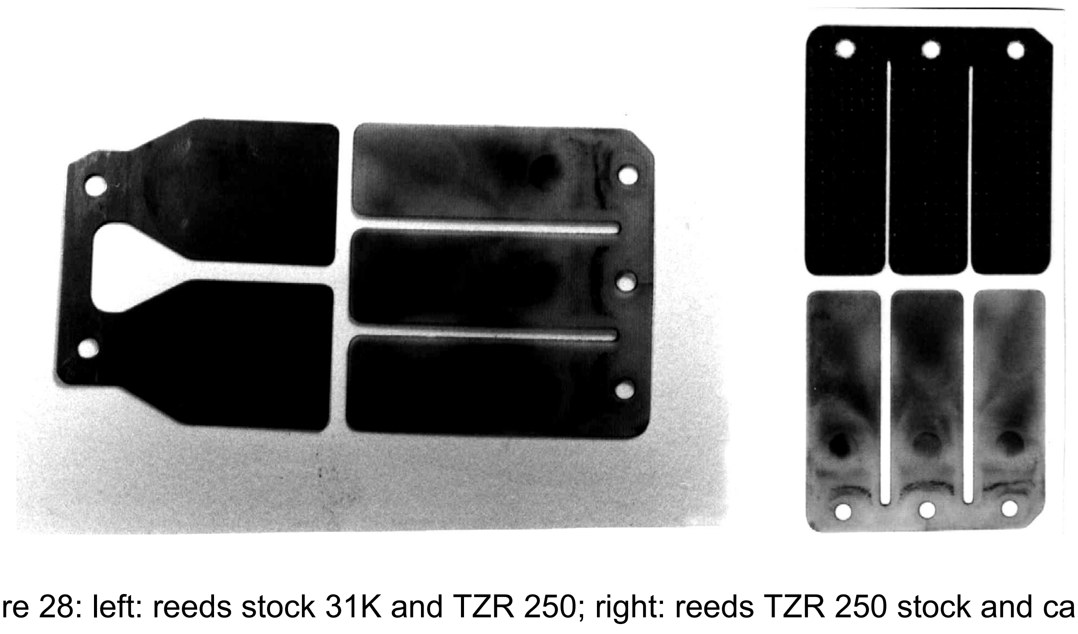


Figure 28: left: reeds stock 31K and TZR 250; right: reeds TZR 250 stock and carbon

In the last years Moto Tassinari (http://store.mototassinari.com) developed the Vforce 3 and 4 Series which is available for the Banshee.
These reeds fit the RZ “as is” and with a bit of machining also the older LC models.

Their design results in almost double the flow area for low reed openings. Each cylinder has 8 reed petals at service.
In Addition they come with a build-in reed stuffer that calms down turbulence and directs the flow.
I have seen dyno charts where the Vforce added some 7 HP, but these were highly modified engines where the reed became the bottle neck.
In stock engines the gain is smaller.
The main disadvantage: At 250 Eur / Set they're absolutely no bargain.

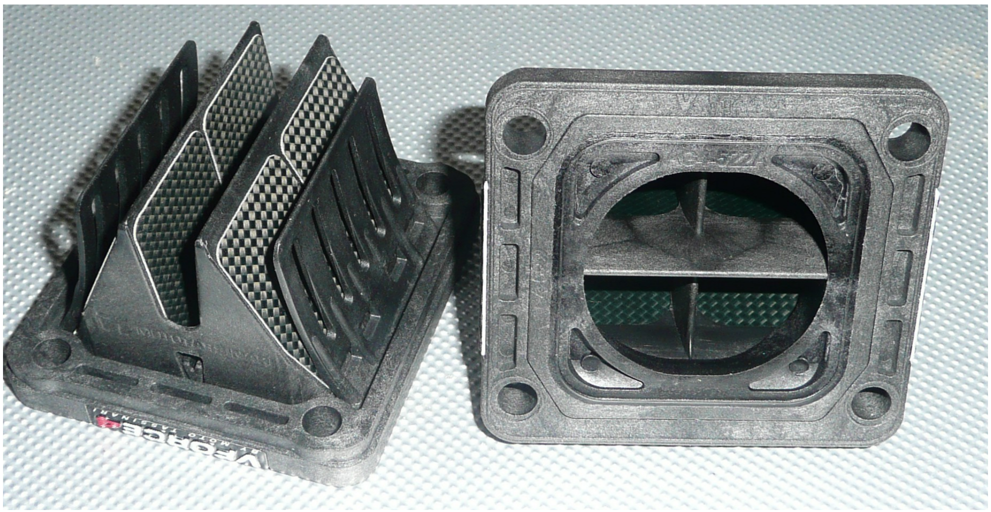


Figure 29: Vforce 4 reeds

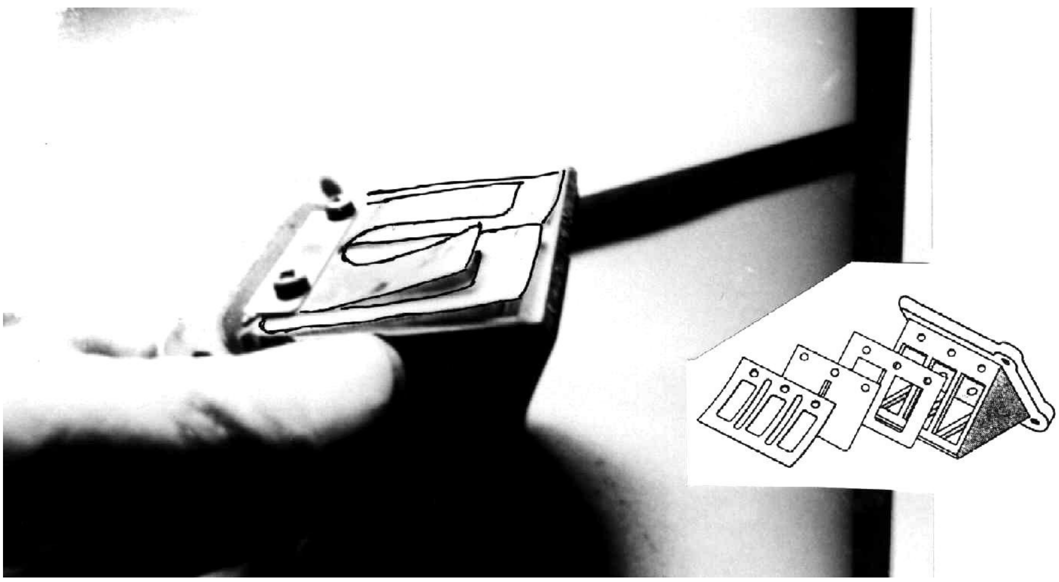


Figure 30: Boyesen reeds

Porting

To increase gas flow the intake area has to be machined as described below:

The port height can be raised about 2 – 5 mm (31K) both at the bottom and at the top. Be careful at the upper port edge, because you must ensure that the lower piston ring does not cover the port area at BDC. The back of the bridge should look like the wing of a plane (see Figure 31).

The 1WW models have a kind of fillet at the lower port edge which should be reproduced after porting.

In other tuning-guides it was proposed only to alter the port height and in any case neither to broaden the port width nor to narrow the bridge. This was based on the experience of the author that this was needed for piston support and that there is “plenty of hole” if you altered the port height. I can agree with that because I have had similar experience (Pistons always seem to seize at the intake bridge area).

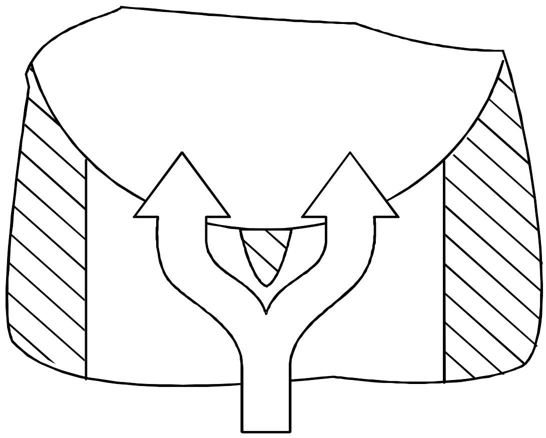


Figure 31: Section of the intake area (reed housing)

If reliability isn’t the main thing, you can increase the port width by about 1 mm (left and right). Narrow the bridge from stock 10 mm to a value around 4 – 6 mm (=> increased piston wear).

It’s also worth smoothing the intake surfaces with #200 sand paper. It has no advantages to polish in this area, because the flow velocities aren’t high enough.

The easiest way to obtain maximum intake cross section area is to connect the intake directly to the transfer ports.

Position the cylinder in a way that enables you to look at the rear surface of the transfer ports and the intake port (see left figure). Begin with a 6 mm drill about 10 mm below the joint face. Drill a hole in the inner, lower direction tangential along the cast iron sleeve. Depending on the thickness of the cast aluminium you can go up to Ø 8-10 mm in stock cylinders and up to 15 mm with some welding or using two component adhesive (WÜRTH, DEVCON).

If you don’t want to add material you can widen the 6 – 8 mm hole to an oval.

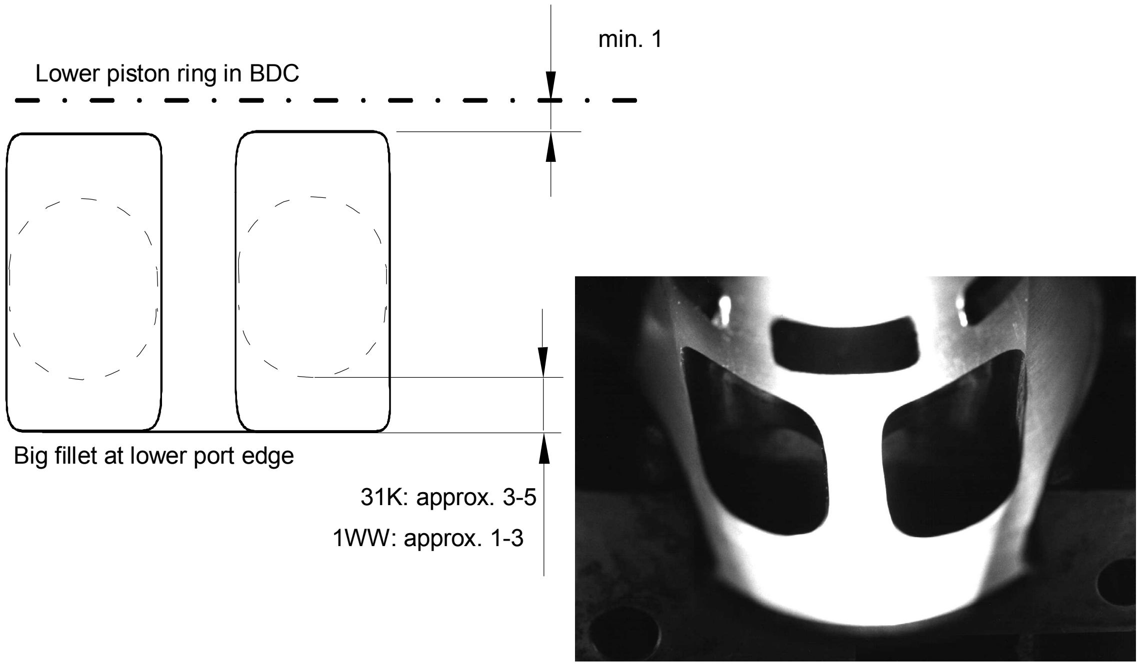


Figure 32: Intake port as seen from the cylinder

Figure 33: Boyesen port between reed region and transfer ports

Crankcase

This chapter is not that important for increasing engine performance but if you've already opened the crankcase for rebuilding, you should rework it as follows.

The top half of the crankcase has about 1 – 2 mm too much material in the transfer port area.
Remove it with a file, a die grinder or other milling tools. Be careful not to cut too deep at once. You can put the cylinder onto the top crankcase half and feel with your fingers how much material is left.
After finishing the milling job you can polish the reworked area or – if you're as lazy as I was – just smooth it with #200 sandpaper.

Figure 34: Crankcase with cylinder-shaped gasket

Before you mount the cylinders onto the crankcase, you have to cut the gaskets to their new shape with a sharp knife. Just use the sealing surface either of the crankcase or the cylinder as the reference pattern and cut the gaskets where they tide over.
Finally I would recommend to mount the gaskets with a thin coating of Dirko on both sides.

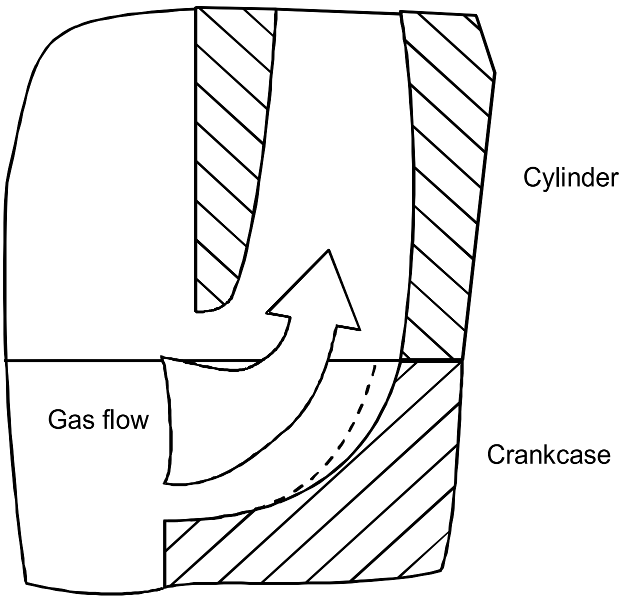


Figure 35: Section through cylinder and crankcase along the transfer-port

Big bore kits

Meanwhile there's a couple of alternatives if you want to enlarge engine displacement. Main source is the USA where the quad Banshee is very popular.
The engine is like an YPVS engine just without the YPVS.

Displacement is given by bore and stroke which leaves two ways to go that also can be combined.
The stroke goes in proportional; i.e. double the stroke = double the displacement.
The bore goes in squared; i.e. double the bore = four times the displacement.
Any larger displacement will boost your low end at the cost of max. revs / over-rev.

The easiest thing is bigger pistons with the max. available oversize. Prox, Vertex and Wiseco offer up to 66.5 mm (= 375 ccm). As an example a +2 mm results in 369 ccm and about +3.6 HP.

Woessner (who used to be the German Wiseco importer) does own pistons that exceed the +2.5 mm up to +4.5 mm (= 68.5 mm)
Caution: They offer two pin positions (one for stock 110 mm connection rods and one for “long rod” 115 mm cranks)

Old fashioned people will remember the DT175 / long rod conversions on the old LC's. The DT has a very light 66 mm piston but the pin position is 5 mm off which requires the longer rod.
From today's point of view the pistons are very weak and I would not recommend that any more.

For all piston conversions you need to know that the stock RZ cast iron sleeve is rather thin. 66.5 mm pistons only fit, if the oversizes before were bored exactly “in the middle”. If that was not the case you're left to smaller max. sizes.
Fortunately there's a lot of sleeve supply for the banshees. (like www.trinityracing.com)
Unfortunately you run in other problems if the sleeve is getting too large in diameter: The cylinder spacing on the RZ is rather narrow and you have rather small transfer duct cross-sections / radii. Now if you make the sleeve much larger, you further reduce this.
Also the Power-Valve region is expensive to manufacture for the YPVS engines.
On the other hand there's much to gain: The RZ engine's bottleneck is blowdown, so if you do a sleeve with a bridged exhaust, you can get much wider in the area above the transfer ports and gain blowdown area.

In Germany you could get one of the first stroker cranks from Armin Collet. It had +2 mm stroke and was manufactured from Hoeckle, THE german crank specialist of that time.
Rumors said it had 80 HP, but I have some details of the Collet modifications and next to the crank it also included lots of other stuff (like boring the carb, different reeds, cylinder porting, ...). Even with the additional mods I still doubt the 80 HP.
As Collet sen. already deceased a few years ago and Hoeckle ran out of buisness long ago, you won't find much of those around ...

In the US you have the HotRod cranks with +4 mm stroke (Marco Böhmer uses them as a standard)
Main advantage: They're a good compromise on what you get for your $$. Depending on the Dollar exchange rate in Europe there were times where it was cheaper than rebuilding a used crank.
Wiseco cranks have a reputation to be somewhat better; Crankworks are supposed to be one of the brands on the market.

The reliability in stock engines is ok, higher revving race engines kill them much quicker. One of the usual damages is that the press fit gets loose. That's why most of the offers are “welded” cranks – they put an additional weld over one or two edges of the rod pin / crank web connection. Unfortunately it doesn't improve the reliability much in case of high rpm abuse and it makes it much more difficult to rebuild.
Another thing: Usually they come with 4 equal bearings with a notch and no pins. To prevent the outer bearing race from spinning in the case they use O-rings which does half way work in stock / undamaged cases. But if the case is already worn that's not as safe as pins.

Concerning the roller bearings you get what you pay for. If you buy as cheap as possible on eBay you don't need to wonder if there's fake Chinese copies instead of Yamaha OEM. There's a lot of variants available, partly with additional balls that claim to bear a higher load.

As a compromise I usually exchange the outer two with Yamaha OEM parts.
If you have a straight cut primary, you can use TZ Bearings on the outer right. This one really has a higher load index, but there's no axial fixation of the crank.
If you want it perfect you need to machine a notch in case for one of the middle bearings. (I have done versions without this additional fix and they're still alive).

On all stroker cranks I had the experience that the piston life is reduced with the stock connection rods (110 mm). With the 115 mm long rod version it seems to be somewhat better; especially when used with a lot of WOT.

Usually people use pistons with a 5mm offset pin position to compensate that but in that case there's not as many different piston choices as with standard rods.
In order to enhance to possible types, I use an aluminum base plate in shape of the gasket. In my case the gasket material was 0.75 mm and the plate had 4 mm which is a total of 5.5 mm (which is exactly +5 mm to just the stock 0.5 mm gasket).


Figure 36: Cylinder base plate to compensate long rod

Next thing to consider is that the piston goes up and down 2 mm more than before.
When using pistons with a very long skirt like the 1WW stock pistons, you may have to machine the skirt in order to maintain clearance with the crank.

On the other side you'll need 2 mm more space at the top of the cylinder.
The lazy slacker method is to use a base plate again; just this time with additional 2 mm. Unfortunately this raises all ports 2 mm and you end up in insane port timing like 206 deg exhaust.
A spacer at the head (like a 2 mm thick gasket) has been used, but all of the aluminum parts leaked either water or burnt gas. Maybe a 2 mm copper part could work but I haven't tested that, yet.
The best solution here is it machine the head contour 2 mm in upward direction (i.e. You create a 2 mm + squish step on the combustion chamber.)
In direct comparison between a base plate and head mod the latter one had some +5 HP in the midrange !

Figure 37: Head mod for a +4 crank

If you need even more stroke you can ask Trinity racing or TDR (bansheedepot.com) – they offer variants like +5, +7, +10 and +12, +14 and +16 cranks.
Note that these need at least machining of the stock housing and mostly require usage of certain cylinder kits. In exchange you get really huge displacement in the 5-600 ccm range.
People I spoke to reported a strongly decreased WOT reliability and state costs in the 2-4000 Eur range!

The most famous cylinder kits were done by the late Calvin Pollet (CPI = Calvin Pollet Industries, http://www.cpindinc.com/) but the company is still on the market with the existing kits. You can get cylinders in stock shape with a 347 cc imprint (=Wampus) or you pick them with a larger water jacket (= Cheetah Cub)
Depending on bore and stroke you can realize giant displacement, but for the larger ones you need really expensive billet engine cases (http://www.mattoonmachine.com/)
All cylinders come with a bunch of advantages over the stock cylinders:

- nikasil plated bore
- triple exhaust port (good blowdown, better for the rings than one wide port)
- water around the whole duct
- cylinder block instead of single cylinders
- Performance in the 80 HP to far more than 100 HP range

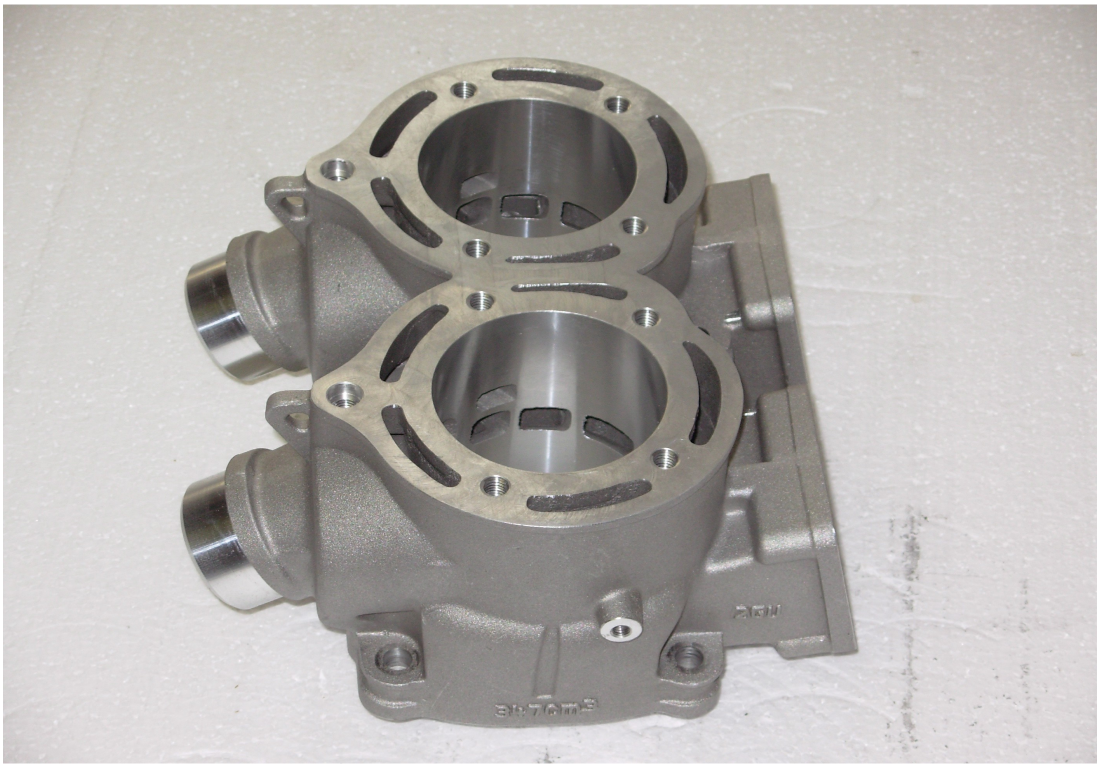


Figure 38: CPI Wampus-kit for the banshee in stealth look (347 ccm mark)

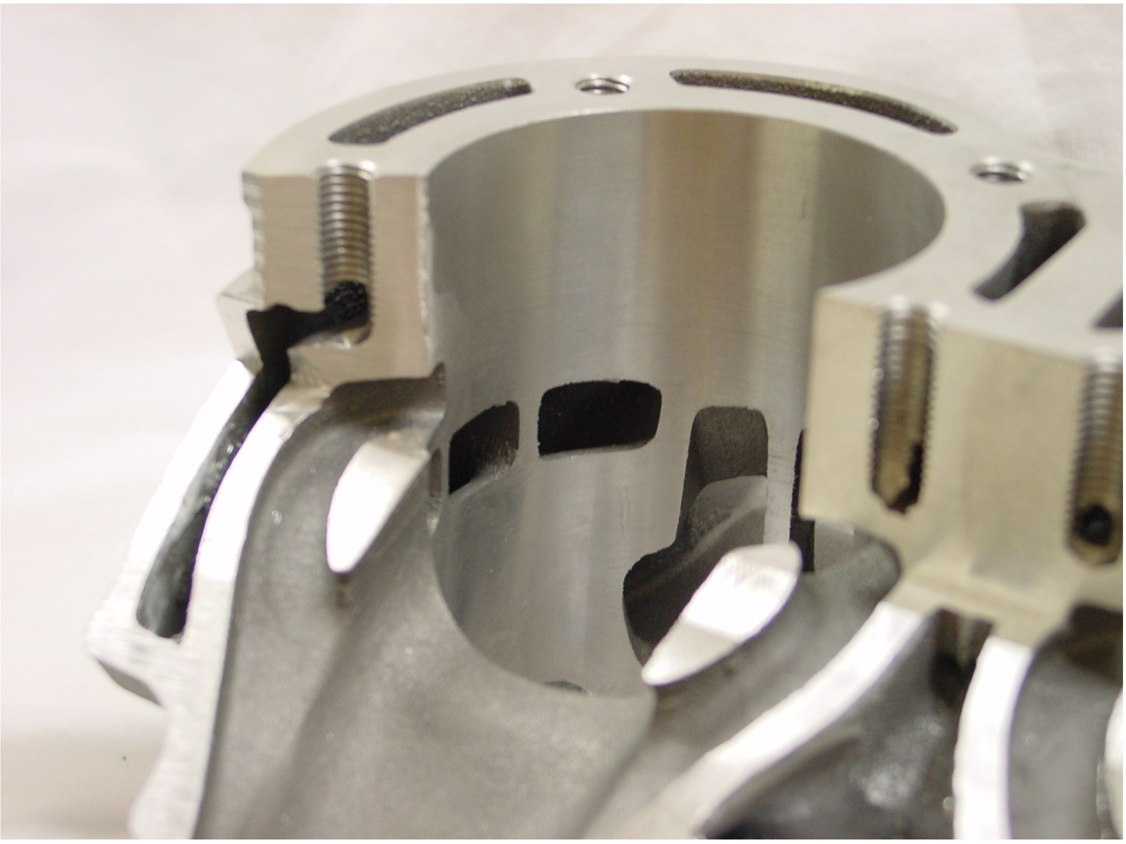


Figure 39: CPI Cheetah Cub port layout

In the last few years the Athena kit grew pretty popular, especially in the UK amongst LC riders.

The kit ist rather cheap (800-1000 Eur) and delivers 70-80 HP without much effort. I've also seen 100 HP dyno cahrts with a 10 mm crank.
Like all non-PV cylinders they have a more or less strong torque-ditch around 5-6 k.

Figure 40: Athena kit for banshee

As usual there's two sides of the story and in this case it's a list of disadvantages:

- No plug and play modification
- Only works with partly costly additional things like (head, ignition, carbs, reeds, radiator, pipes, cases, ...)
- Pipe flange different between Banshee and RZ
- Nikasil plating is costly to repair if damaged
- Partly wrong piston tolerances (for example TSS required 0.06 mm whereas 0.1 mm will be more reliable)
- Reduced reliability; especially when used for road racing with long WOT
- Strong 2 stroke kick due to weak mid range / ditch in torque curve. Annoying in road use
- Partly heard of leaking o-rings

Pistons

As you may already know pistons wear quite rapidly in RD engines. In normal conditions they should last about 20-30.000 km. After that mileage you should use new ones when opening your engine; if not, just wait until they seize or other damage occurs ... . With rising mileage they become more and more sensitive to cracking. In this case the whole piston skirt may come off and result in severe (i.e. very expensive) crank failure.

The stock 1WW pistons have 2 mm longer skirts and YAMAHA claims that they changed the ring material which increases reliability. In addition the engine runs with less noise due to reduced piston tilt.
Nevertheless both pistons fit in both cylinder types (31K and 1WW).
Stock pistons are available in two overbores (64,25 and 64,5 mm); if you manage to get the 1WU (swiss model) pistons you gain two more stock sizes (64,75 and 65 mm).

In mildly tuned engines I always use Prox pistons because they are stock quality but for half of the stock costs (about 160,- DM complete kit with gudgeon pin and rings).
In Germany they are imported by Großewächter and distributed through your local dealer. They deliver pistons up to 66,5 mm bore in steps of 0,25 mm.
The Mitaka brand seems to have similar origin and quality. People successfully used them on RZ's.

Forged pistons are slightly lighter and have thinner rings which allows much higher maximum revs. (When using Prox pistons you have the risk of ring breaking if you combine them with pipes revving more than 10.500 rpm.)
The disadvantages are the higher price and the and a higher thermal expansion of the material. In order to avoid early seizures they recommend to increase piston clearance from stock 0,065 mm to 0,07 - 0,08 mm with Wiseco pistons.
In at least some of the Wisecos people observed that the piston clerance rapidly changed when the engine was very hot for a single time. When the water gets above some 80 deg C the piston completely looses form and strength. So if you decide to go that way, get the biggest rad you can fit.

The former German Wiseco importer Woesser now does own pistons.
Regarding the price they're in the upper range, but the quality is, too.
They have a strong material for high loads, a friction coating and thin rings for high rpm. The pistons are available even in +2.75, +3, +4 and +4.5 mm oversize.
They even do pistons upon customer specification at a reasonable price.

Though it's a forged piston they recommend 0.06 mm clerance – I've used that a couple of times and can confirm that it works.

Figure 41: Woessner forged piston

A good compromise between cast and forged pistons is Vertex. It's also a cast material, but tit has more strength than the Prox. The rings have stock specification and are only suited for moderate rpm levels up to some 10.000.
They also have a friction coating and the price is a bit lower than the forged pistons.
Main advantage: No question mark on material properties changing due to excessive heat/load.

If you have cylinders in perfect condition with 64 mm stock bore or you’ve had them rebuilt with new cast iron sleeves you can use the TZ350 pistons (Model code 3G3, 6 transfer port cylinders). They unite lightweight (reduced bearing wear), one slim ring (max. revs of 12.000 Rpm),short skirt (less friction), higher compression ratio (higher dome) and a durable material.

The disadvantages are higher ring wear due to higher preload and increased noise due to piston tilt.
You can order them at your local YAMAHA dealer for about 150,- DM per kit (piston, ring, gudgeon pin, clips).

The piston skirt should be machined and polished to a knife-like shape as shown in .

Figure 42: Modified pistons (upper row: Prox, lower row left to right: Prox, Wiseco, TZ350)

Meanwhile I leave the the ports in the inlet skirt as they are.
On cast pistons you weaken the structure and making the holes bigger doesn't result in a noticeable increase of performance.
In the next step you ought to bring in some lubrication bores at the inlet bridge and at the exhaust skirt. Don't forget to deburr with a 90° counterbore. (see Figure 44, too)

You're right if you think that the outlet side bore comes in contact with the exhaust port area in TDC, but don't be afraid, it works!
These pistons won't have the typical dark or seized exhaust skirt area (see left figure) even after thousands of kilometers.

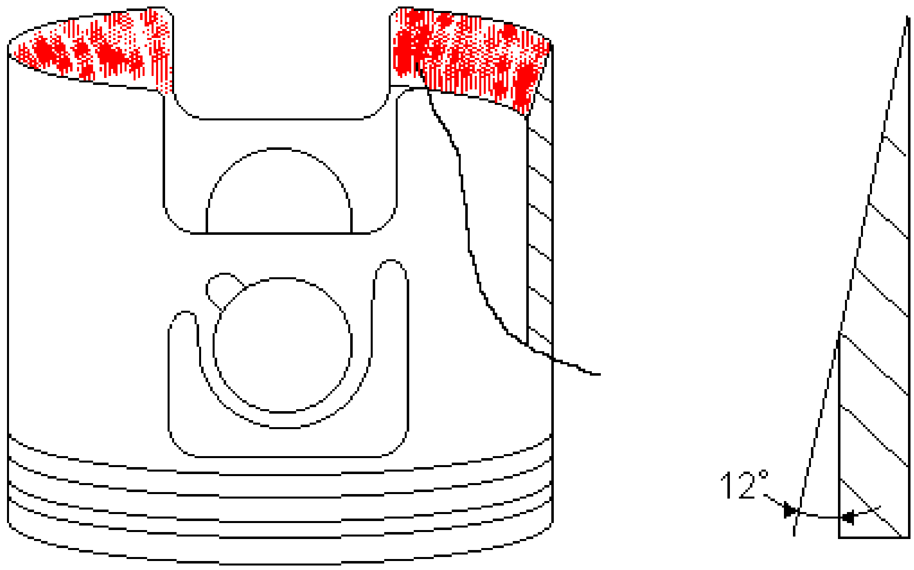


Figure 43: Piston skirt cross section after machining

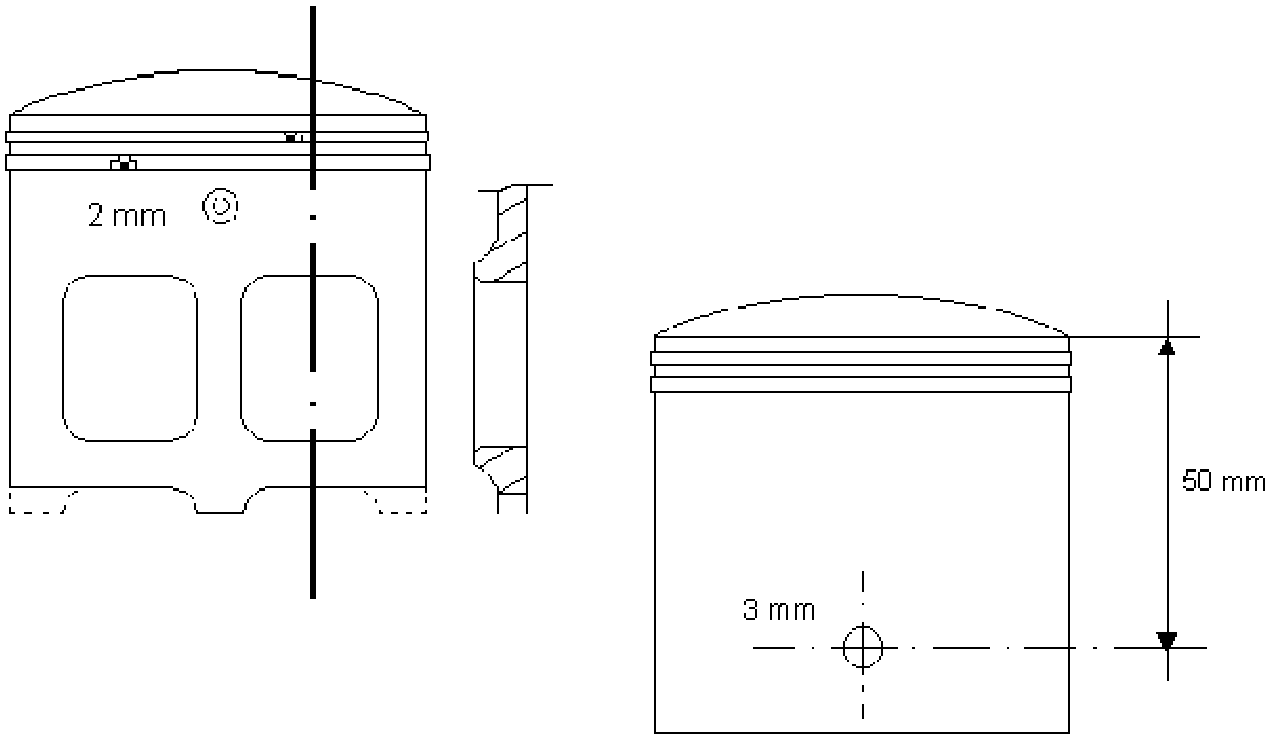


Figure 44: Piston lubrication holes

The last process is – you may have guessed already – to polish the top side of the piston to avoid too much oil-carbon deposit.

Figure 45: Some of my scrapped pistons (torn connecting rod, seizures, melted with free rings, ...)

Transfer Ports

Converting the scavenging system is a very tricky piece of work even for a skilled person and you need a very tiny die grinder. Even if you manage to perform this difficult task you have no guarantee that it works. For this reason I have decided not to change the port layout, but only to do some minor optimization.

The bridge which separates the two transfer ports should be ground to a wing shape (similar to the inlet port bridge). The sleeve gets a little radius in this area. (see Figure 46).

You can broaden the boost port quite easily with a round file about 1 mm at each side, but don’t alter the port height!

All transfer ports have some burrs at the sleeve which you can mill with a spherical cutter. This is a problem of manufacturing because the (cast iron) sleeve is put in the cylinder mould and then the aluminium is cast around the sleeve. It is quite difficult to position the sand core for the ports 100% accurately so this always leaves some burrs where they bother engine performance.

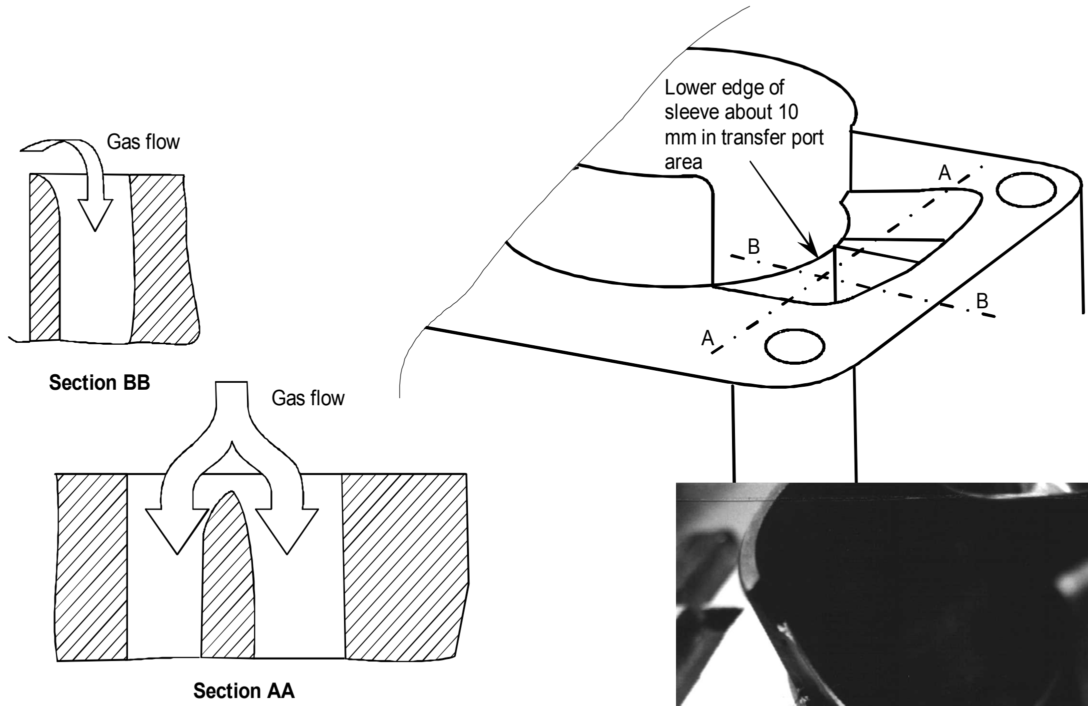


Figure 46: Modifications for the transfer ports

After finishing the other steps you can smoothen the port surface with #200 sand paper. Save the polishing - it doesn't make a difference at all in the transfer area.

In ye goode olde times it was popular to raise the transfer ports quite radically with additional gaskets / base plates.
This is not what you'd do today. Experiment and simulation resulted in the knowledge that not the highest port is the best for performance. It's more or less some 120-125 deg transfer timing that you want.
The stock 31K cylinders have 120 deg, if you raise the port about 1 mm (or use 1WW cylinders) it equals about +5.5 deg.

Generally it's better to use broader rather than higher ports, because this will have the lowest influence on the resonance in you engine; your mid range power will benefit from this. Altered ports always take performance from the bottom to the top. For my driving style (wheelies with shifting from 1 to 5) the 1WW cylinders did not offer enough performance to keep the front upwards after shifting gears so I changed back to 31K cylinders.

Armin Collet did a partial modification by raising the port in the area facing the intake side. If you do this the pressure pulse on port opening is not as high as with a straight port, but it's somehow widening the resonance range of the engine. I have one set of cylinders that has a very broad torque curve.

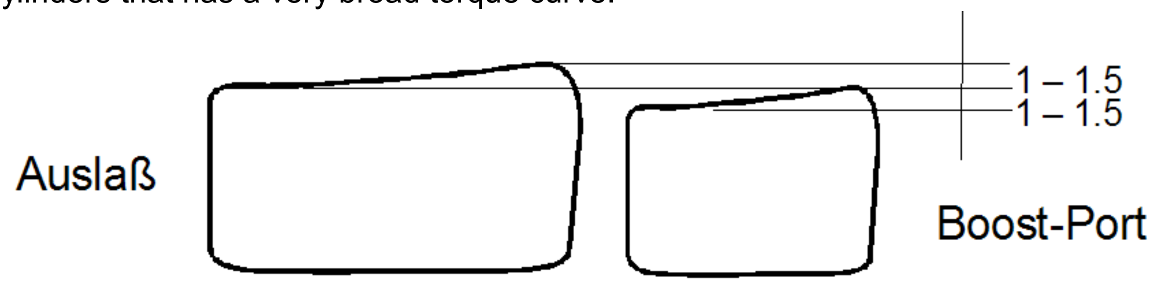


Figure 47: Collet style transfer ports

Cylinder head

A higher compression will improve torque in the lower and middle engine speed range. As a side-effect the fuel consumption will decline.

The maximum possible compression ratio is mainly influenced by the fuel type, ignition timing and combustion chamber shape. If you exceed the limit the combustion will detonate which will damage either the piston or the rod/crank bearings or all of them.

The octane value numbers the ability of the fuel to resist these undesired detonations. If you altered the compression ratio I'd recommend only premium fuel (leaded or unleaded) with at least 98 octane. In stock engines of the '83/84 31K regular can be used, in the other stock engines YAMAHA recommends the German Super Plus (a mix between premium and regular with 95 octane).
Another feature which influences the needed octane value is the ignition timing. If you convert the ignition plate from the stock 6 mm holes to slotted holes you can choose ignition timing. An advanced ignition requires higher octane values and vice versa.

There are two main ways to determine the compression ratio. In four stroke engines they use the whole displacement of a single cylinder for the calculation. In two strokes the Japanese use the volume above the Piston when it just closes the exhaust port. European two stroke constructors like Aprilia or Cagiva use the whole displacement.

$$\varepsilon = \frac{V_d + V_c}{V_c}$$

V_d = Volume of displacement (Either whole cylinder or from upper edge of exhaust)
V_c = Volume of combustion chamber in TDC
ε = Compression ratio

Yamaha claims the compression to be 1:6 (ε = 6) for all models with a combustion chamber of 21,3 ccm to 21,9 ccm. Maybe the engineers had some glasses of Sake (the Japanese rice wine) before they wrote this down, because my own measurements were quite different: The 31K-models (marking at the head: 31K Y-1) have a combustion chamber of 18,2 ccm with a Prox piston of 65,25 mm bore. The 1WW (and also the 31K from the production year '85) with the head 31K Y-2 were measured with 17,2 ccm (combustion chamber in TDC filled with oil up to the beginning of the spark plug thread).

As the compression ratio depends on the height of the exhaust port I made the assumption that the Power Valves were closed, because this yields to the higher compression values. The closed Power Valves reduce the port height by 6.5 mm, so the new distance from the upper port edge to the top of the cylinder is 33.5 mm for the 31K and 32.5 mm for the 1WW. Using these values in the upper formula you will get compression ratios around 1:7 for both models (31K: 1:6,92 ; 1WW: 1:7,04).

After head milling you should measure combustion chamber volume and compare it with the following tables. They assumed a height of 25.5 mm from the upper port edge to the top of the cylinder (32 mm with closed Power Valves). Remember that milling part of the head just compensates the higher port edge (If you alter the port without head milling the compression sinks from 6.92 to 6.66)

I would guess the maximum (road-)usable is around about 7,5 to 7,7. Standard stock engines like the TZR or RGV have values about 7 to 7,5; the TZ-Racers claim 12,5 (or 8,3 in Japanese sight). Italian 125 cc bikes hang around 1:15 but this is not a very fair comparison. You can run a much higher compression ratio, if the combustion chamber geometry is smaller (most 125 cc bores are roughly 56 mm).

A more accurate method to measure compression is to use a pressure gauge. In this case I can give you some values of experience: In the stock and tuned engines I measured values in a range of 7.5 to 8.5 Bar (105 to 120 Psi). A good value for a stock reworked engine would be 8.5 Bar, a tuned engine should give 9.5 to 10 Bar (130 to 140 Psi). All these values were measured with **open** Power Valves. If you stop the idle running engine with the ignition switch, the Valves are closed, which will increase the compression about 1 Bar (14 Psi).
On the Internet you can find a statement from Dale Alexander who uses RZ engines for racing purposes and he claims to run a compression of up to 175 Psi (approx. 12.5 Bar) in reworked state with a squish clearance of 0.03 to 0.035 inch (0.75 to 0.9 mm). Others supply values from 115 – 135 Psi (8.2 – 9.6 bar) for overhauled / tuned engines. As seen in the RZ Owners Club Newsletter 4/98 the RD500 runs at 125 to 155 Psi (8.9 – 11 bar).

I had the Y-1 head milled about 0,6 mm and reworked the squishband (If you use the Y-2 head you can mill about 0,33 mm without squish mods), which lead to a compression of 7,29 (+ 5,34 % compared to stock). Calculated with the total displacement it was 1:11,62 (stock : 1:10,54).

Mill about [mm]	Combustion chamber [ccm]	Compression ratio (with 173 ccm)	Compression ratio (with 102,94 ccm)
0	18,20	10,54	6,66
0,1	17,87	10,72	6,76
0,2	17,55	10,90	6,86
0,3	17,24	11,08	6,97
0,4	16,94	11,26	7,08
0,5	16,64	11,44	7,19
0,6	**16,35**	**11,62**	**7,29**
0,7	**16,07**	**11,81**	**7,40**
0,8	16,07	11,81	7,41
0,9	16,06	11,82	7,41
1	16,04	11,83	7,42
1,1	16,01	11,85	7,43
1,2	15,97	11,88	7,45
1,3	15,93	11,91	7,46
1,4	15,88	11,94	7,48
1,5	15,82	11,98	7,51

Table 8: Compression ratios for the **Y-1 cylinder head** (31K)

Mill about [mm]	**Combustion chamber [ccm]**	**Compression ratio (with 173 ccm)**	**Compression ratio (with 102,94 ccm)**
0	17,20	11,10	6,98
0,1	16,87	11,30	7,10
0,2	16,55	11,49	7,22
0,3	**16,24**	**11,70**	**7,34**
0,4	**15,94**	**11,90**	**7,46**
0,5	15,64	12,11	7,58
0,6	15,35	12,32	7,70
0,7	15,07	12,53	7,83
0,8	15,07	12,53	7,83
0,9	15,06	12,54	7,84
1	15,04	12,55	7,85
1,1	15,01	12,58	7,86
1,2	14,97	12,60	7,88
1,3	14,93	12,64	7,90
1,4	14,88	12,68	7,92
1,5	14,82	12,72	7,95

Table 9: Compression ratios for the **Y-2 cylinder head** (1WW and 31K '85)

The tables assume an exhaust port height of 25,5 mm and a reworked squish area (ref. Figure 50). Up to 0,7 mm you will subtract cylinder of 65,5 mm diameter from the stock combustion chamber volume. When reworking the squish-area you will add the volume of a torus with triangular cross-section (height 0,6 mm, width 2,4 mm, angle 15°). In clear text: that'll lower the compression ratio slightly.

All table values consider this effect. Slight deviations are possible because of the given dimensions 65,5 mm and 0,7 +0,1 mm.

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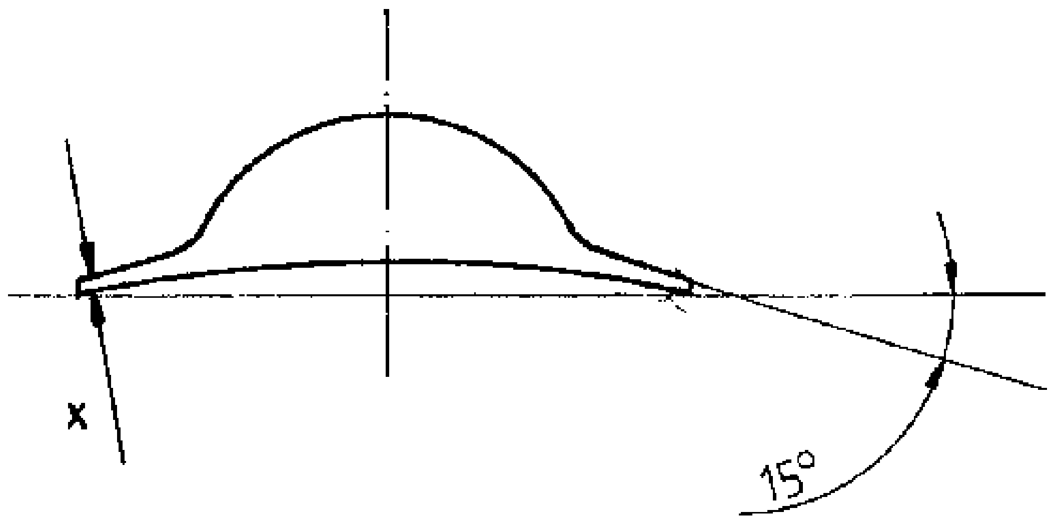


Figure 48: Cross-section of the stock combustion chamber in TDC position
(optimum dimension X: 0.8 – 0.9 mm or 0.0315 – 0.035 inch)

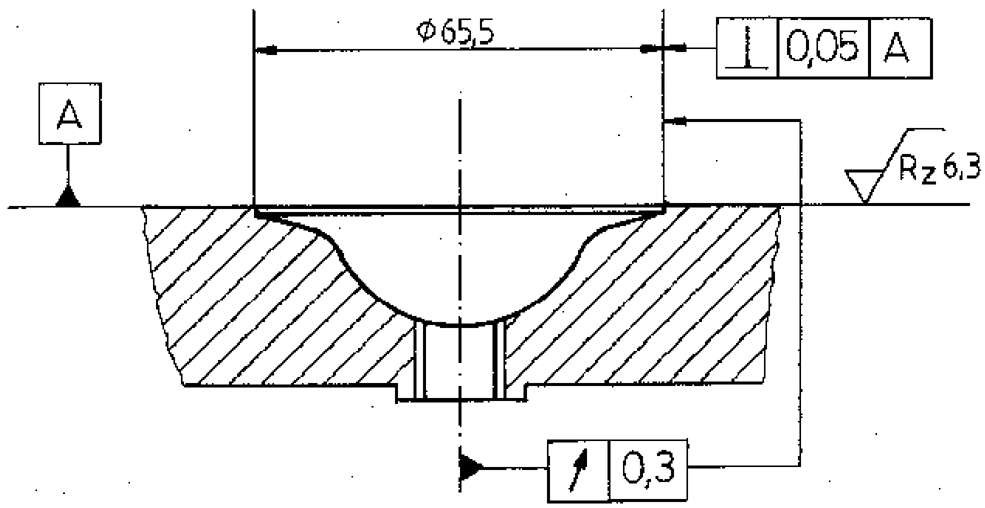


Figure 49: Cross-section of the cylinder head with rework dimensions

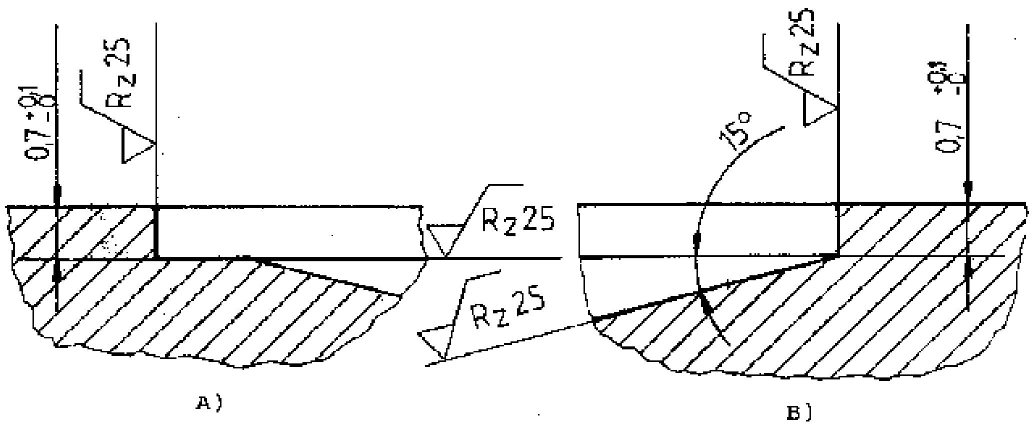


Figure 50: Reworked squish-area; A) The easy way: edge with 90° and 0,7 mm height. ; B) The better way: angle of 15° remains.

What is very important before the assembly is the finish of the cylinder head's joint face. It has to be absolutely fine ground otherwise it will be leaky (You will realize it when cooling liquid pours out of the overflow at full throttle operation).

At this point I'd like to dissuade from a too high compression ratio! If it doesn't result in immediate disaster you will shorten the lifetime of your crank and pistons extremely. An engine with high compression runs much hotter than a mildly tuned one and it is much more sensitive towards jetting faults!

In any case you should run 98 octane fuel (Super plus unleaded or Super leaded) in your engine. Stock RD's require 95 octane, unleaded.

Exhaust system

Porting

These modifications and the head milling are most important for optimum performance so just have an extra eye on performing this very carefully.

The most important constant for the point where the engine has its peak performance is the height of the exhaust port. If you broaden the port it will result in an higher engine torque but at the same rpm level. If you change the port height by one and a half mm it will change the max. performance rev by 350 rpm. A good value for the port height of any two-stroke in road use is half of the engine stroke (54 mm / 2 = 27 mm).

The exact formula for the tuned pipe length is:

$$L_A = \frac{\alpha_0 \bullet c_s \bullet 1000}{12n}$$

L_a: Length of exhaust in mm

α_0: Port opening angle in ° (Stock 193°)
c_s: Sonic speed in burnt gas (approx. 520 m/s)
n: Desired rev of max. performance (Stock 9200 rpm)

The port opening angle is 193° with 27 mm left to the top of the cylinder. In a stock engine the performance comes at 9.200 rpm which yields to the stock exhaust length of about 909 mm. This is almost the length up to beginning of the internal muffler (after the plate with the welded 20 mm tube). In a race pipe with a two cone design (one opening cone, a straight cylinder in the middle and one closing cone with a tube and muffler) the exhaust length is measured from the port to the middle of the closing cone.

At this point you have to decide whether you want to use the stock or race pipes.
Stock pipes (especially the 1WW) require a rather high exhaust timing to work; for race pipes the max. rpm is a critical value for reliability. If you combine that with a high exhaust, you easily create excessive rpms.

If you remove the stock “burrs” at the upper port edge you alter it by 1 to 1.5 mm (New height = 26 – 25.5 mm). This alters the point of max. performance from 9200 rpm to 9550 rpm.
In addition you can broaden the port by one mm at each side and grind the edges to chamfers and radii as shown in Figure 54.
This increases the flow rate and maintains the reliability of the piston rings.

Note: The main bottleneck with the RZ exhaust is too small blowdown area. So if you widen the port, you just focus on the area above the upper transfer edge which results in a trapezoidal shape.
A common rule for port width is to use not more than 70% of the bore. At 64 mm bore that's 45 mm; for overbore cylinders of 66 mm it's 46.2 mm.

Frits Overmars (Netherlands) is recommending the following port shape. In his concept the radius for the upper port edge is rather small (50'ish) whereas I already used radii in the 100 mm region.

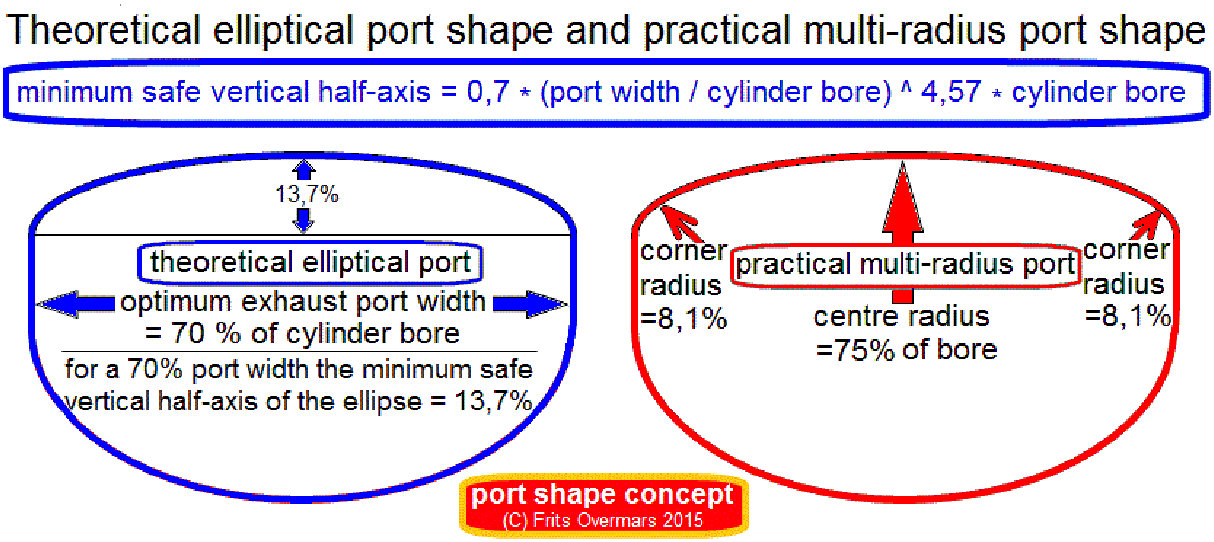


Figure 51: FOS concept for exhaust port (with 65 mm bore : exhaust port width = 45.5 mm, vertical half-axis = 8,91 mm, corner radius = 5,.7 mm, center radius = 48.75 mm)

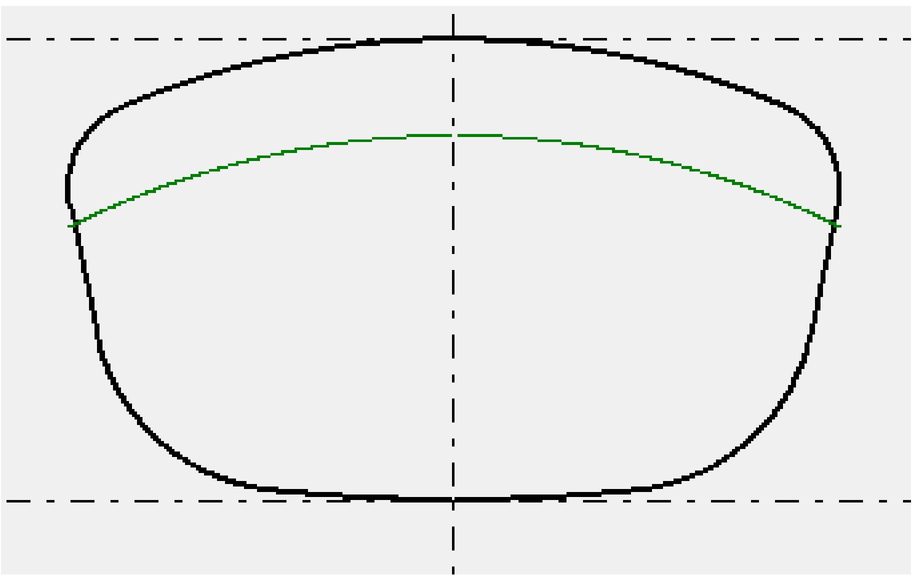


Figure 52: Port shape as seen from the Cylinder

After that you should remove lots of aluminum in the port to get a smooth way from the oval shape at the cylinder to the round form of the exhaust gasket (The 1WW cylinders are cast better, so you'll have less work here).

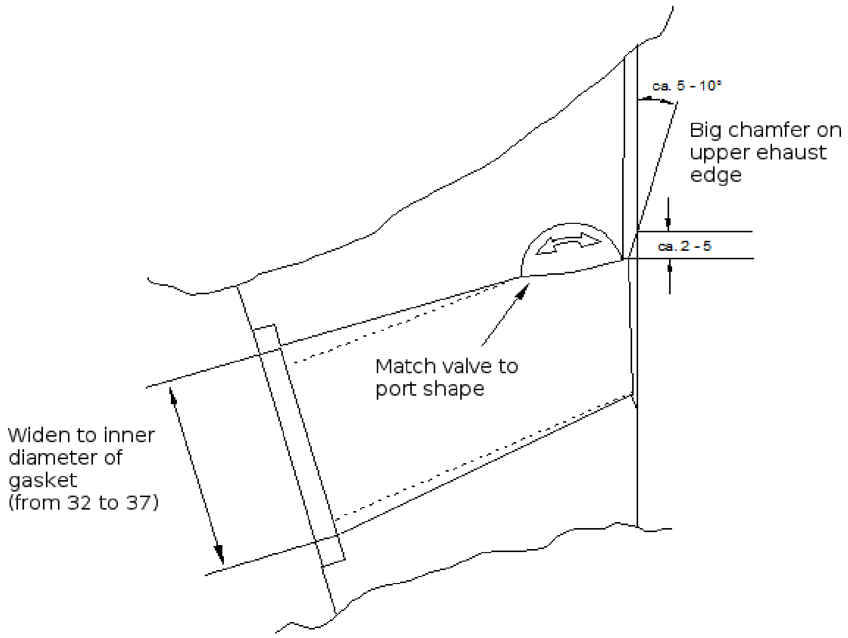


Figure 53: Cross section along flow way

When performing this point I should stress that it is very important that you have a close look at the power valves.
On the one hand they should fit perfectly into the port shape, but on the other hand this should be the same for both cylinders in mounted position!
To check this out I use either the engine block or the cylinder head. Mount the cylinders on a common joint surface (I use the cylinder head) and connect both valves.

> *Only in this configuration you can see if both valves fit well! After remounting the cylinders to the engine you'd check that the servo motor has driven the valves in this position after turning on the ignition switch. Just have a look at them before mounting the pipes, or if you prefer, feel them with one finger. If the position is not perfect you can adjust it with the cables.*

As a final operation it is important to polish all milled surfaces. I've used a small high speed drilling machine (Proxxon, Drehmel, ...), my special polishing shaft and lots of sandpaper (#60 to #1000).

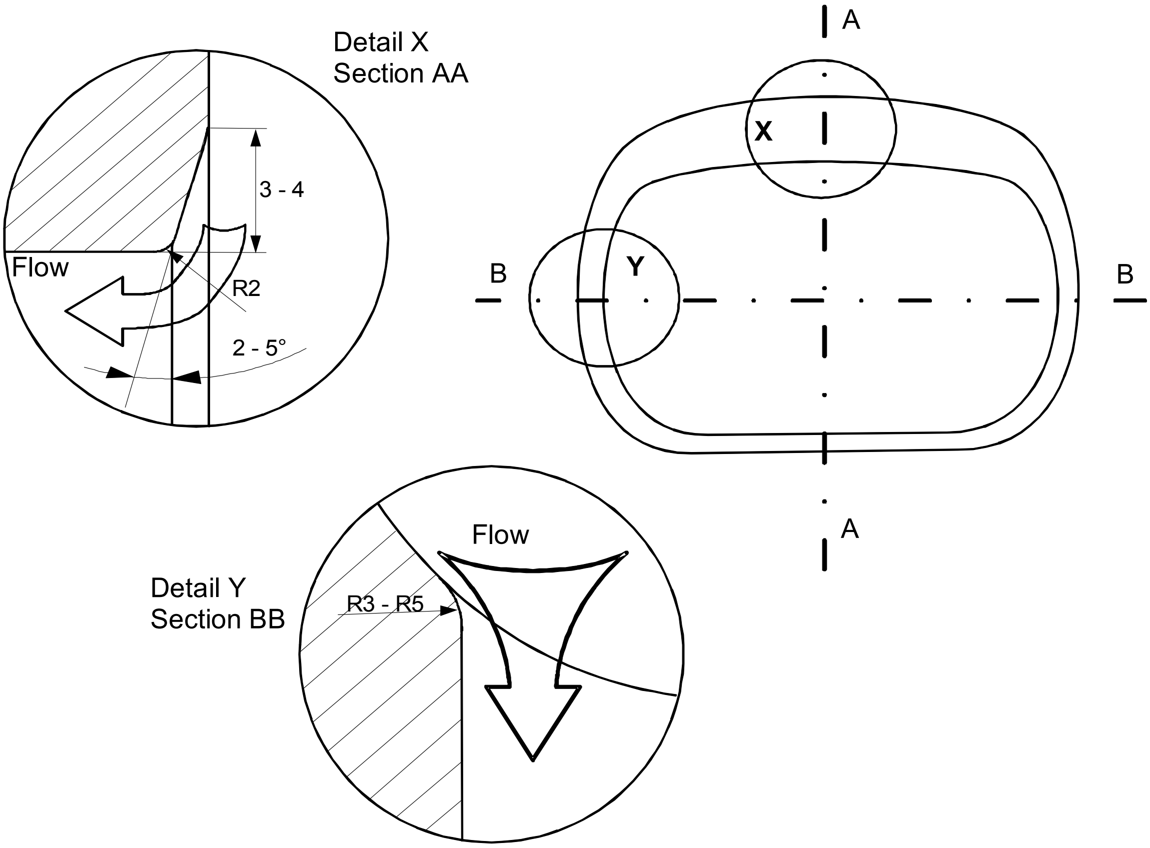


Figure 54: Details of chamfering and radii at port edges

Figure 55: Exhaust port machined and polished

Power Valve Bearings

In stock engines the power valve bearing bushings are built in with an O-Ring and MoS_2 grease. I prefer to “glue” them in with a silicone based sealing compound (Dirko from Elring).
First clean and degrease the cylinders and the bushings. Then grease only the bearing surfaces. The outer surface is treated with Dirko and then you can push the bushing into the cylinder. To complete the operation use Loctite for the screw of the quarter moon shaped holding plate (M5x12), because this is the first step for the O-Ring to lose its function. If you lose this screw the bushing will move, wear the bore and then oil and ugly sounds will get free.
The O-Rings are offered in two colours: black and orange. The orange ones are for the older models, but I use the black ones for the two inner bushings (They are slightly thicker and maintain a stronger hold).

You could also get those from an industry supply store as Viton-Rings in 31x2.5.
I used Dirko for a lot of engines and it always lasted. Manufacturer specification is 180 deg C, so if you get O-Rings, just check that they can endure a 180 deg C and you're save.


Figure 56: Inner power valve bearing bushings (Left: stock; Right: Emil Schwarz)

From Emil Schwarz you can get special bearings either with an integrated holding plate (about 150,- DM) or he converts them to roller bearings (about 300,- DM). These won’t come loose ever (I used it for more than 100.000 km and thanks to Dirko I never had problems).

Pipes

My personal attitude to most race pipes is that several companies make money with nothing but promises in exchange for turning your engine into a fuel-to-noise converter.
If you go that way, then pick one that at least increases performance, too.

As preface: The flanges of all pipes are fastened with springs and leak more or less oil. No matter if singe or dual tube, o-ring or whatever.
Everyone who tried to handle the springs with pliers and slipped off can share a painful experience.
Another point is the correct fit: Yamaha has tolerances and slight differences between the models. Depending on which bike the pipe layout was done it can happen that you need to dent the pipes to fit your individual bike.

The pipes that are on the market for the longest period are the Jolly Motos from Italy. They offer good midrange power and have max. performance at about 11.000 rpm. In a dyno test with 36 mm carbs they even revved up to 12.500 rpm!

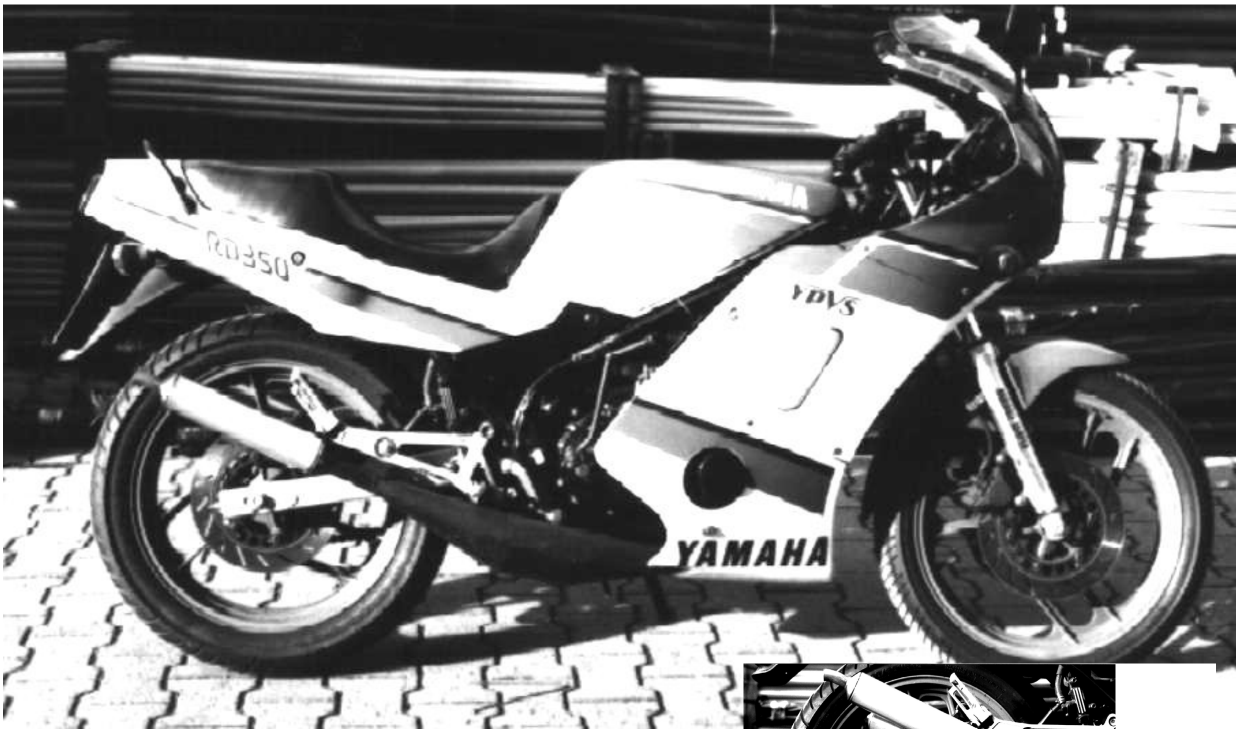


Figure 57: 1WW with Jolly pipes

They're made from mild steel and need some coating to prevent rust. Over the years there were a couple of versions available.
They're one of the few that are done in a GP version with both cans on the right side.
The low-end is acceptable and what is even more appreciated is the silencers offer good sound absorption. With closed Power Valves they are at stock level, when performing hard acceleration they become louder.
The fit is not perfect; you need to modify the side stand or use just the thin spring here. The main stand must be removed or you'd need to weld an end-stop at the left pipe.

Since 2002 you can get mild steel Pipes under the brand name Soni-X in Germany. They were developed by Marco Böhmer (www.sonic-speed.net) and the current version Evo III offers one of the the best performance results you can get.
The manufacturing quality is high (reinforcements, exchangeable stinger insert, EGT fittings); the price is still lower than a pair of Jollys.

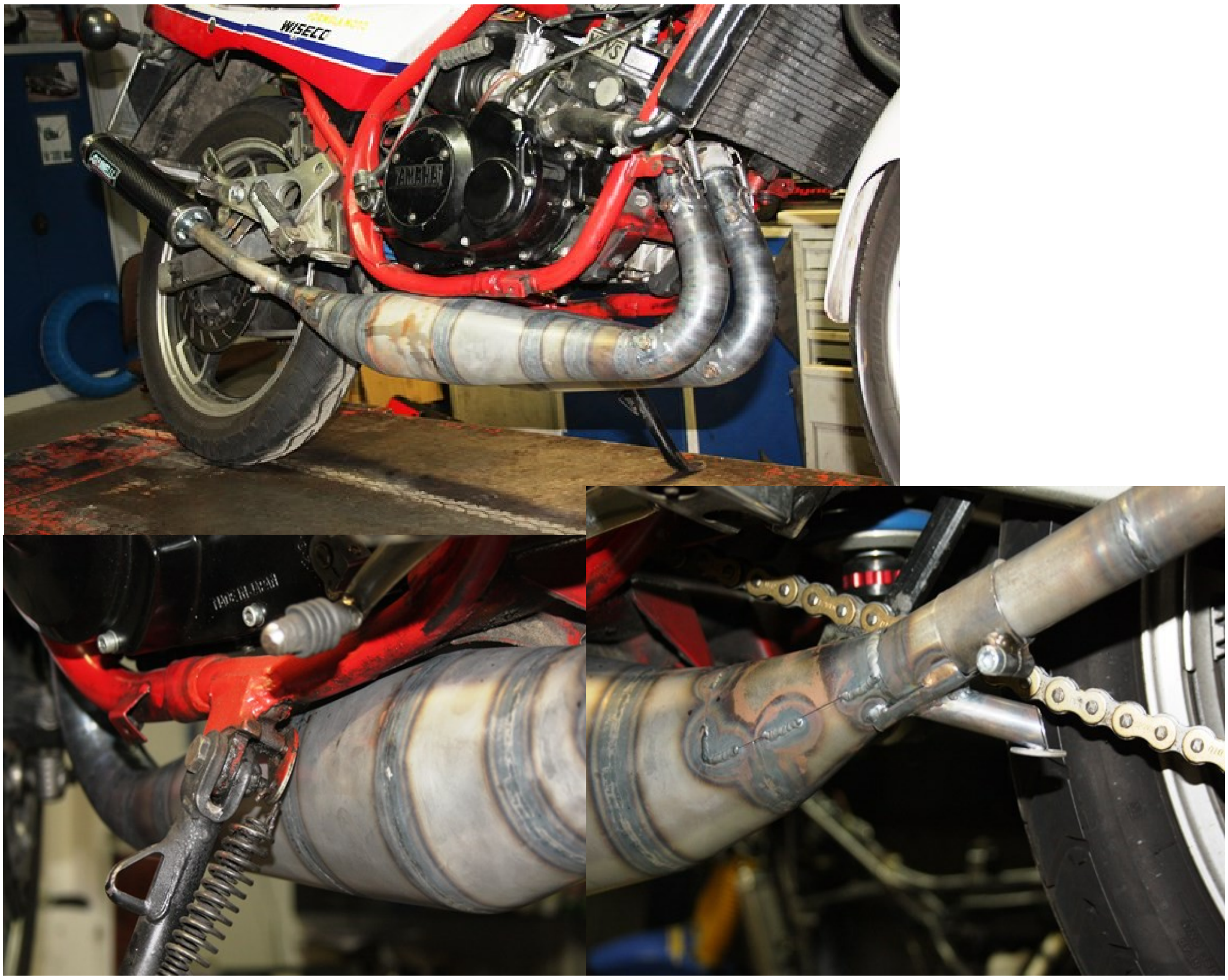


Figure 58: Soni-X Evo III

In 2013 the German Tuner www.dn-performance.de released RD350 pipes that nuked everything else on the market. They came with a really comprehensive pipe shootout that proved the first customer reports.
The best thing about them is that they're designed to cope with a broad range of RD's without additional work required. I had the pleasure to test-ride it on a bike meet. Pipes were swapped to a different RD and that one was riding very good. performance all over the rpm range, no ditch or whatsoever.
Unfortunately the first series had quality issues with symmetry of the cans and performance followed by a forum shitstorm. The owner of DN got pretty fed of that and is now only doing them on an individual base (i.e. bring the bike there for building and setup)

Figure 59: DN prototype (German RD rally in Lichtenberg/Erzgebirge 2012)

In the UK the TSA pipes from Ken Gubbins (www.twostrokeaddicts.co.uk) are well known. He does pipes for RD350LC and YPVS and customer reports as well as dyno charts prove the performance level.
His philosophy is not high revs, but good midrange and moderate peak rpm.
The specialty: Instead of mild steel he's using zinc coated steel which has a unique look and prevents rust. People were using them without coating.
If required, he also does stainless pipes.

As he is also an EngMod2T user, you can get individual pipes tailored to your application like high ccm kits or RD engine in Mito frame.

Figure 60: TSA pipes

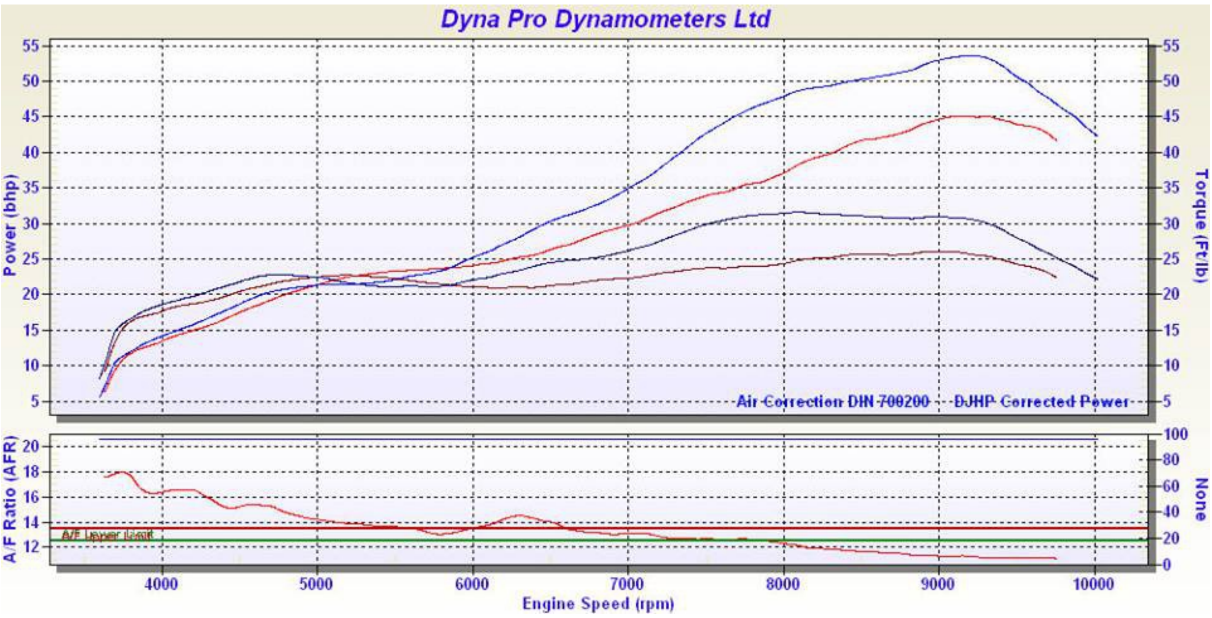


Figure 61: TSA dyno chart (before and after)

Since the early 2000's you can get JL pipes (www.jl-exhausts.com) in Germany. The owner Jim Lomas was famous in the 80's for his TZ pipes.
What I like most about them is the versatility. You can get them in mild steel, stainless with steel or carbon cans. A GP version and also a “classic” one called “Street-Retro” (looking like the old microns).

Figure 62: JL GP-Style pipes in stainless steel

All JL pipes have really beautiful welds but as they're hand cut they have deviations in performance. If you're lucky, you have one that works, but there are people who spend money on pipes that don't perform much better than before.
The peak rpm is much higher than stock which reduces crank life.

Figure 63: Micron Hypower (originally this was sold for the RD350YPVS but as you see it fits well to the RD 350 LC, too)

On the RD250/350LC the stock pipes are complete crap. Any other pipes will increase performance. As the fitting points are the same as on the other RD's the

31K pipes will fit. This is the most cheap and legal way to get more midrange power and about 500 – 1000 rpm more at the top end.

Figure 64: Silencer baffle 31K (with rockwool wrapping)

A small but noticeable improvement is possible with the stock 31K (and 4L0) baffles. If you wrap them at the perforated tube with mineral wool (or rockwool) and tighten the wrapping with some thin wire you will gain a slight increase in midrange power. Furthermore the sound amplitude and frequency is a little bit lower than stock.

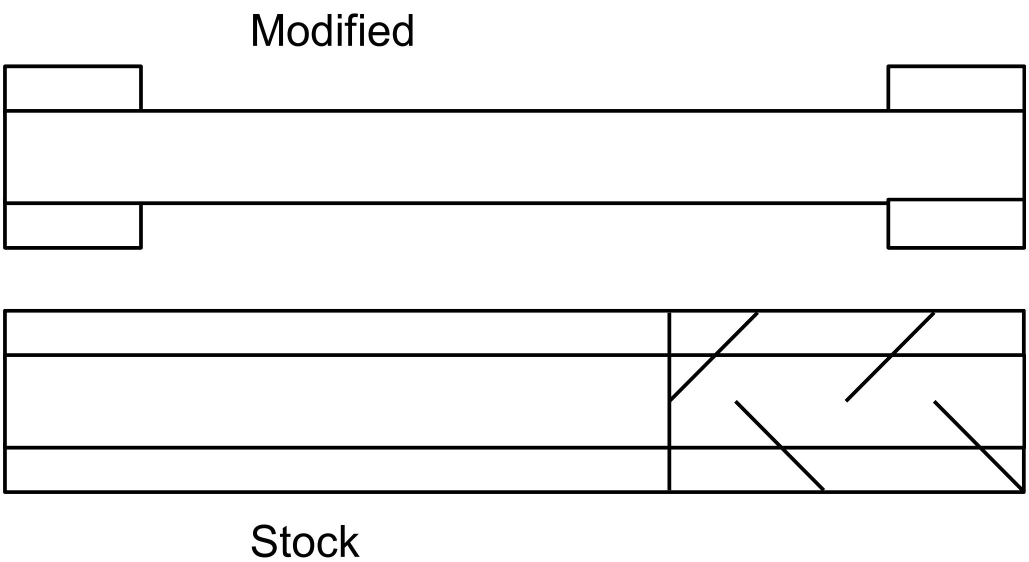


Figure 65: Silencer baffle modification 31K/4L0

Those of us who don’t live in restricted areas (like me in Germany) can build some new mufflers. Take a stock one as an example but leave out the labyrinth at the end and use a wider perforated tube of 22 mm diameter. When ready wrap the tube again with mineral wool and tighten it together with wire.
The new sound will be a little bit deeper and somewhat louder than stock. The performance result is convincing: Top- and midrange power is significantly higher which yields to faster acceleration and lower piston temperatures due to cooler exhaust gases.

The 1WW (aka F2) pipes cannot be modified that easily and furthermore a certain percentage of them restrict top revs to 8.500 – 9.000 rpm. From experience I found, that bikes which formerly had good performance and top revs of 9.500 rpm lost about 500 rpm over the years. When mounting 31K pipes everything was ok again. Your 1WW runs like a 125 and you’ve already checked everything twice? Don’t go nuts, read this:

The reason is production finishing accuracy for the “diameter” 20 mm of the little tube at the end of the closing cone. This tube is formed by the two halves of the pipe which are put together in a welding jig. The cross section shape is not a circle but a hexagon which cuts off some area compared to the desired round shape.
The positioning and welding process has certain deviations. So there are pipes with a wider tube which are “good” and there are pipes with a narrower tube which restrict power. If there is carbon build-up over the years a “good” pipe can turn into a “bad” one due to the narrower cross section area. I’ve seen pipes with a one mm thick carbon coating inside this tube! Anyway even the YAMAHA stock dimension of 20 mm is too narrow, so I’d advise anyone to widen the tube as follows:

Carefully cut off the silencer near the welding (check 1WW pipe drawing in appendix). Take an arbor of 22 mm diameter and drive it into the tube with a heavy hammer (I named my device “anal intruder” ...). Another possibility is to use a long enough screw with a M22 thread and a welded T-bar at the end. After driving this into the tube you just have to screw it out.
After performing the widening you have the choice of using the stock silencers or other ones. I’ve tried both and both were working well.
If you use the stock silencers, the bike will stay quiet and you will gain significantly more mid-and top-range power. How significantly depends on your starting point, but you’ll be amazed how “good” “bad” pipes can become ... .

But caution: Whatever you do to the F2 pipes, they'll always be critical on WOT operation. You either have a problem with the carb setup (i.e. performance lacks) or it's melting pistons like mad. If you have that a lot, then you're better off using race pipes.

Pipe building

This chapter deals with all aspects of twostroke pipe manufacturing and is intended to encourage anxious people to give it a try.
I started this on 2011 as a complete autodidact and since then I successfully build half a dozen pipe sets for RD350 & RD500.
As I distributed lasered parts to fellow enthusiasts, I hopefully infected more than a dozen people allover Germany.

Intro

The described pipes were tested on 4 RD's on which I had first hand experience and all of them made about 66 – 70 rear wheel HP (Ignitech, 30 mm carbs, headwork, porting). Just for comparison: a stock RD has 45-50 rear wheel HP.

In Germany it was possible to get the pipes TÜV approved and thus road legal. If you keep the airbox and use Aprilia RS250 cans the drive by noise was 82 dB – 2 dB less than tolerated!
The costs for testing & paperwork were about 250-300 Eur.

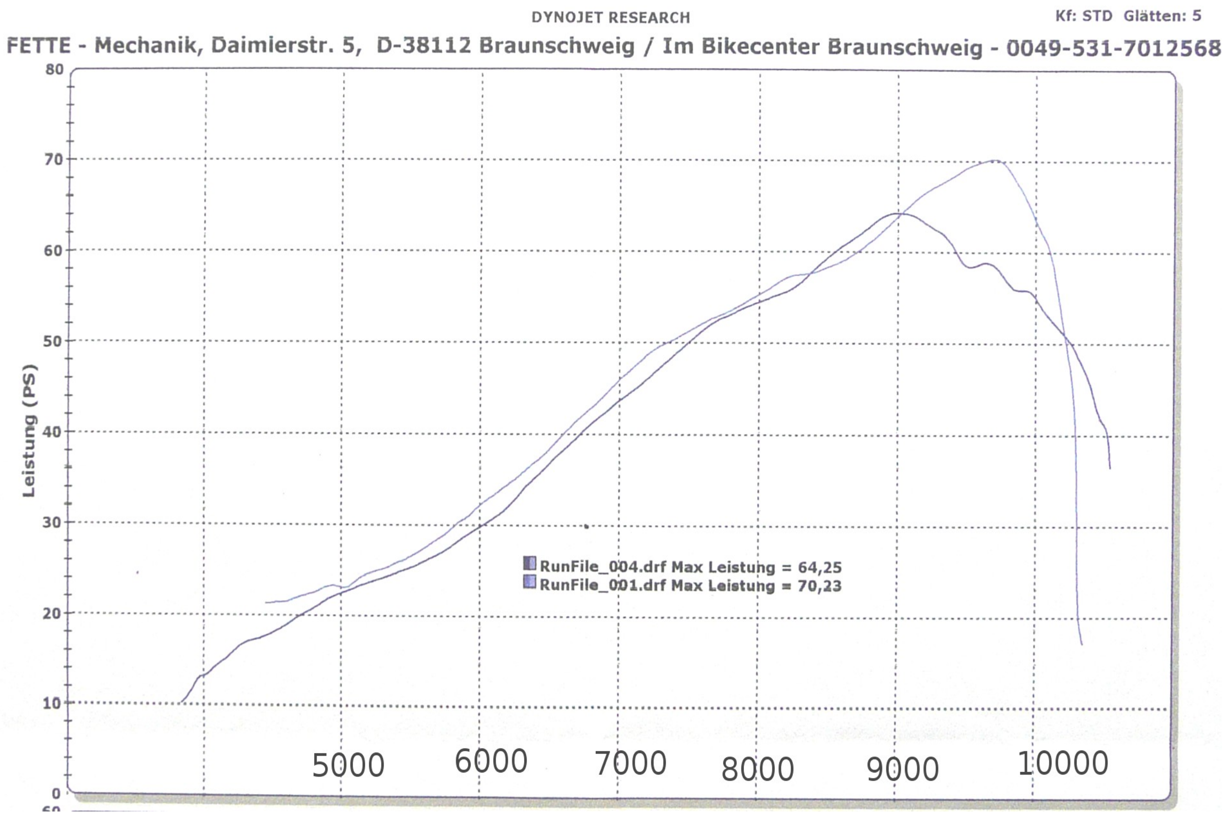


Figure 66: : Dyno curves of DIY pipes (2 RD350YPVS from 10/2011)

If you want to start pipe building you'd need the following lost of tools

- Computer/Software for layout/printing the angled cones
- Suitable welding device (preferably TIG)
- Suitable welding rods (diameter close to sheet thickness)
- Welding helmet with automatic visor (as you need both hands to weld)
- Tin snips (preferably electrical)
- Slip roll
- Belt or plate sander
- Rods with welded spheres in different sizes
- Hammer, plies
- Emery cloth #60 ... #120
- Blueprint paper, drawing board
- Training sheet material (flat and rolled)
- A lot of gas (a set of pipes needs about 10-15 l of Argon)

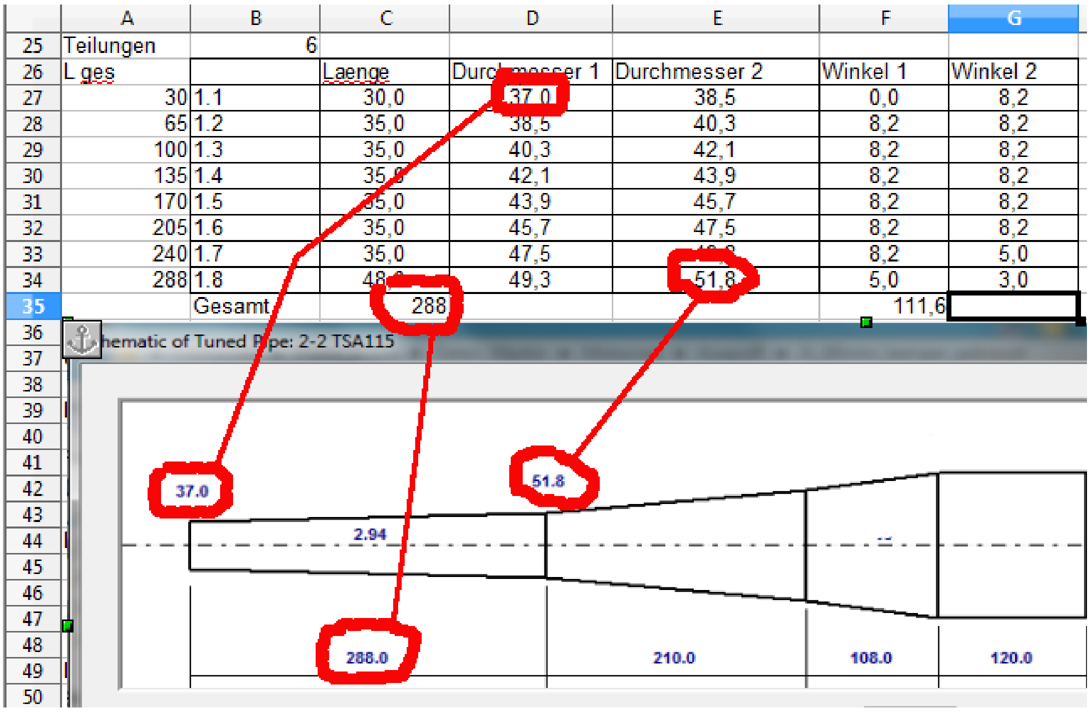
Concept

At the beginning you have the problem of getting “good” pipe dimensions which I solved by using “proven” dimensions and just modify them to my needs.
In the simplest case you measure them on existing hardware (I call that the “Chinese parametrization”). My first try was a JL that I made with some longer sections to reduce peak rpm.
Other methods are to search the net if other people would supply their dimensions or get a twostroke simulation software and try own designs.

At the beginning this basic layout is straight and you need to divide it into shorter cones with angled joint faces to create the desired bends.
One suitable method for a first paper layout is the following:
Get a thick copper wire (2.5 mm ground wire) that has the straight length of the pipe and bend it into the desired form using the bike as a jig.
In the luxurious form you use small cardboard circles taped to the wire at the appropriate position to give you a hint for the outer shape of the pipe.
This 3D for can easily be transferred to paper and there you can measure the necessary angles.

Example: The header ought to get a length of 288 mm, so you mark that position on the wire. You measure the angle of the tangent at that point to the starting tangent of the wire (at the cylinder). In my case that was some 111 deg.
Now you decide how many segments you'll use. As a rule of thumb you should not exceed 20 deg per seam.

In our example that would be a minimum of 6 segments but I chose 8 because a smaller included angle yields into a smoother shape which is somehow important for optimum performance (I have information that it's worth a 1.x hp in a 50 hp engine to carefully smoothen the header)
Now you use a spreadsheet and the intercept theorem to calculate each segment start/end diameter and length. If your math skills are a limitation you can still draw the full straight cone on a piece of paper, draw 90 deg intersections at the appropriate positions and measure the diameters of each segment with a ruler.



	A	B	C	D	E	F	G
25	Teilungen	6					
26	L ges		Laenge	Durchmesser 1	Durchmesser 2	Winkel 1	Winkel 2
27	30	1.1	30,0	37,0	38,5	0,0	8,2
28	65	1.2	35,0	38,5	40,3	8,2	8,2
29	100	1.3	35,0	40,3	42,1	8,2	8,2
30	135	1.4	35,0	42,1	43,9	8,2	8,2
31	170	1.5	35,0	43,9	45,7	8,2	8,2
32	205	1.6	35,0	45,7	47,5	8,2	8,2
33	240	1.7	35,0	47,5	[illegible]	8,2	5,0
34	288	1.8	48,0	49,3	51,8	5,0	3,0
35		Gesamt	288			111,6	

Figure 67: Layout-Spreadsheet

Caution: Each mating surface MUST have the same angle on each side. If you cut a cone at an angle you get an ellipse and that will be different for different angles. If the joint face shape and length is different you'll have a very hard time in welding that together.

At this point you have all the necessary cone angles/lengths and would just transfer them to cardboard.
The cone layout can be easily done with the freeware “cone” from www.pulsrate.com. You enter the dimensions and can print out the developed view (i.e. the “flat” cone outer surface). Then blueprint it to cardboard, bend cones, glue/tape them together and test if the “proto-pipe” fits the bike.

Figure 68: Header Yamaha RD350 and paper model

The desired 3D direction of each section can be varied if you rotate the cones against each other.
Here cardboard has the advantage that it's much easier to cut & glue/tape if you need to fine tune some angles to make the fit better.

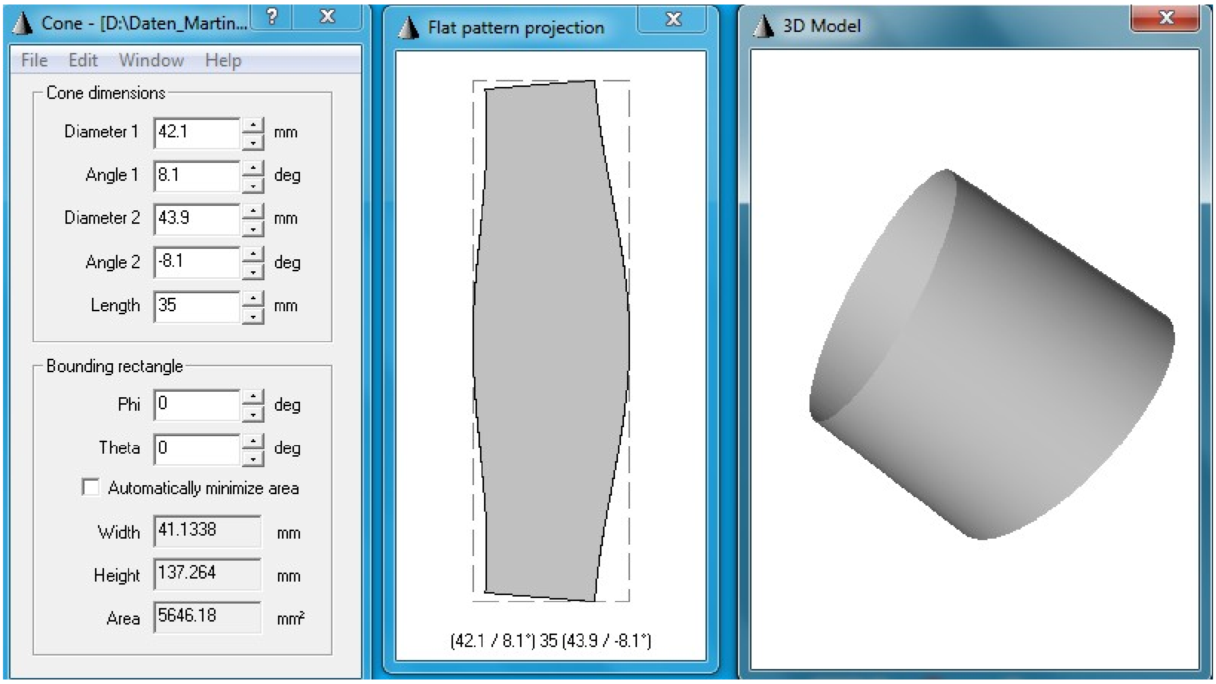


Figure 69: Screenshot cone Software

Figure 70: Pipe concepts in paper

The pipe routing is not the only constraint you have to follow. Often things like side stand or suspension linkage have to be avoided

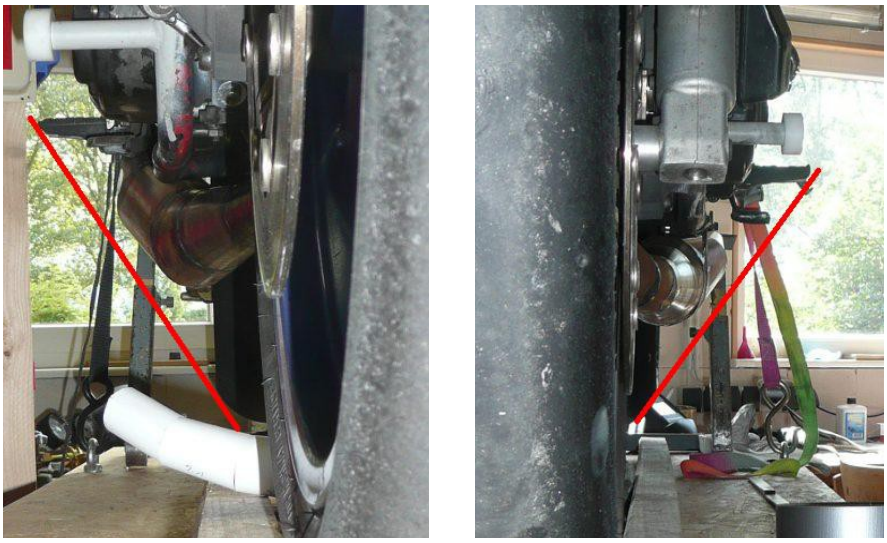


Figure 71: Don't forget to check the cornering clearance !

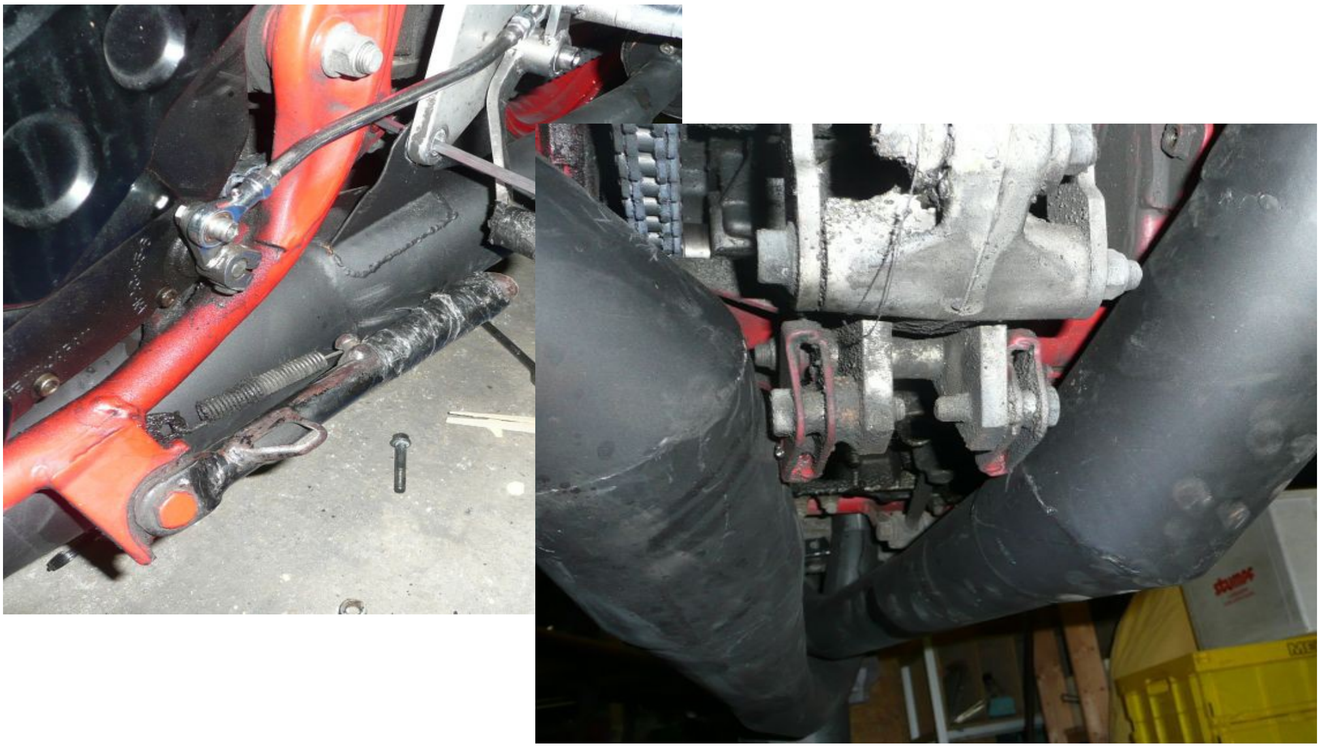


Figure 72: RD350 problem zones

Sheet metal work

Now as you have the concept you have two ways to get the parts in sheet metal form
1) Export dxf files with cone and have them laser cut
2) Print out the cones and transfer the shape to sheet metal and cut it out with tin sips

#2 is pretty easy as you already did that with cardboard. Just exchange that with appropriate sheet metal. You need to cut out the shapes very very carefully because every little gap between the cones will need additional reworking or creates holes during welding.
The straight edges on each cone must be dead straight for the same reason. It needs to fit without any gap after rolling the cone.

#1 may be pretty expensive if you handle each part separately. For that reason I negotiated a 365x365 mm layout with my laser workshop that carried several parts in it. The contour was done as open cuts; i.e. I used a CAD package to create small (1mm) connections between the cone part and the surrounding.
The Software “DraftSight” is available from Dassault in a free version for private usage.

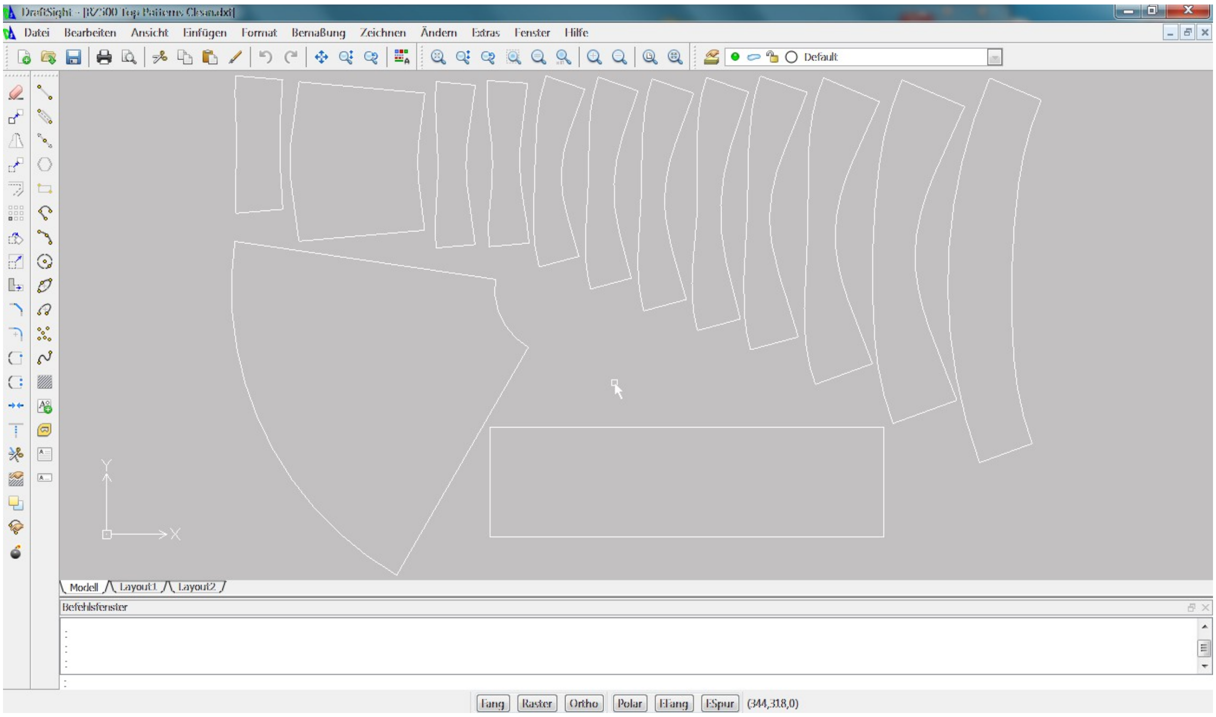


Figure 73: Screenshot DraftSight

Figure 74: Hand cut cones

Figure 75: Laser cut cones

In both cases I prefer DC01 material (deep-draw sheet) in 0.8 – 1.0 mm thickness. This is easy to cut, roll and weld. The finished pipes are stiff enough and still very lightweight.
Example: The JL for the RD350 had approximately 5 kg, my DIY version had 5.5 kg. Stock pipes weight around 11 kg.
Stainless steel of equal thickness is much harder to bend and what's worse: you need to bend more that the end-condition as it springs back a noticeable amount.
In addition the puddle is "more liquid" than with mild steel which one one hand gives you very nice welds but on the other a higher risk of holes.

Manufacturing the cones requires a slip roll which is available for around 150 Eur on ebay.
This device consists of three rolls, two that guide and drive the sheet material and the third that adjusts the bending radius. The upper of the two front rolls is adjustable to cope with different sheet thickness and it can be driven by a handle which transports the sheet when rotating.
You adjust the third roll to create a slight bending and repeat that in several steps until your cone couture is closed. Note that you may need to adjust a slightly higher bending (i.e. cone ends overlap) because the material "springs back" when releasing the cone from the slip roll. This effect is higher with higher material stiffness (stainless, titanium).

The more conicity is required the more difficulties you'll experience when rolling the cone.
Parallel rolls create a cylinder and not a cone. This is accomplished a) by different setting at each end on the adjuster roll (i.e. you misalign it deliberately) or b) by manually re-adjusting the sheet direction while it's being pulled through the rolls. In the latter case you try to hold the outer surface perpendicular to the driving rolls.
This can be very difficult with huge parts with large difference between start/end diameter (like the last cone of the pipe that had 103 and 30 mm diameters in my application).
Here I used the help of some plies to hold back the small end and let the big end being pulled through faster. Adjusting the driving roll very tight helps to develop more torque here.
The second way to skin the cat is to additionally push the side with the large diameter by hand. This feeds the material faster on that side which has the same effect than slowing it down on the other side with plies.
If you prefer that method you may loosen the thickness adjustment roll in order to ease the manual pushing.

As an ideal result the cone is all the way round and the mating edge matches or is at least close and parallel.

Figure 76: Slip roll

Figure 77: Rolled raw cones

Welding technique

Welding thin sheet can be done wit a couple of methods like MAG welding or acetylene. My absolute favorite is TIG (tungsten inert gas) because of the plain welds, it's clean and silent and compared to acetylene/oxygen the argon is cheap stuff.
For rookies I'd recommend weldingtipsandtricks.com as a how-to reference.

As an example they encouraged me to let the needle stick out much more (like 5-10 mm) that you usually find in the literature (2.4 mm for a 2.4 mm needle). With this method you still have nice welds but you can see the puddle area much better.
Same applies for holding the torch. Most people stay with the standard position as you need to press the button to switch on/off
For example I had cases where I held it like a big felt pen in connection with a remote control (foot pedal).

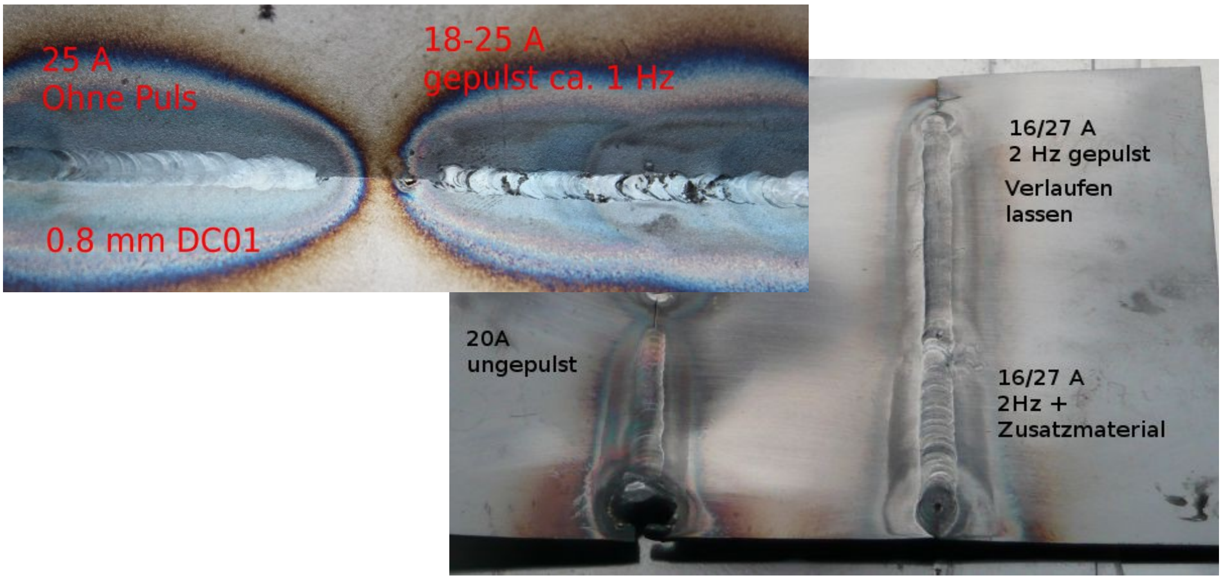


Figure 78: Material samples

Before you start to fuck up your valuable rolled cones, you should test your necessary machine settings and welding technique on some flat sheet material. Here the holes don't matter ...

The main welding parameter is the current. For my machine it was around 15-34 A, partly pulsed between a valley and peak current.
Mild steel (DC01) preferred a constant current whereas stainless wanted it pulsed.

At first I used needles of 2.4 mm for everything which gave not too bad results (and you didn't need to change the needle when welding other things than pipes).

Later I ended up with 1.6 and 1.0 mm needles as they reduce the width of your welds and as a result it looks more elegant.
After a lot of trying my favorite needle material for steel sheet is WL15 (gold color).

On higher quality welding machines you can adjust 2 cycle and 4 cycle mode.
2 cycle: Press and hold torch button = arc active ; release button = arc off
4 cycle: Press & release torch button = arc active ; Press torch button again = arc off
I prefer 2 cycle to tack things together and 4 cycle for longer welds. With the 4 cycle mode it's easier to hold the torch differently as you're not forced to have the thumb on the button all the time.

As we talk about quality: Cheap welding helmets filter a fixed intensity of light which is designed for standard welding operations like steel with 100 A. If you weld with just 15 A, you may want to see more and better pick helmets with adjustable level.
After using a cheap one, I ended up with a Speedglas 9x series helmet.

As a welding gas I used Argon 4.6 with a flow rate of around 5-7 l/min with jets between 5 and 7
For stainless or titanium you'll need a gas lens which is available in different sizes. No matter what you wife says: Up to my experience in this case size matters!
Rule of thumb: The bigger the gas lens, the better you keep oxygen away from the hot zone and the prettier the weld.

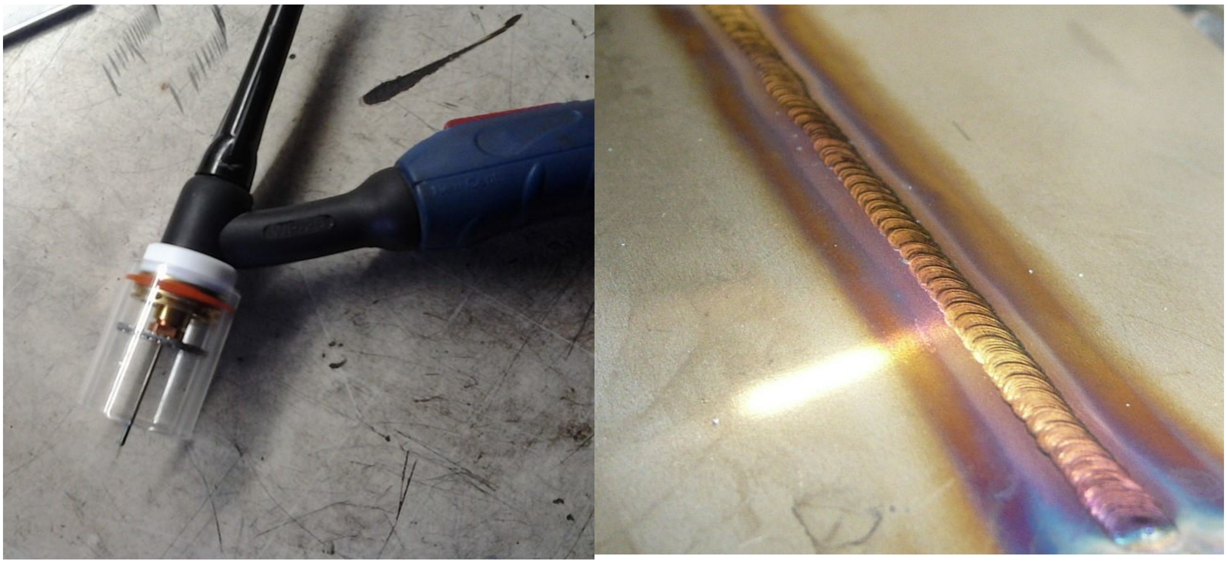


Figure 79: Gas lens XXL and stainless test sheet

Very important for both of these materials is the so called purging (i.e. techniques to keep oxygen away from the back side of the welding seam).
If you don't do that with stainless, the backside develops a structure that looks like cauliflower which is the starting zone for cracking.

If it's in the header area, it'll have a negative influence on performance and you'll have to grind it down.
There are a couple of professional ways of purging like gas, paste, tape that are all very expensive. For the DIY'ers it's the easiest to get a simple T inside the gas line and flood the welding object with Argon from the inside.
A positive side effect is that even the front side of the seam benefits from purging. It's smoother and the annealing colors are less distinct.

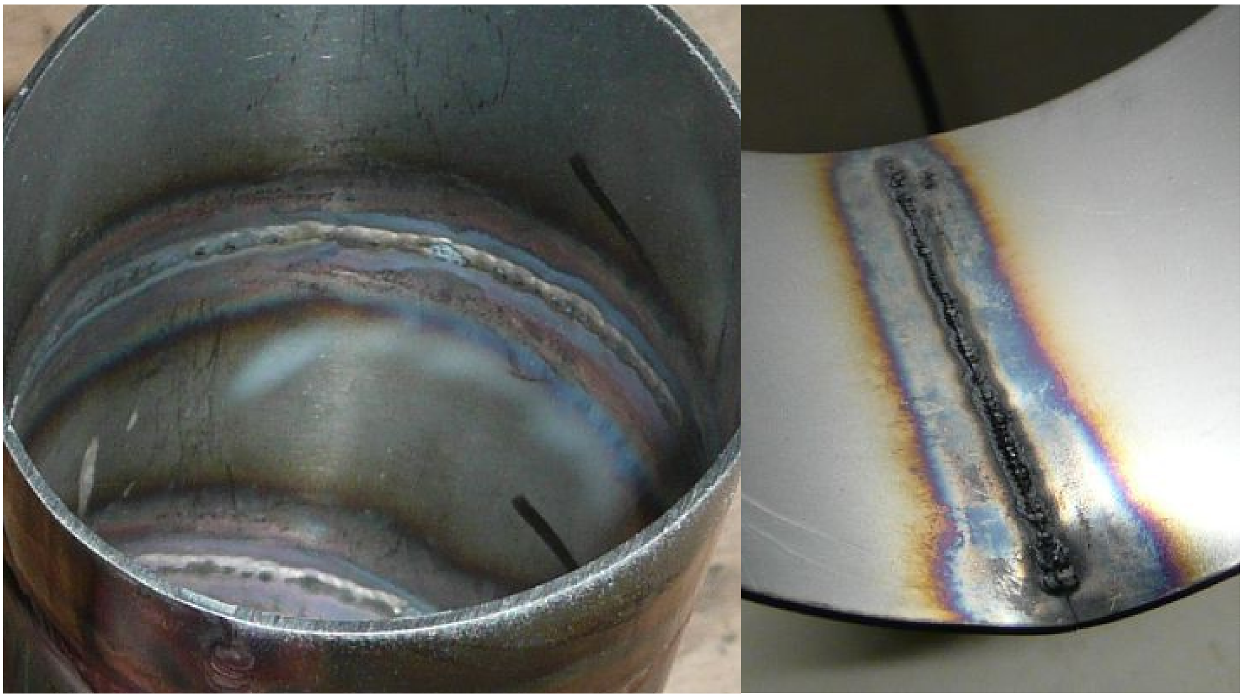


Figure 80: Inner side with purge gas (left) and “cauliflower” without purging (right)

Just for curiosity I got myself some titanium sheet for testing as you always read it would be so difficult to weld.
If you ask me I'd rate it even easier than steel or aluminum as it “flows” very nicely and builds up pretty welds without much effort.
The important thing here is to check for signs of overheating (deep blue annealing color). This initiates changes in internal material structure that'll promote later cracking in that region.
Practical hint to reduce costs: Titanium rods will cost you a fortune. If you have sheet material left, just cut it to thin stripes and you have short rods for free ...

The main trick with all thin sheet material is seam preparation over and over. Your target is absolutely no visible gap.
Every visible gap will result in a hole that needs to be filled later (which costs a lot of time and doesn't look very nice). So better spend your time on preparation than on filling holes.
If you require small drops of rod at some locations I used very thin stuff like 1.6 mm.

Figure 81: Header in titanium

For tacking a cone I put them on a flat surface and press it along the circumference to match the longitudinal edges first. Then I tack it two times for short cones and multiple times for the bigger ones (about 1 tack per inch).
After that I put it on a mandrel, hammer the seam flat & close and do the final welding. Leave some mm at start & end, otherwise you'll fabricate ugly holes (you'll finish that later when putting the pipe together)

Now I use a flat belt grinder or a DIY plate to create exactly flat mating surfaces between the cones. (#80-#120 sand paper was just fine)
In order to connect the single segments I match the contour as good as possible and tack it where the match is best. After that I hammer the seam to create a perfect match on the whole length of the later weld.

The best way to hammer these round structures is a DIY mandrel where I used a 30 mm rod and welded/screwed different spheres at one end. You position the seams to be exactly over the sphere, the other end goes into the vise and you have a fine “anvil”.

If you position the cones, try to avoid cross-joints as they'll likely result in holes. Instead you can rotate the segments slightly for just a few mm offset.

After that preparation you can weld without any additional rod. You just pass the torch over the desired area with an appropriate speed. I try to weld as long as possible in one operation (without having to stop/restart) because that way the annealing colours are the most even.

Figure 82: DIY grinding plate

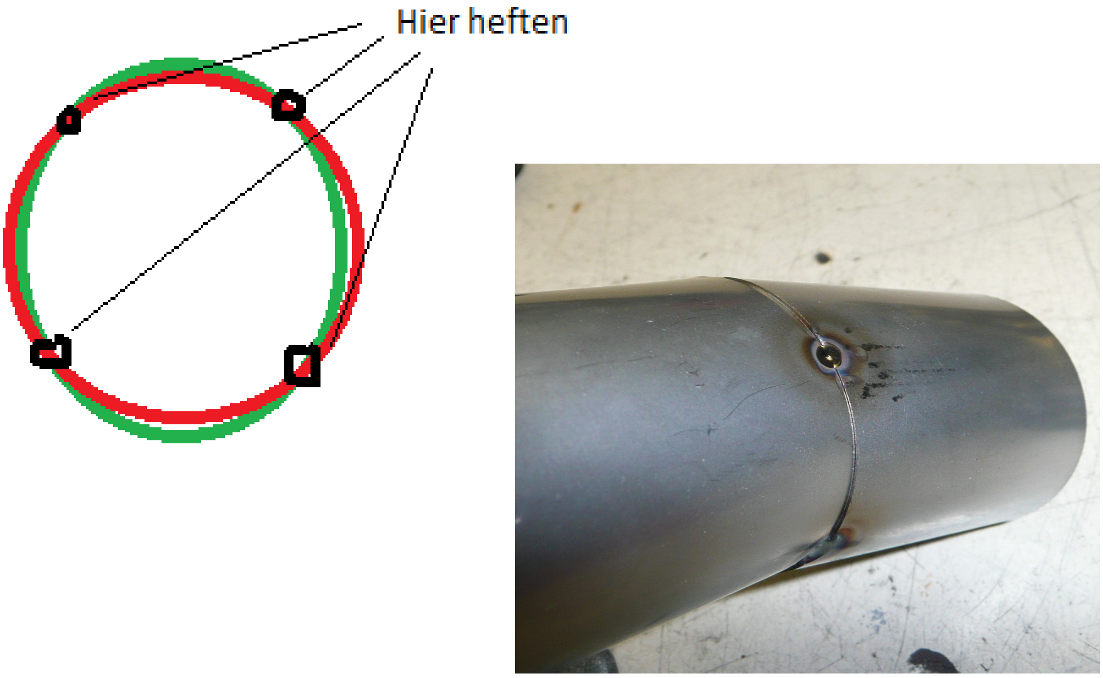


Figure 83:Tack segments at “best fit” locations

Figure 84: Hammer after tack-weld and desired perfect (=gap-less) seam.

Figure 85: Mandrel for hammering round seams

Figure 86: Finished weld before and after hammering

To have a reference, I start at at the first segment of the header with the flange part not attached. So you can fine-tune the later routing and at the end you finally fix the flange-part.

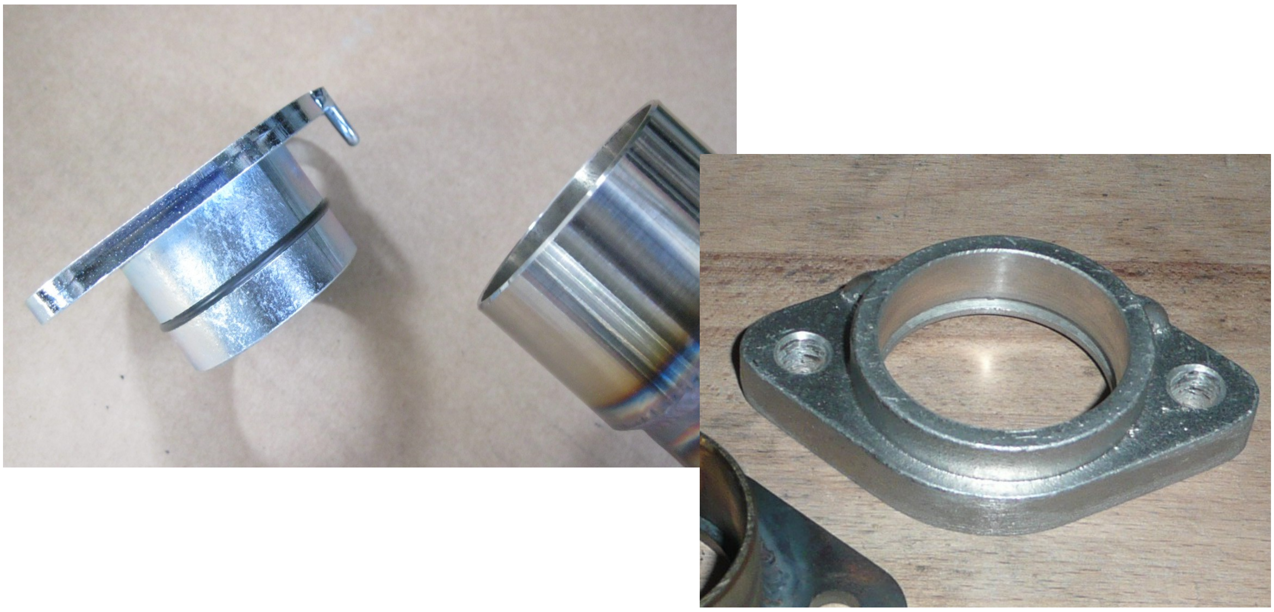


Figure 87: Cylinder flanges with O-Ring (left: JL, right: Jolly Moto)

Figure 88: Cylinder flanges (DIY)

For he flanges it's the easiest to buy off-the-shelf units like JL and Jolly Moto offer.
For around 25-30 Eur the Jollys are made from aluminum and have an o-ring.
The JLs come with a single + o-ring or double tube (design changed from time to time)
My own version was a single tube without o-ring that used silicone seal agent.
All flanges attach the pipe with at least 2 springs. You need that to de-couple the pipe from the engine vibrations. If you directly weld the pipe to a flange it'll develop cracks within a short period of time.

With the above method the pipe would grow from the front to the back. On the last cone you'd have the issue that you couldn't hammer the seam after tacking as you can't use the mandrel through the small stinger opening.
Even worse: The big diameters don't match that good anyway and they warp if you weld on the other end. Consequence: You likely will need to add some rod and the weld will look worse compared to the rest of the pipe. And that in THE region that visible the most.
I solved this dilemma by leaving out one weld at the end of the header (or one of the first expansion cone parts). Here the diameter is half way small and thus can be

welded later without the above negative results. For the following parts you continue to weld.
This leaves an opening in the pipe for the last cone where you can preprocess the seam in the necessary way.

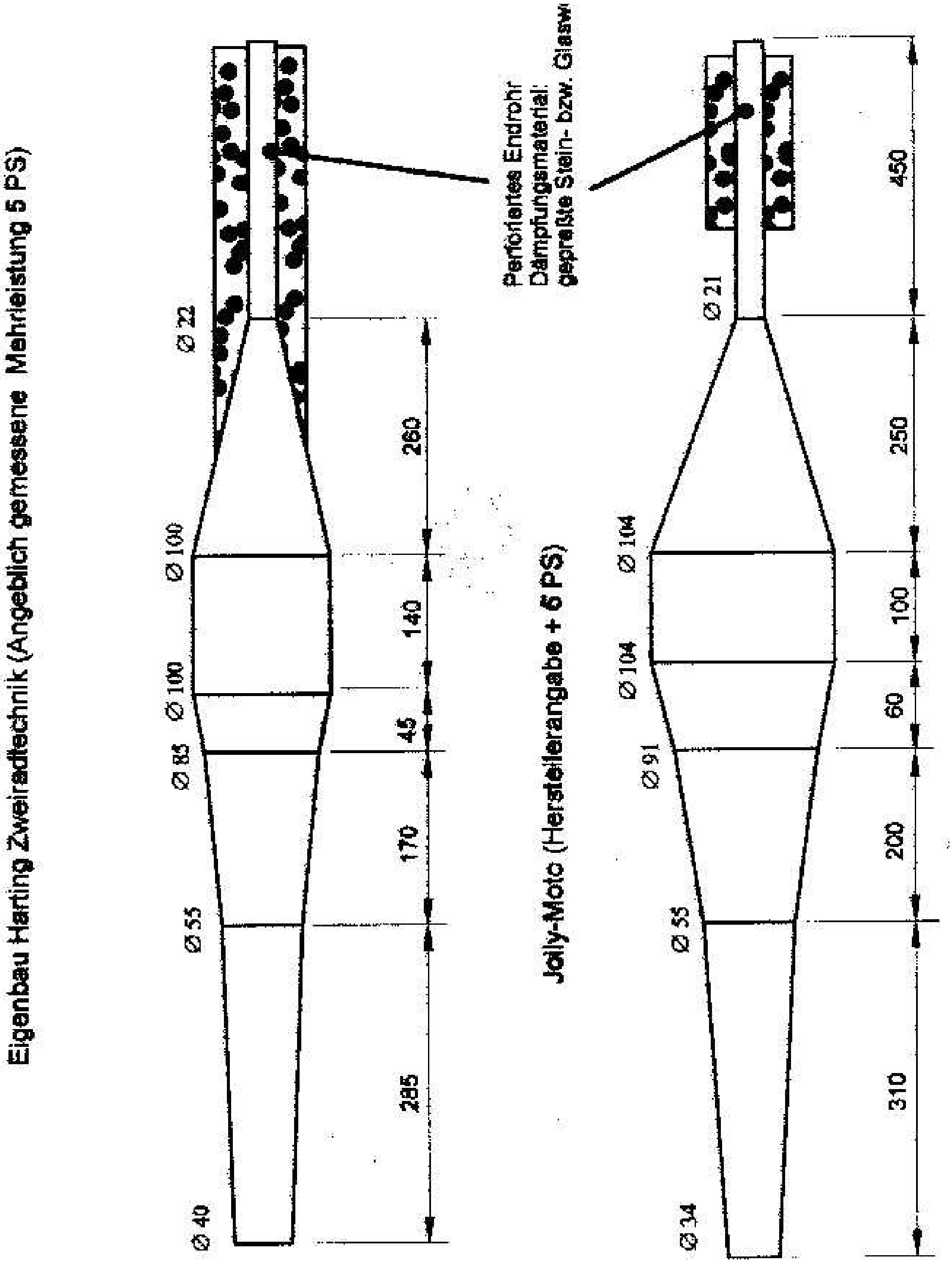


Figure 89: Pipe dimensions Harting and Jolly-Moto for RD350YPVS

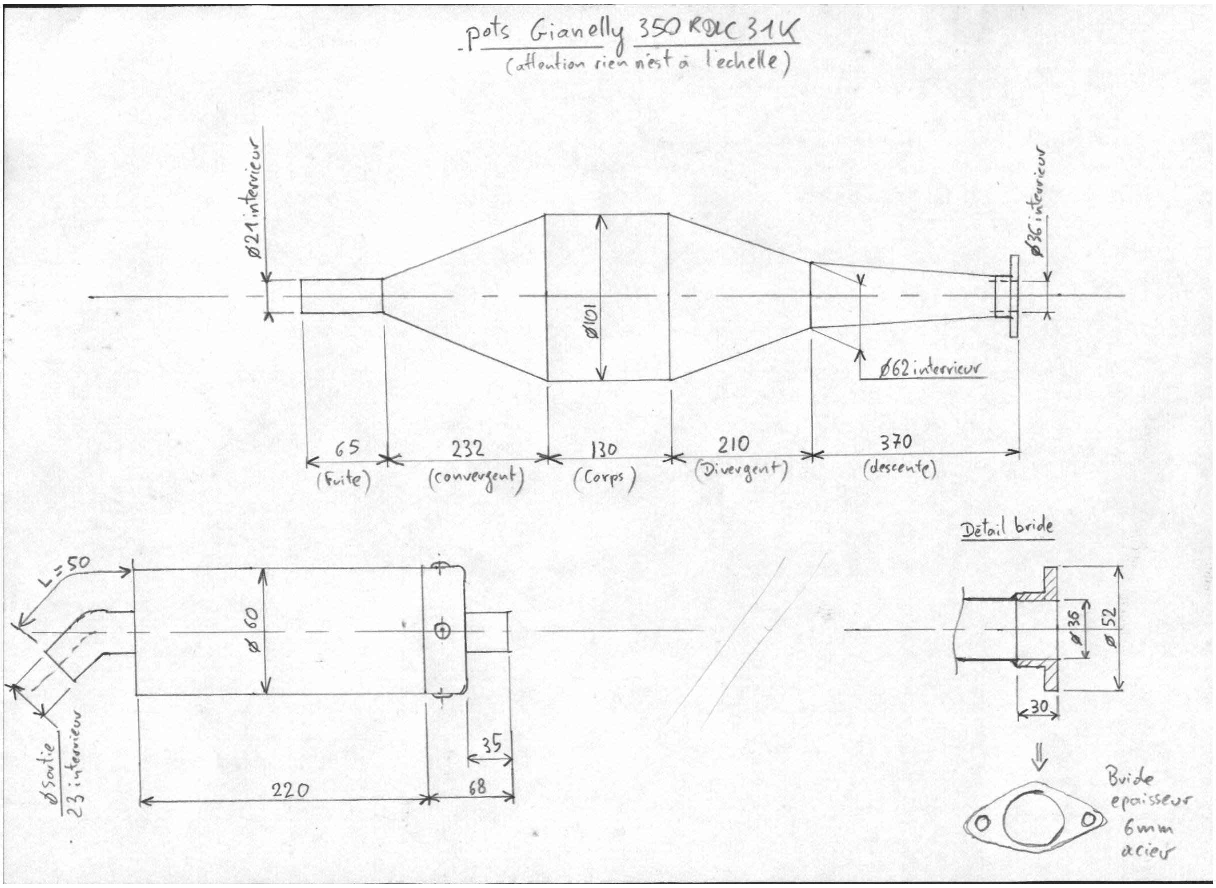


Figure 90: Dimensions Gianelli for RD350YPVS

Figure 91: Crossed layout DIY pipes

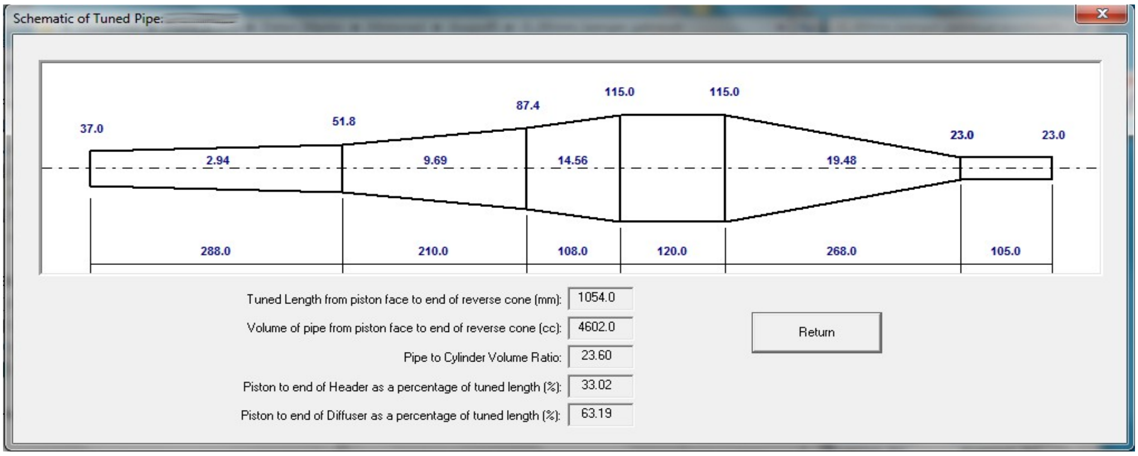


Figure 92: Dimensions DIY for RD350YPVS

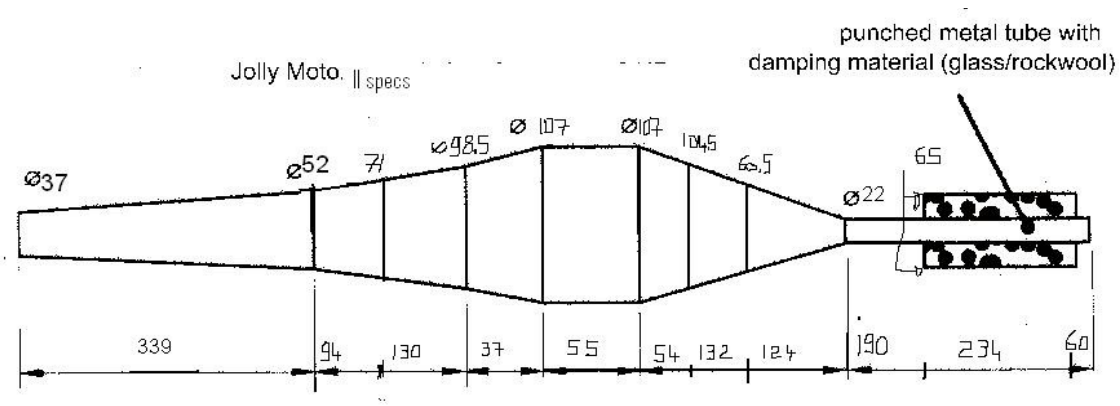


Figure 93: Jolly Moto II für RD350YPVS

As a starting point for own experiments you cam use the following approximation formula from Frits Overmars (Netherlands).

Caution: The stinger is VERY small here and Frits himself is making the restriction that the engine needs to be thermally sound (i.e. water cooled and healthy jetting).

With that formula you end up with 18-20 mm for the RD wheras I use 22-27 mm.

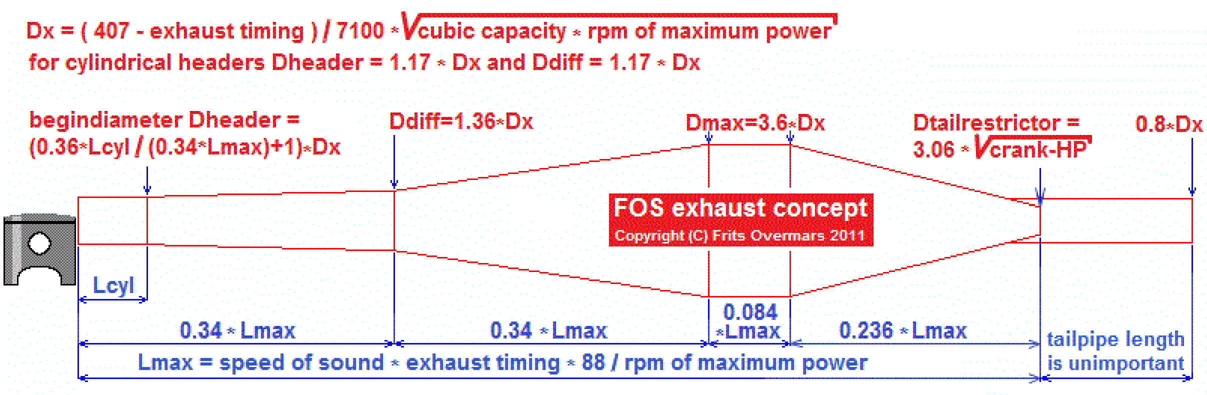


Figure 94: Frits Overmars pipe concept

Cooling System

Most of you would say: “My cooling system is ok. Only in summer when driving around town the temperature sometimes reaches the red zone”
This is right, because the stock temperature gauge gauges anything else but engine temperature. If you fit a digital one you will see that in summer 80° - 90° C is normal and when driving around steep mountains it will climb over 100° C.
Twostroke race bikes run with 55 °C ± 5° water temperature, so everyone will agree that improvements in the cooling system are to be made.

Radiator

Leaving out the thermostat and using only 2% anti-freeze in the cooling liquid can be regarded as cosmetic measures – to improve cooling performance significantly there is no other way than a bigger radiator.
This “bigger” can mean two things: area and thickness. The following list contains some radiators I have already tried.

If you have a RD with fairing the choice isn’t that great. The fairing limits the maximum radiator width to about 350 mm or you have to change the mounting points or cut out the fairing.
The RD 250/350LC radiator is identical with the former TZ models (up to 1983). The size is almost the same as the YPVS but it’s 100% thicker. The hoses are identical to the YPVS ones except the missing cooling surge tank. When you weld the new brackets you have to put them off centre to get enough clearance for the radiator cap. The 10 mm hose from the head to the filler cap can be closed through using an M8-screw as a plug. With this radiator the temperatures sank by 7-10°C.

Other people use the RD500 radiator which is also slightly bigger than the stock YPVS rad.

Since 2001 Marco Böhmer can source radiator raw parts and he's able to do custom radiators. The grid thickness is available up to 54 mm (stock 16 mm), so you can create much better cooling on almost the same area.
Especially if you have to squeeze it into a fairing this is the easy way to go.

One medium sized option for naked RD's would be Cagiva Mito. This one is quite wide (about 380 mm) and has the modern radius shape. Due to its thickness and bigger area it has about twice the cooling surface than the YPVS stock radiator.
The brackets can be mounted with rivets at the upper and lower edge of the radiator (no water inside) but welding is also possible. It is a little bit tricky to custom the

hoses but with the help of a T- or Y-connector you will succeed. You can use the RGV T-connector or you can have a look at ¾ inch aquarium or gardening accessories. The T (or Y) is inserted on the way between the cylinder head and the filler cap to get a connection to the radiators top. The other hose goes from the radiator back to the water pump. In this configuration the cooling surge tank remains in stock function and position.
The temperature level declined significantly: At 10° outside temperature the engine ran at 53° C with full throttle operation. You can find the radiator on all Cagiva road 125 cc bikes later than 1991 (Mito I+II+III, Planet)

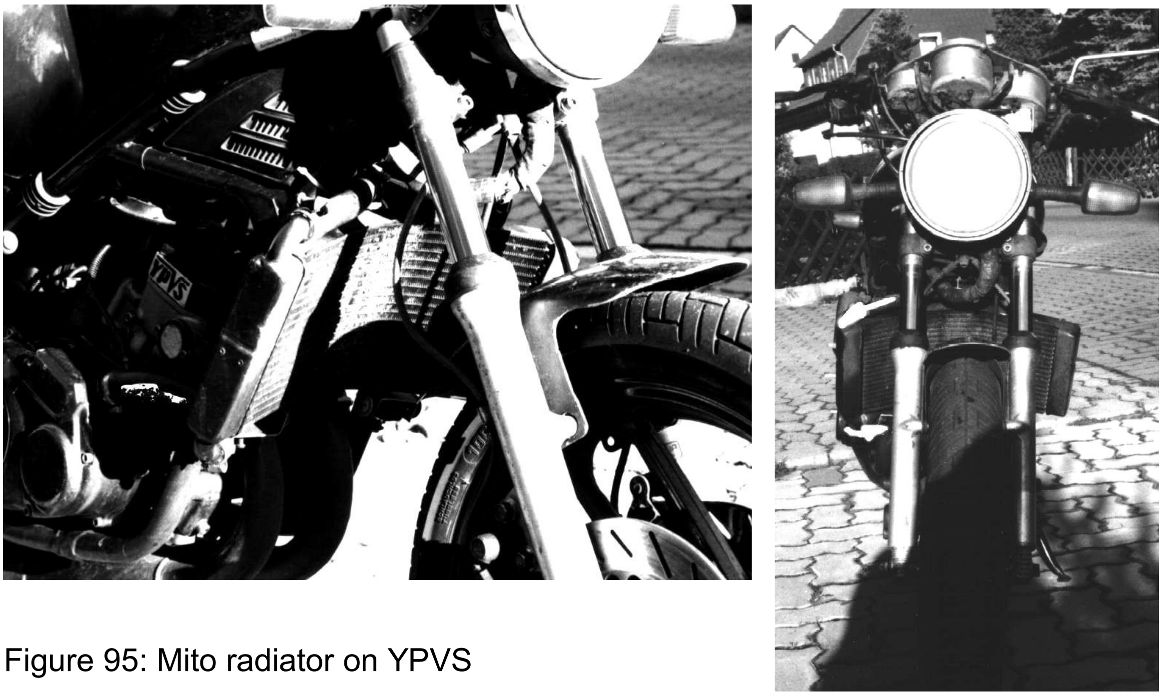


Figure 95: Mito radiator on YPVS

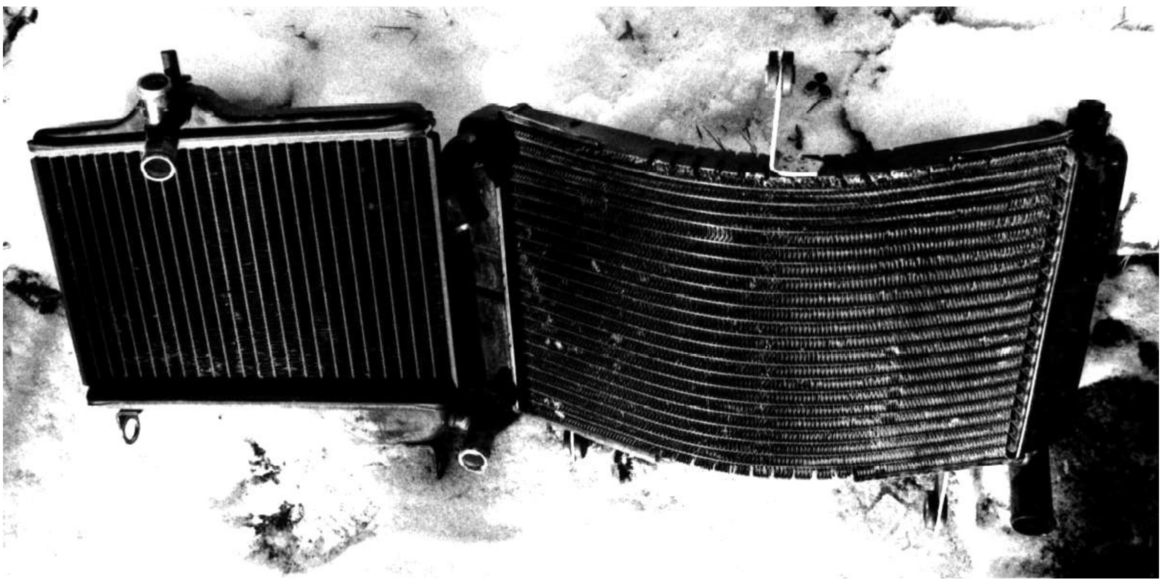


Figure 96: YPVS radiator vs RGV

After looking around for several bigger radiators I decided to use the RGV one (1991 or later). It is almost as wide as the Mito radiator but it has 25 mm more height (370 mm x 225 mm x 24 mm; the older ones are only 16 mm thick).
The connections are similar to the Mito version with riveted brackets and a Y-connector for the hoses to connect the head, the filler cap and the upper radiator. I converted a T-connector to a Y-connector by using a hot air blower.
This one survived a two day practice (on the race track in Polish Tor Poznan) at 30°C outside temperature with max. engine temperatures of 74°C.

Figure 97: RGV radiator attached to my RD

On strongly tuned engines you need an even bigger one. If you use it on race tracks (or worse for SuperMotard) even the RGV radiator is too small.
On the market there's plenty of huge stuff that can be fit to the RD's like Suzuki (GSXR 750/1100 W width appx. 380 mm, height appx. 320 mm, RF600/900) or Kawasaki (ZZR & GPZ1100, ZX 6/7/9 R, ZXR400/750 width appx. 400 mm, height appx. 330 mm).

All radiators above have the inlet at the upper right and the outlet at the lower left which doesn't ease the water tube routing ... you'd need the exact opposite.
Furthermore they are quite high and so they may touch the pipes with the lower edge.

For that reason I moved the radiator maximum upwards (check for collision with the fork while steering left/right) and also I moved the lower end more to the front. That avoided collision with the pipes and enabled me to route the inlet tube behind the radiator (check for collision with front wheel during full wheel travel & steering).
For the pipe you must not use any other than aluminum, stainless steel or plastic. Don't use steel or copper or it'll corrode rapidly.

The upper mount usually has small subframe that is mounted to the radiator with rubber bushes. This can easily be connected to the frame somewhere.
The lower mount needs some more “freestyle-fantasy” as the radiators differ from each other. The GSXR type I used has two bushes with M6 threads welded that can be used (Note the Dirko-sealing at the right. You can save that when buying a radiator that's not already leaking ...)

Since beginning of 2004 I use these on both of my RD's and since then I never exceeded 70° C water temperature! Not even while racing.
It's very important when using Wiseco pistons as they loose their mechanical properties once they've been over a certain temperature. If they've been too hot they deform and seize.

For road usage may have a new problem of too low water temperature in winter. For that reason some people use the RGV thermostat (52° C)
But unlike in a 4 stroke it doesn't really hurt if the water is too cold, so I have no thermostat.

Figure 98: GSXR 1100 W radiator attached to my RD

If you're looking for a suitable radiator eBay is a really good source as most of them have pictures where you can see the hose positions.
Important: Take care you have all sensors, plugs, caps and so on. Often a M22x1,5 plug will be more expensive than the whole rad …

That's how I found my actual radiator: The first R6 (1999 model) has the hoses on the light locations, it's not too big (400 x 290 x 25 mm) and they're cheap as shit (like 25-30 Eur) as nobody needs them anymore.

Another goodie is that the filler cap is integrated on the upper right side and you can get rid of the plastic stuff under the tank.

Figure 99: R6 radiator (good low-cost solution)

Miscellaneous

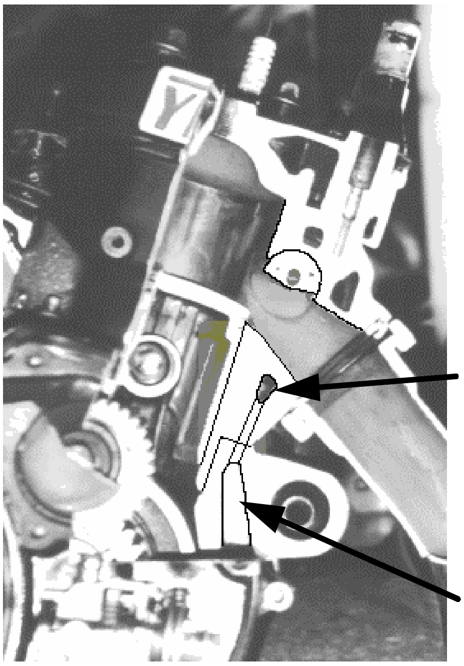


Figure 100: Crankcase/Exhaust port in cross section

Those of you who have the expertise and facilities for advanced metalworking can think about supplying the cavity below the exhaust port with cooling liquid.

The main reason for the typically melted pistons is the power valve system. It is a kind of resistance for heat transfer and this results in pretty high piston temperatures. In the stock engine the piston can only get rid of some heat in the time around TDC. In the RD350LC, the TZR250 and in the RD500LC there is an additional cooling passage below the exhaust port.

This helps the piston to cool down in BDC and as a result these models only suffer seizures when something has gone wrong instead of blowing half the piston out of the pipes.

My idea was to close the cavities below the exhaust ports and to drill a connection through the gasket area to the cavities in the crankcase. There you could insert some tubes and hoses (8-10 mm diameter) to connect the additional circuits to the cooling system.
The junction between the cylinder and the crankcase could be sealed with small O-rings. I would use an extra electrical water pump to provide the needed amount of water.
At the moment there is no prototype of this conversion, as it’s quite difficult to realise.

If you are already working on the cooling system you should think of changing the coolants flowing direction through the head. You just have to change the in and out hoses to get the coolest water to the hottest spot in your engine: the exhaust region. The greater temperature difference will increase the cooling performance. There is only one thing about this: I haven’t tried it and it bears the risk of head damage due to increased tension in the aluminum material.

Armin Collet used to weld additional material at the cylinder to stiffen it against getting deformed by heat. After doing so you’ve to mill at least the joint face to the crankcase to get an even surface.

In several English magazines I’ve seen a coolant pump conversion by using TZ equivalents. But I do not know if they used the whole right cover or only the pump. I’d assume it has a greater flow rate.

Clutch

The stock RD clutch tends to slip when maintenance was poor or when the engine has more power. I can offer three solutions:

- First just try some special light gearbox oil like Bel-Ray MC-4. I found that this prevents/reduces clutch slip during engine warm up or when the friction plates are somewhat worn. If the oil doesn't help you ought to open the engine and modify the clutch springs (you may also use a set of new friction plates).
- Use 6 washers of 1.5 to 2 mm thickness and 14 mm bore. The outer diameter should equal the clutch spring's outer diameter (You may have to manufacture that on your own). These washers are mounted with the clutch springs and increase pressure about 15 to 20 Newton each (about 20% increase) which enables the clutch to transfer a higher torque.
- The same effect can be reached by using reinforced clutch springs. You can get them in several bike stores as Hein Gericke, Polo or Götz for about 20,- DM a set. There are reinforced YAMHA springs, too (Part No.: 90501-23142, 42 mm free length)

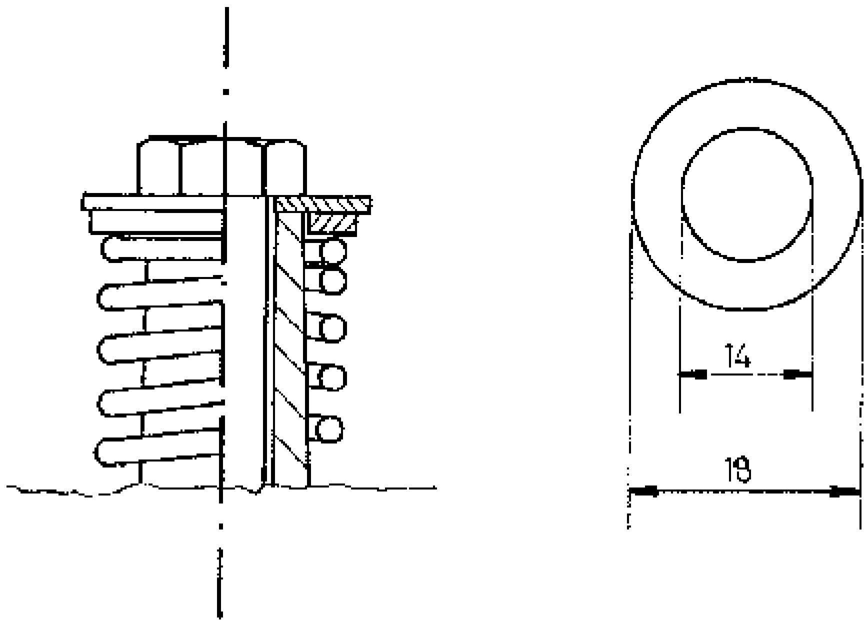


Figure 101: Clutch spring with washer

Free length of spring: max. 36,4 mm ; min. 34,4 mm
(Thickness of friction plates: max. 3,0 mm ; minimum. 2,7 mm)

You can get “reinforced” springs from a couple of sources (around 15 Eur/Set). These have a somewhat stronger effect than increasing preload via washers.
But “reinforced” doesn't equal “reinforced”! In a stock engine it doesn't bother too much (as long it's stringer than stock), but in a race engine it will make the difference between slipping or reliable clutch! Or the springs may get too strong and you end up with far too high actuation force at the clutch lever. In the latter case you can simply use 3 or 4 new springs and 3 or 2 old ones.
The next table shows you what I have measured from different springs.

Active windings	7	6	5	
Wire diameter	2,3	2,38	2,34	**mm**
Medium spring diameter	14,6	14,42	14,21	**mm**
	Stock (31K)	**Unknown**	**Lucas**	
Stiffness=	**13**	**19**	**22**	**N/mm**
	100	**139**	**163**	**%**
Force in Kg for 2 mm compression	2,72	3,77	4,42	**Kg**

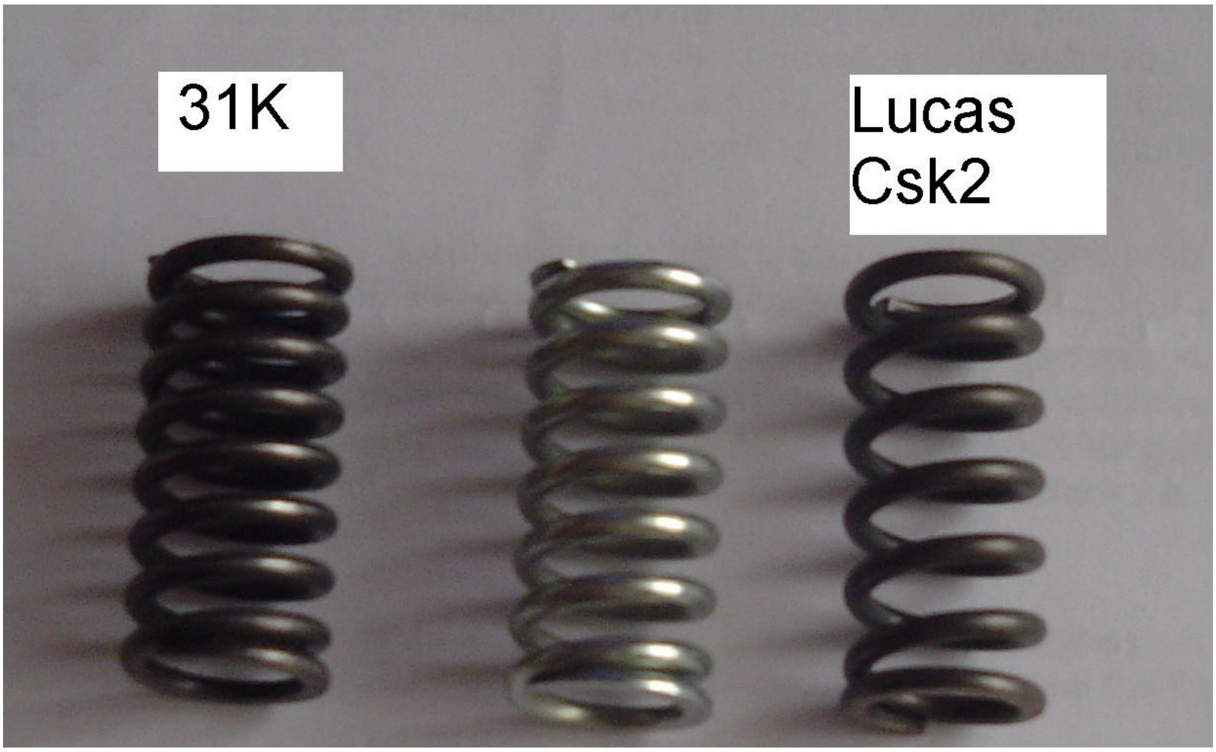


Figure 102: Clutch springs Stock, unknown and Lucas

One Method to persuade the clutch to transfer a bigger torque without slipping is to use an additional steel/friction plate. One more plate adds you 8/7 = +14 % of max. torque.
The necessary design space calculates from one steel plate (1.2 mm) + one friction plate (3 mm) = 4.2 mm total

In order to keep the clutch plate and hub in the same relative position you need to shave off 3 mm from the plate and 1.2 mm from the hub. The relative position is important because in the plate and hub there are the same grooves. If you pull the clutch lever the plate must make a small move along these grooves to release the spring force from the plates.
The relative position also has an influence on the spring preload.

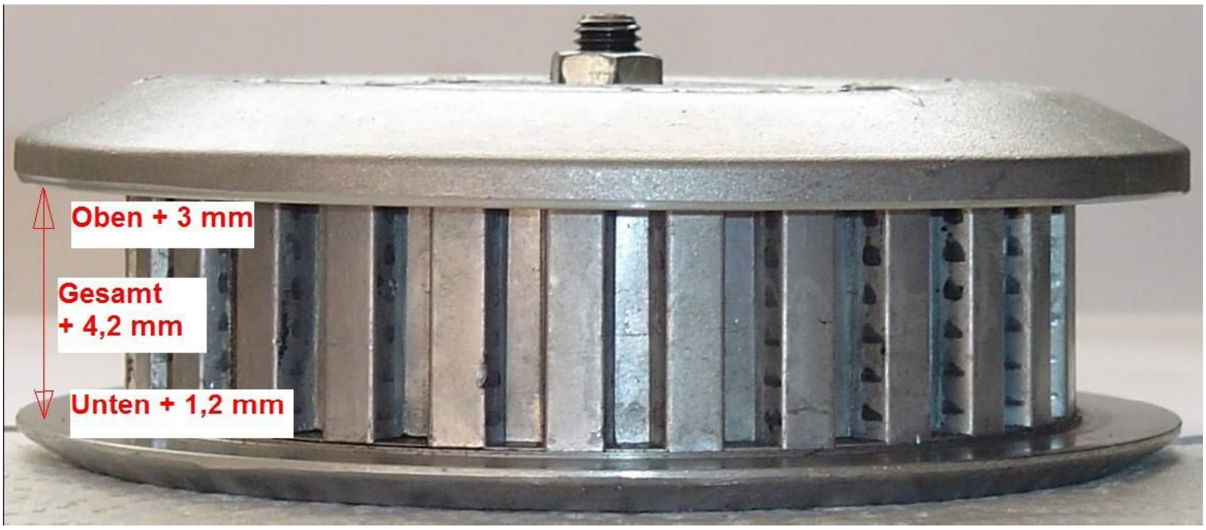


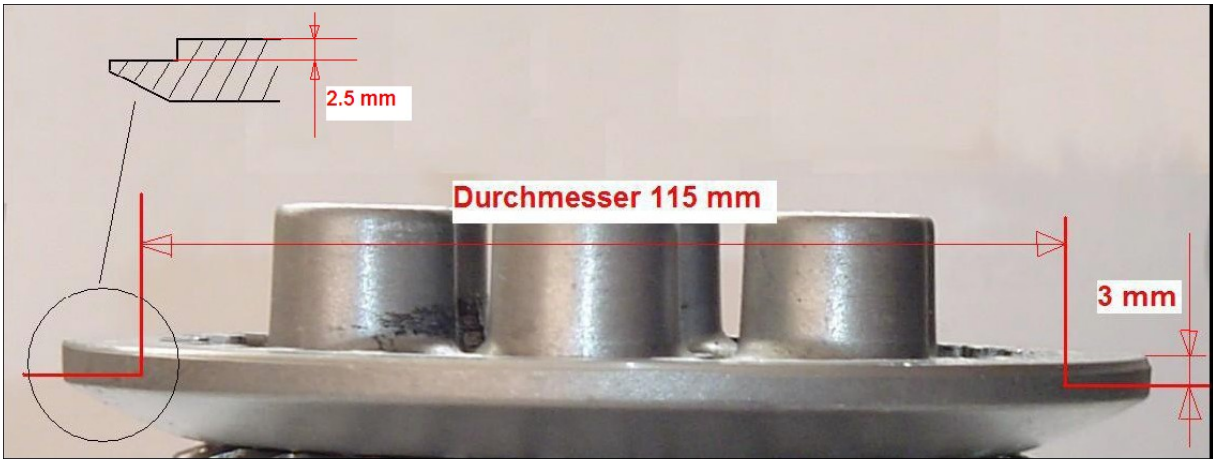
Figure 103: Concept of clutch mod.

Figure 104: Modification for the hub

You can save some more height, if you grind down the steel plates by some 1/10 mm from both sides. In addition this gives you about 0.5 – 1 mm. But if you do so, you have to take that into account when modifying the clutch plate. The measure 3 mm has to be reduced by the amount you grind off (for example if you take 0.1 mm it's

6x0.1 mm = 0.6 mm => The 3 mm must be 2.4 now). If you forget that, the clutch springs loose exactly that amount of preload!

Caution: On the plate the remaining height must be less than the thickness of one friction plate (3 mm) otherwise the first steel plate will contact the aluminium! That's the why I'd first make a 3 mm step and then shave off the inner/upper surface by some 0.5 mm to have a remaining edge height of 2.5 mm.



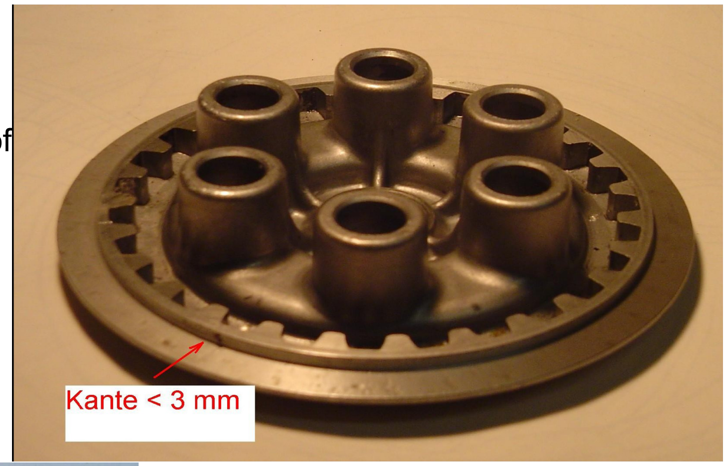


Figure 105: Upper: Modification of the clutch plate
Right: Finished Version

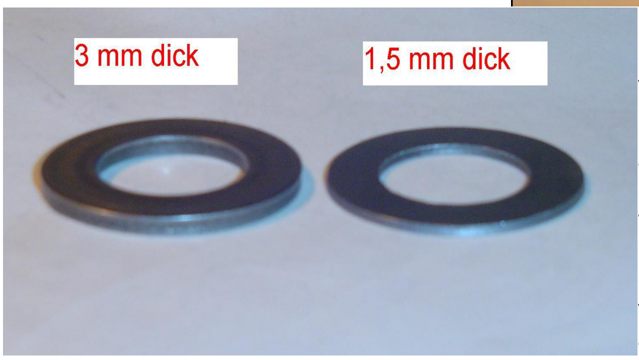


Figure 106: Washer mod

Now you only have the problem that the whole package would come out of the grooves when pulling the clutch lever.
To overcome that you have to relocate the hub along the shaft. 1.5 mm can be made easily by grinding down the inner washer from 3 to 1.5 mm.
Then you need to rework the slots in the clutch basket to enable the friction plates going down 1.5 mm more.

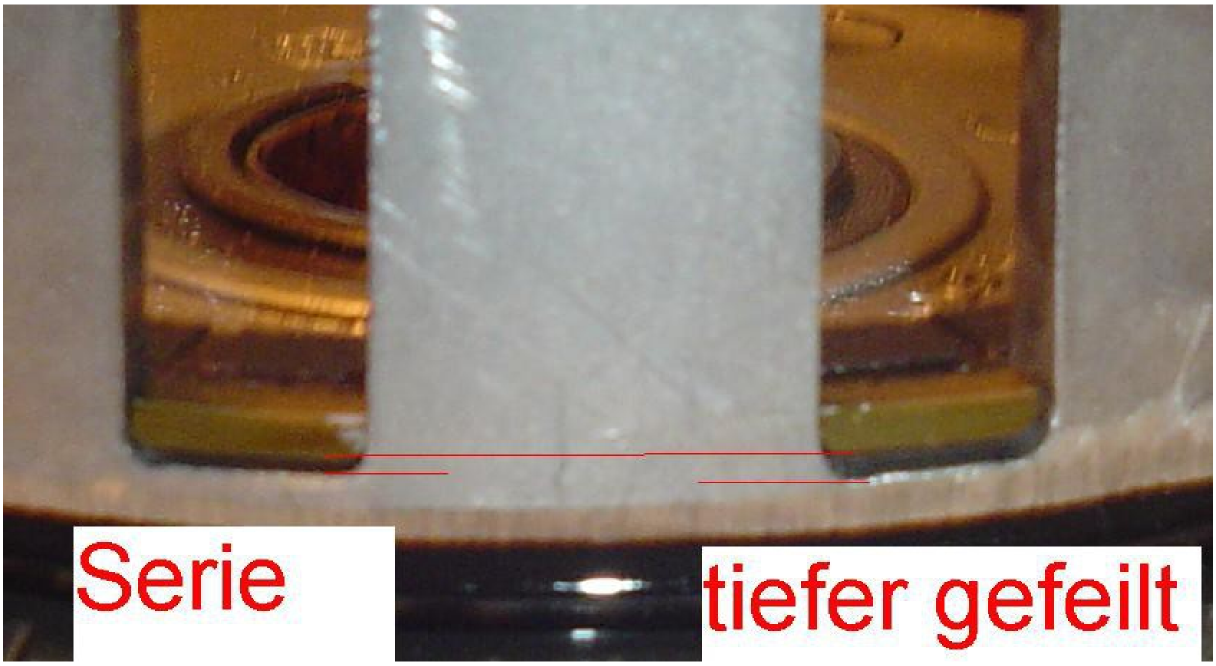


Figure 107: Slot modification (Clutch basket)

As the slot is radiused at the bottom, you'll have to round the lower edges of the friction plates in order to have them fitting perfectly (and not locking in the end-position)

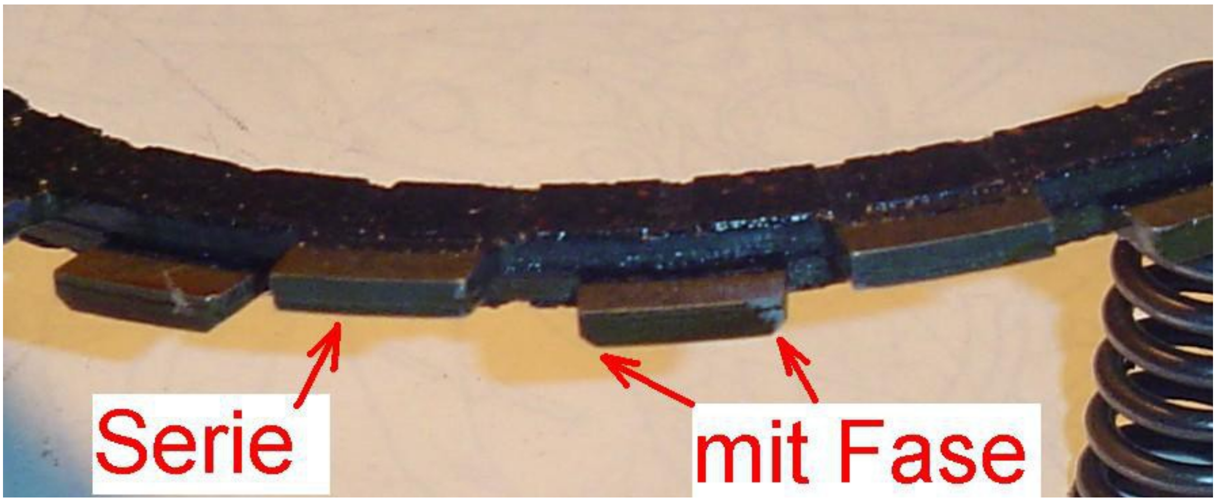


Figure 108: Fitting the lowest friction plate.

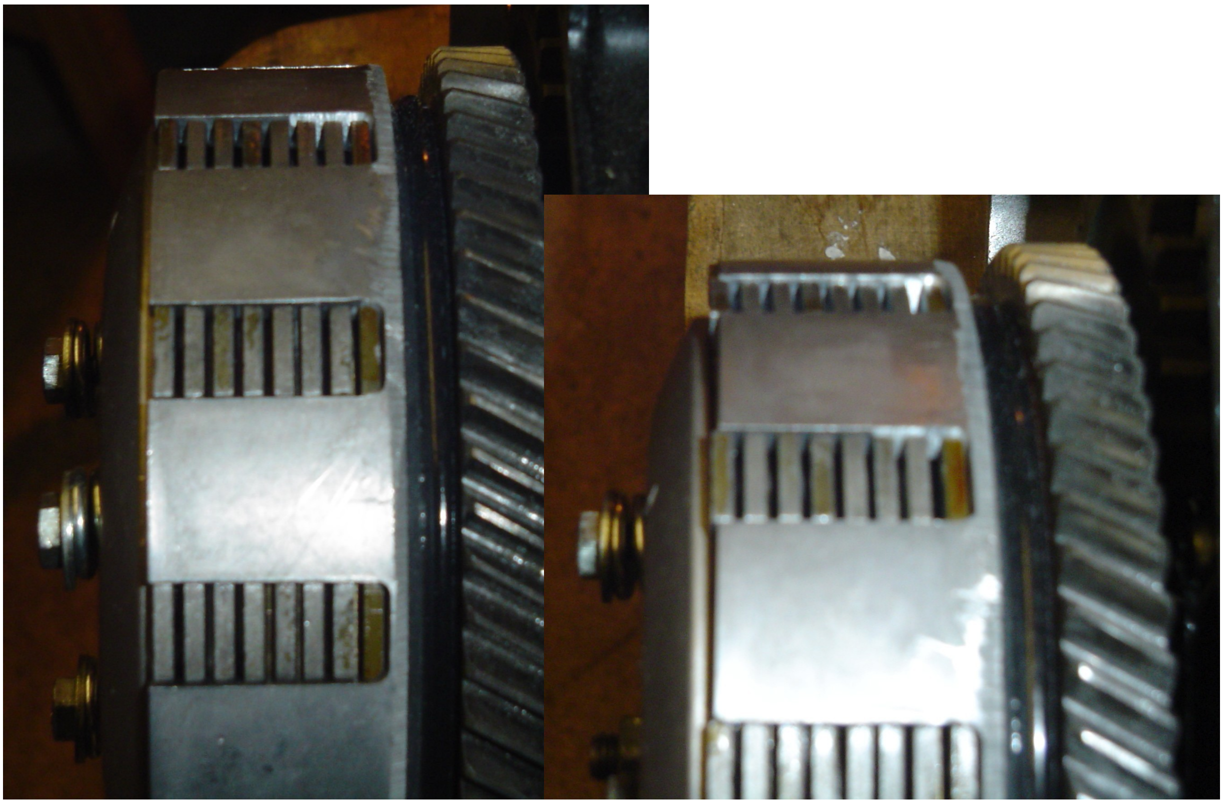


Figure 109: Finished clutch. Left: released, right: engaged

On assembling the clutch you should check for the two critical things

- The lowest friction plate moves freely and does not jam anywhere.
- When pulling the clutch lever the outer friction plate does not come out of the slot.

Who has access to the necessary machines can manufacture a new basket with 3 mm longer slots. In this case you don't need all the fuss written above and directly use one plate more ...

For the Bashee there's lots of supply of several baskets and steel/friction plates. As they fit the RZ you can order them without worries.

Highly recommended are friction plates with carbon-composites for example from Barnett. These guys also offer baskets with one or two additional plates.

EBC offers the kit DRC43EP – EP stands for **E**xtra **P**late. It has thinner plates made from carbon-compound and so that kit fit's into the stock basket with minor modifications.

If you consider buying any of the carbon kit's then sit down when they tell you the price – these are quite expensive (about 150 Eur. a set).

Electronics

Stock ignition

For the stock ignition you can widen the mounting holes in the stator plate in order to turn the stator clockwise. (So you widen the holes counter-clockwise)
A range of about 3 deg can be done with this method.

The banshee guys have ignition keys (the little half moon that locks the rotor on the crank) with a step. A usual size is 4 deg, but I also saw 7 deg keys.
As you can mount them in both directions it is essential to insert the key in a way that the outer part is on the left side of the lower part. (i.e. rotates the rotor counter-clockwise to make the lobe arrive "earlier" at the pick up)

The timing plates you can get are mostly made to fit the banshee. They have slotted holes and allow for a wide range of adjustment.

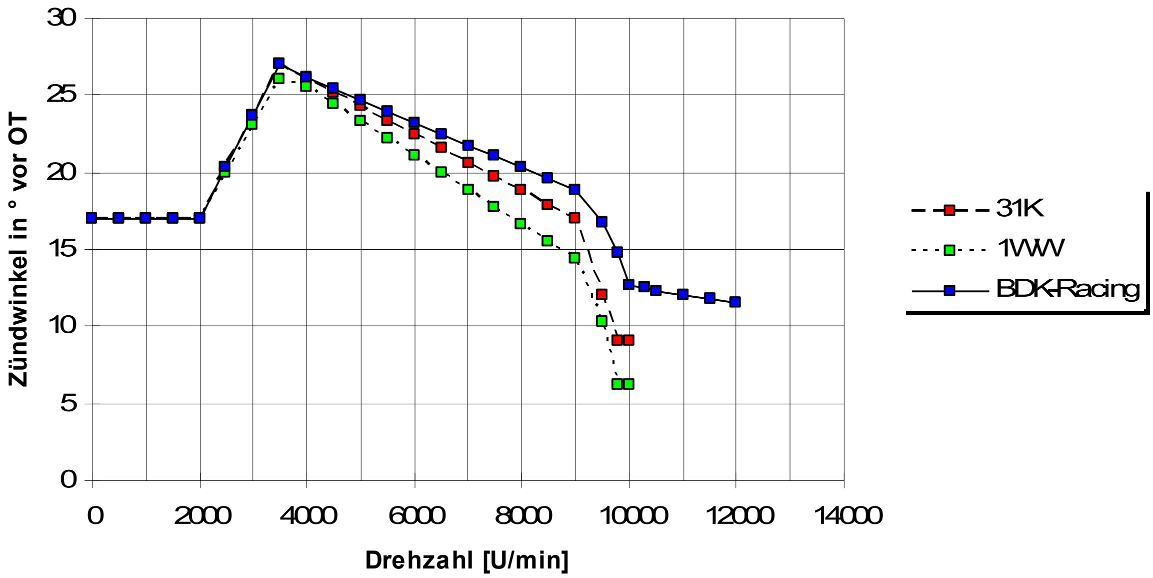


Figure 110: Stock ignition advance curves and BDK modified

The stock CDI does not have a hard limiter for max. rpm but it's far from optimal for other than stock pipes.
The spark is there even at 12.000 rpm, but If you exceed 9800 the advance is held constant. This is not promoting a good performance in that region and what's worse it raises EGT as you virtually "fire into the pipe" instead of letting the hot gases cool down when working on the piston.

Programmable Ignitions

On the market there's quite some ignitions that would fit a YPVS RD. This chapter deals with the two manufacturers that offer a working PV control (most others cannot operate the YPVS or the lights and thus are not suitable for road use).

Their common features are

- Programmable curves for ignition and PV
- Input for throttle position sensor (TPS)
- Rpm limiter
- Shift control
- Output for stock tach & PV box.
- Good price (200 – 300 Eur)

www.zeeltronics.com (aka „Borut ignition“)

In 2005 I got in contact with Borut Zemlijc from Slovenia who offered programmable ignitions for aircooled RD's at that time.
His concept was very modular: He had a CDI that was getting the juice from the source coils in the stator and that was firing each time it sees the pick-up signal.
If you split up the connection between CDI and Pick-Up and insert the VCDI, you can kind of delay the pick up signal.
The command to fire the CDI now comes from the VCDI that holds the programmed curve.
If you need the PV programmable, you'd need a third box named PPV-RZ.

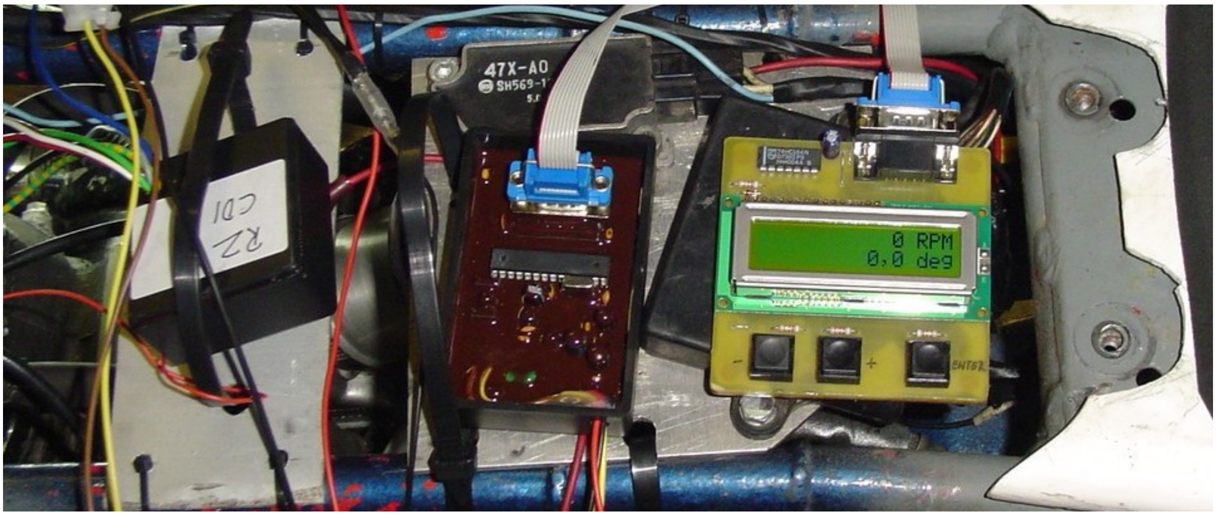


Figure 111: CDI (left), VCDI (mid) & handheld (right) (www.zeeltronic.com prototypes from 2005)

Over the years customer requested all-in one boxes that unite all 3 functions in one device. The principal difference is that the PCDI-series needs a working source-coil in the stator whereas the PDCI-series converts 12V from the battery to a high voltage required for creating a spark.
The latter one is suitable if you have a faulty stator, because for the cost of a rewind or spare part you can already buy a DC-CDI.

The programming is done with a separate handheld which makes it pretty easy to program on the road or at the race track.
In contrast to a laptop the handheld is powered by the bike's 12V, can be read in full sun, can survive moderate dropping and it's not attracting stealing scum.
Meanwhile you can also program it with a PC-software and USB cable (Zeel-Prog), but the price is the same than the handheld.

All Zeeltronic boxes come with loose cables coming out of the epoxied box. Attaching that to your own harness is pretty easy as you can solder on the stock connectors, solder it directly to cables or use bullet connectors. I've also seen luster terminals.

The results were impressive. Marco Böhmer had two RD's on his dyno.
A stock'ish 1WW (F2) went up around 4kW (+5.5 HP) and an extensively tuned RD grew from 47kW to 54kW at the rear wheel (+9.5HP)

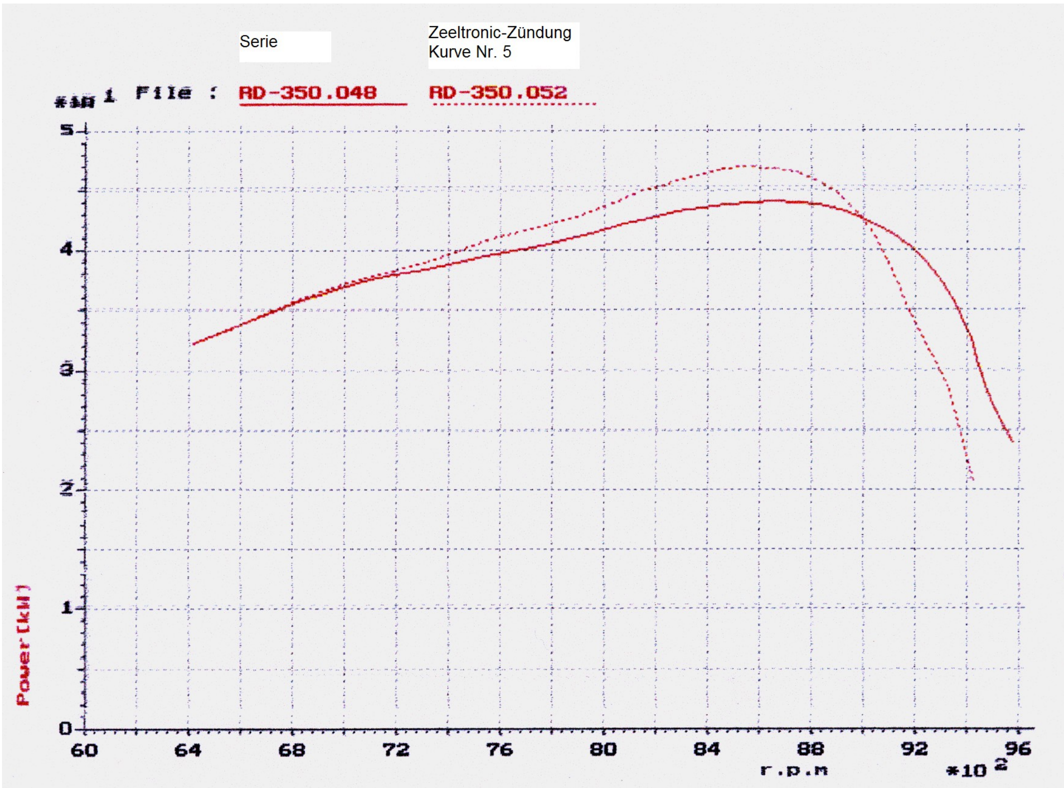


Figure 112: Dyno chart 1WW (before/after)

The closer you are to stock, the less likely you need to change the jetting.
Above bike remained stock, but lost around 800 rpm at the top – it would require a longer gearing to keep the same top speed.

Since 2007 they offer a TPS input that feeds the CDI with the throttle position. The RGV has one build in it's cable distributor and I use that in a couple of my bikes.
With this input you enhance your 2D (ignition advance vs rpm) curve to a 3D map (ignition advance vs rpm vs TPS). It enables you to have a large advance at WOT and a more tame one at partial load (engine runs smoother)
In my EFI bike I successfully ironed out a rough spot at around 4.500 rpm below 20% throttle opening by reducing ignition advance just in this area.

As a principle you can say that a reduced advance will make the engine run smoother but raises EGT. So in my maps I usually only run reduced advance at lower rpms (below 7000)

www.ignitech.cz

Ignitech offers two suitable DC-CDIs: The DC-CDI P2 and the P2 race.
I wouldn't recommend the latter one to anyone who's not using it for high end racing purposes (many features not needed on road, more complicated programming and wiring)

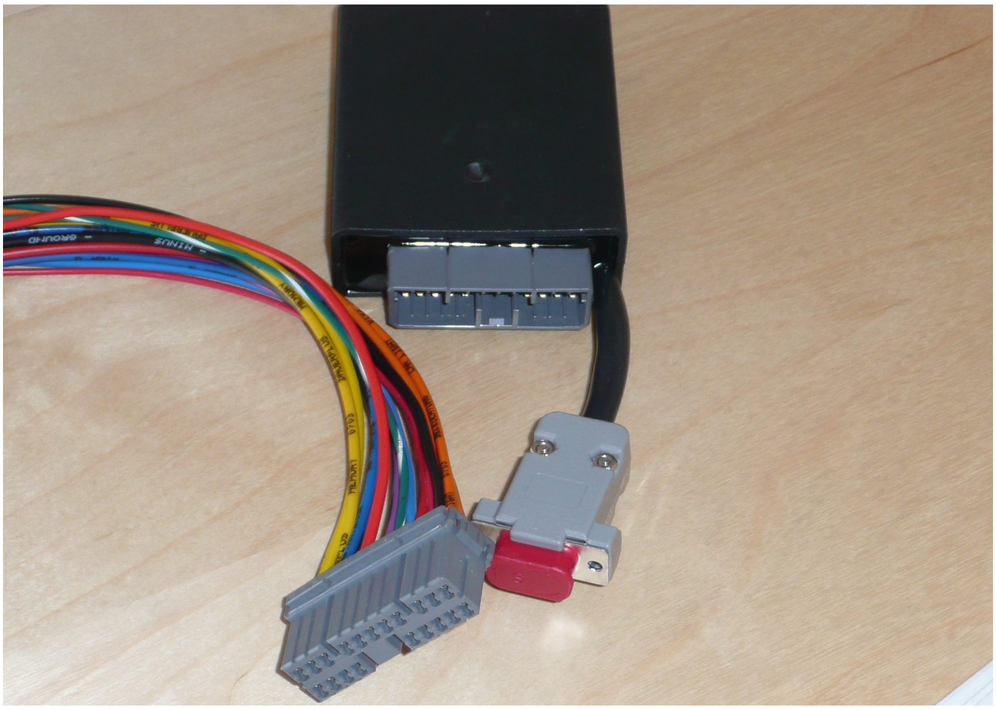


Figure 113: Ignitech DC-CDI P2 with per-fabricated harness

Feature-wise they're pretty even, except that the Ignitech can be programmed with a rather cheap USB2Serial cable and a PC. The settings can be visualized graphically which is more convenient that just numbers on a handheld.
Also the data can be saved to a textfile which is convenient if you need assistance with your settings (just mail them to knowledgeable people).
Being forced to use a laptop is not the best thing at race tracks (empty battery, visibility in bright sun, theft).
And just use “any laptop from a mate” is also prone to failure as you need the cable and install the right software + drivers (been there at track days when people wanted me to debug their boxes ...)

The standard delivery contains a plug with the inserts that have to be crimped to the cables. That requires quite some expertise in electrics and a crimping tool.
Do yourself a favor and add the 10 Eur for a pre-fabricated cable/plug – this is much easier to install and absolutely worth the extra cash !

The pricing of the Ignitech is a bit better than the Zeeltronic but from the performance there is no difference you would notice.

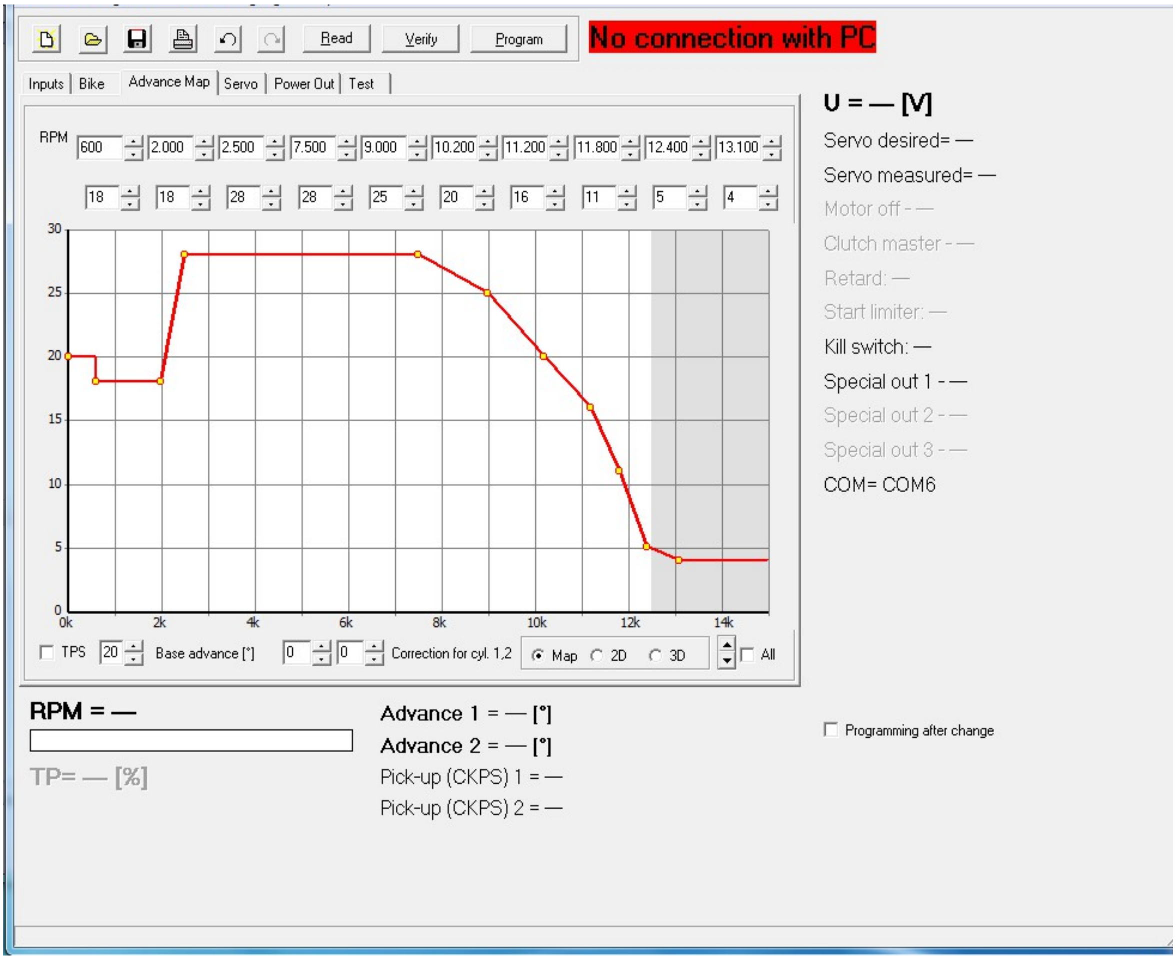


Figure 114: Screenshot Ignitech-Software

Settings

All CDIs need a reference point. The common one is the crank angle at which the pick-up signal occurs.
Zeeltronic calls that Static Angle, Ignitech Base Advance

For the Zeeltronic and 31K rotor/stator I found a Static Angle of 34,6° +/- 0,75° BTDC.

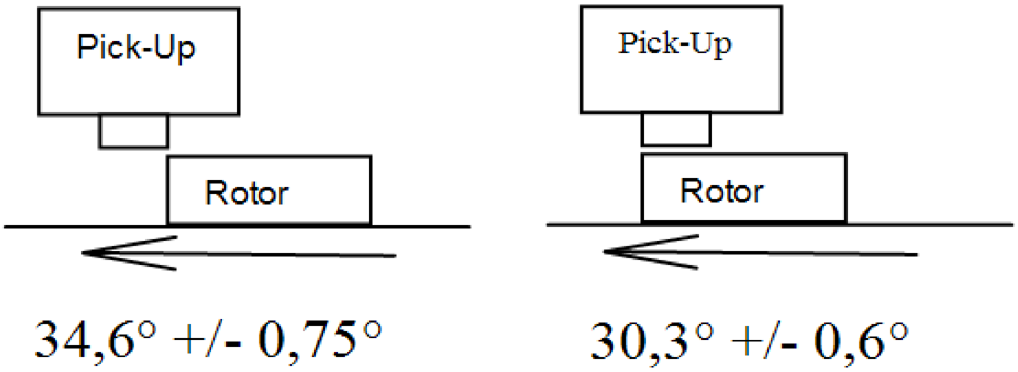


Figure 115: Position of lobe relative to Pick-Up

The Ignitech requires a different position: They sense the middle of the pick-up over the second edge of the lobe (see next pic). In my engines this was between 18 and 20 deg BTDC.

Figure 116: Base-Advance for Ignitech.

I have a straight forward test to determine if the reference angle was right:

- Bring the piston of the left cylinder to 2mm BTDC (for stock crank, 54 mm, 110 mm rod). Use a felt pen to mark the rotor.
- Now program a “curve” with 20 deg allover the rpm range and use a strobe to check if the mark would match.
- If it doesn't, correct Base Advance/ Static Angle until it does.
- In the Zeeltronic you have a value for “compensation”. Rev up the engine and check if the mark wanders upon high rpm. If it does, change the compensation value.
- After that you can program your desired curve.

Ignition curves

Concerning a “good curve” I liked this writeup from the late Bill Givens:

> *“So what is correct timing. Correct timing in my mind is running the least amount of advance that you can to reach a maximum cylinder pressure around 10-15 degrees ATDC.*
>
> *Yes you are right…spark strength effects timing. The stronger the gap current the more ionized the flame front becomes and this will cause it to burn quicker. To compensate for this quicker burn and to reach our goal of max cylinder pressure at10-15° ATDC we would need to retard the timing some.*
>
> *The faster the burn rate of the fuel the less advance I need to reach my goal and the higher the octane rating the more compression I can run. You are looking for a balance of compression, octane and burn rate and your timing will be based on the application and fuel you have available. Again each situation is slightly different.*
>
> *Whatever I do to speed up the burn rate requires less advance and that is a good thing, because the less advance I can run, the less negative work my piston must fight against.*
>
> *Speaking of compression… the higher the compression the more heat that I generate and unless I have a way of getting rid of that heat I can only go so far with that parameter… no matter what the octane rating is! I can run considerably more compression in a water cooled than an air cooled for that reason. The higher the compression the less timing I need to reach my ATDC goal because it takes less time for the burn. So a water-cooled engine can run more compression and would normally require less advance.*

As we all know head geometry plays a major roll in all of this also. Shape and size of the dome… squish effect, etc all figure into the burn time. If you increase the MSV you will increase the burn rate… faster burn rate requires less advance.

So why do people associate that more timing is a good thing…quiet simply they don't know anything about it and a lot of this comes from the old hot rodders conception of 4/ days where they would increase the compression and increase the advance to a point and all was cool… but that is a totally different ball game with different rules. They had/have twice as much time to get rid of the heat as we do.

There are no hard fast rules on what timing will work in every situation. You have to develop the timing and timing curve based on what your specific engine design and fuel allow you… all with a goal of achieving max cylinder pressure around the 10-15° point.

So let's develop a curve…

To keep the motor from kicking back, the cranking/idle speed timing should only be advanced 3-6°'s. Cranking/idle speed starts at 0 RPM, and can extend to 1200-2500 RPM. This will allow a motor to start easily without kickback, and main a smooth idle without the timing curve varying it to any degree... generally 3° - 6° advance BTDC is all that is necessary. The higher the compression, the less advance necessary...as general rule.

I always felt that the standard factory straight-line timing was a compromise between low and high RPM engine safety and drivability... so what I do to get a starting point, is increase the std timing above the idle area by a factor of 1.5.

Let's say in the method above… that the standard straight-line timing was 20°. Then 1.5 X 20=30° timing… from the idle area to roughly 75% of the peak torque RPM. If the motor makes peak torque at 10500, this is about 7875 RPM. So from 0 RPM to about 2500 RPM we have 3-6° advance. At 2500 RPM we ramp straight up to the 30° point, or what ever 1.5 time the standard timing was, and stay at that point till we reach 75% of the peak torque RPM.

Now we get to the slope… that is critical to the engines power and longevity, and it will typically start where the engine starts to pull on the pipe...a range from roughly 75% to 110% of the Peak Torque RPM.

If the motor makes peak torque at 10,500 RPM, this would be roughly 7875-11,550 RPM. The port timing values and pipe design will affect the specific value, but this is a pretty close baseline for most motors.

Generally the resulting timing curve is a straight-line flat slope between these points, although there can be variations to where optimization is found to be needed.... particularly around the peak torque RPM.

The peak torque timing should fall on the slope at around .75 of your original straight-line timing to get in the ball park. In our example, the peak torque timing would be 15°.

The timing slope continues to decline in a more or less straight line to a point about 110% of peak torque RPM. At that point sustaining a retard beyond this region will extend the usable power range by a good margin. This can enable a lower gear ratio and provides a wider power band with no loss of peak torque.

At a point of about 125% of peak torque RPM you are probably at the end of the over-rev region and can start to plug in some advance to act as a Rev limiter if you want. I normally just straight line it out to the right.

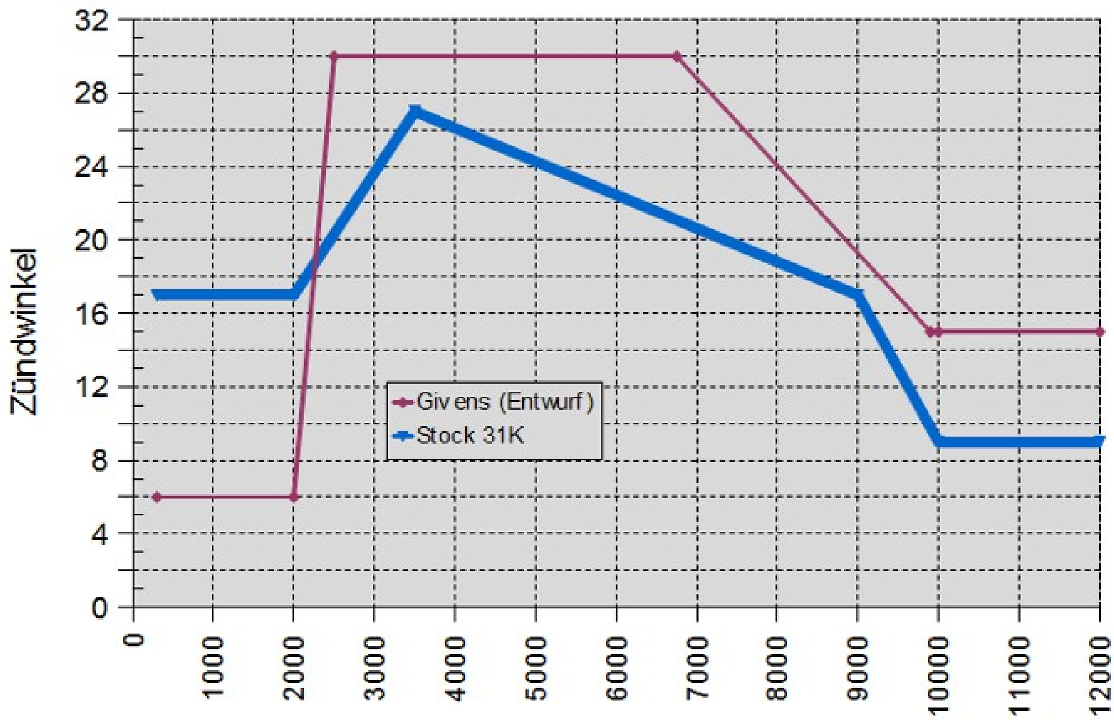


Figure 117: Base curve for RZ350 following Bills method

This should get you a curve that is close enough to start some serious testing. Without the use of a dyno to help you optimize the curve, then you need to make sure you are jetted correctly and start the on the track testing. Monitor CHT and EGT and take numerous plug chops looking for detonation... primarily around the peak torque RPM. What I do is keep advancing the slope until I start to get a little soft count detonation and then back the curve off by 1-2°'s.

EGT and CHT should follow each other... If the EGT is rising along with CHT you're probably ok. If EGT start to fall under acceleration and CHT continues to rise then that's a sure sign of detonation.

Important point…Now if I know from experience that with my engine design that I can't run the factory advance during the ramp up point and to the 75% point then I back that down to a number that will work in the mid RPM range.

Depending on the variables...I've ran all the way down to 0° advance at peak hp"

This "manual" doesn't match a 100% with my own findings (for example the RZ's like a bit more advance for idling) but it's the best base for your own experiments.

Figure 118: Ignition curve for DIY pipes (peak at 9.500 rpm)

	Analog System	Digital System
50 ccm / 60 ccm / 80 ccm	1,4 to 1,6 mm	1,2 to 1,4 mm
125 ccm	1,2 to 1,4 mm	1,0 to 1,2 mm
175 ccm	2,2 to 2,4 mm	2,0 to 2,2 mm
250 ccm	1,8 to 2,2 mm	0,8 to 1,0 mm
Open class	2,2 to 2,4 mm	

Table 10: Ignition advance for kart engines (Source: PVL)

PVL recommends a a reduced advance for digital systems with a stronger spark which perfectly fits to what was mentioned before. The higher spark energy makes the mix burn faster and thus a smaller advance is required.
For example the TDR250 has a lower curve than the pretty similar TZR250. Main reason is that the TZR has a classic analog system and the TDR a digital one.

Power-Valve modifications

As already mentioned in the exhaust port section the max rpm of the cylinder/pipe system depends on the height of the port.
The Power-Valve varies the height by rotating the valve above the port. At low rpm the upper port edge is lowered down which is very beneficial for the low end torque.

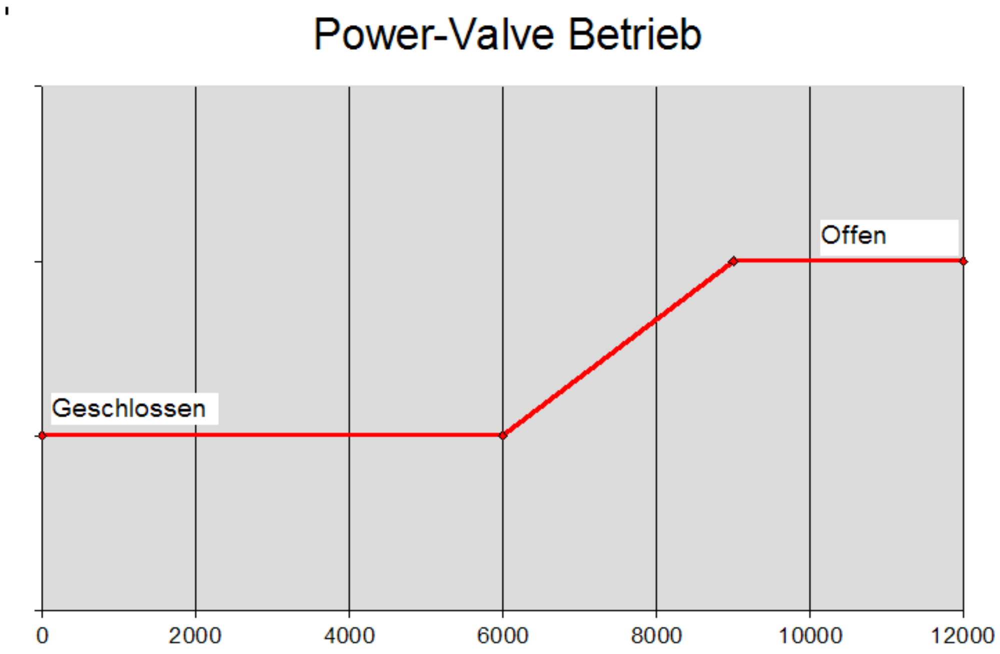


Figure 119: Power-Valve principle operation

The operation rpms for start/end are different between the models. The coding is done by soldered bridges on the controller PCB (see next chapter)

If you have a look at the 1WW (F2) values, you don't wonder anymore why those bikes don't rev. If the max rpm is about 9k but the valve is fully open at 10.200 – what were they thinking with a valve that's never fully open ?

Model	Opening starts @	Fully open @
RD350 (31K)	5550 rpm	9450 rpm
RD350 1WW	6000 rpm	10200 rpm
TZR250 (1KT, 2MA)	5850 rpm	10050 rpm
RD500 (47X, 1GE)	6150 rpm	7950 rpm
Kurve 14	6000 rpm	8550 rpm
TZR MOD1	5700 rpm	9000 rpm

Table 11:Actuation rpms of Yamaha PV boxes (Source: BDK)

The method to determine the optimum actuation is pretty easy:

- Unplug the PV when fully open and testride
- Note the usable rpm range (like 6.500 to 10.000)
- Unplug the PV when closed and testride
- Note the usable rpm range (like 3.000 to 7.000)

In this example a start between 6-7k and fully open @ 9.500 rpm would be appropriate. A bit of finetuning is still required

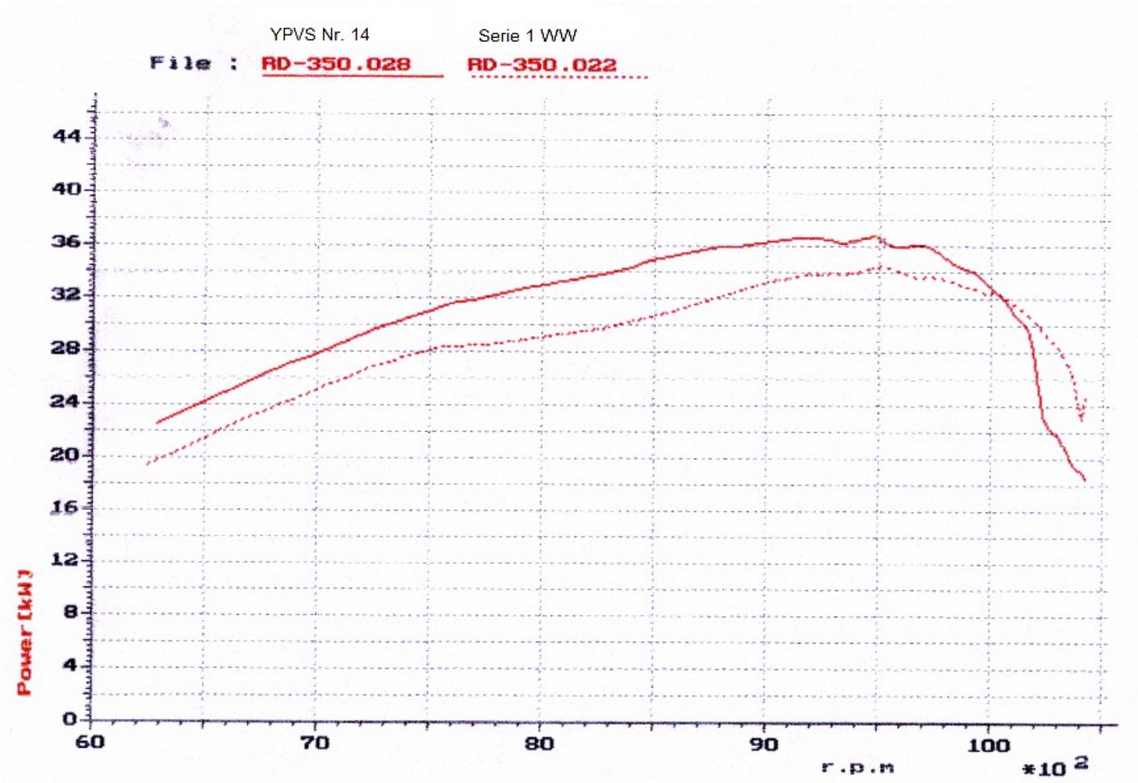


Figure 120: Dyno chart with YPVS curve 1WW and BDK #14

After I tried several settings on my RD (F2 pipes), I preferred BDK's curve #14.
Modified RD's benefit over the whole rpm range and may also gain some max rpm.
Marco Böhmer tested curve #14 and TRZ MOD1 as best suited for RD350's. 31K was also possible.
The gain was around 3-4 kW.

And this is how you do the mod on your own:
The separate PV control boxes of the years 1983-1989 all have that huge IC that has the rpms & angle coded via bridges on the PCB.
The 31K box from 83/84 is not that comfortable to modify as it has a layer of clear coat on the back of the PCB that is hard to remove. (That's the thick case on the left)
All the later boxes (case on the right) have a 2-3 mm soft transparent coat that is easy to strip off.

Figure 121: Yamaha PV boxes: left: 31K, right: later RD's, RD500, TZR250

You can do an eBay search for TZR250, RD350YPVS, RD500. They're all electrically compatible but just have different connectors (some have slightly different cable colors).

On the back side of the PCB you can see the pins of the main IC. It has 12 pins that are numbered from left to right.

Whether a bridge is active or not can be determined with the protruding wire ends in the 2'nd and 3'rd row (row 1 = top row of pins)
If there is a wire it means “active” (= 1), No wire means “inactive” (= 0)

You can change a “1” into a “0” if you cut the bridges at one of the two indicated locations. Use a Dremel and interrupt the copper path on the PCB.

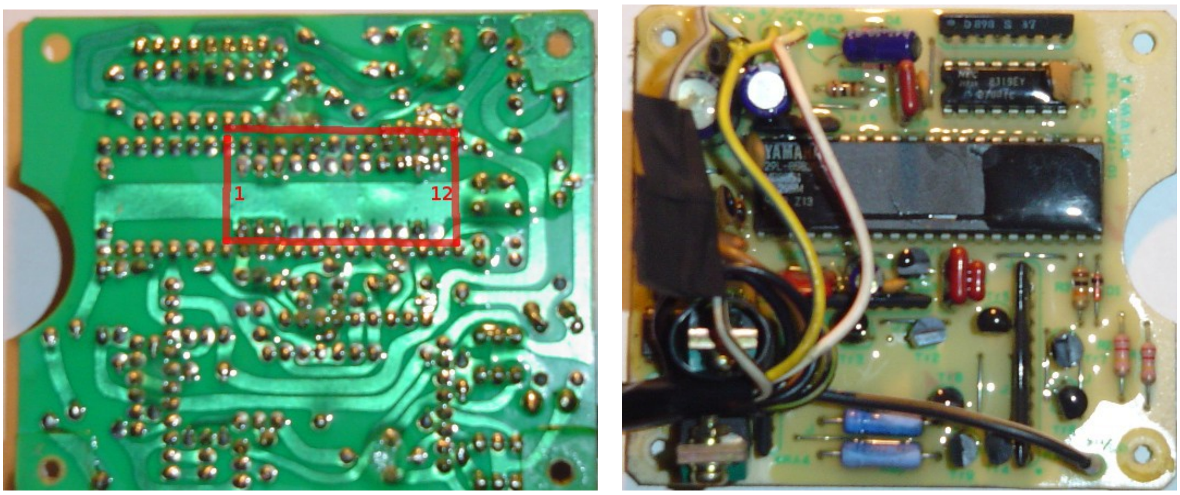


Figure 122: PCB 31K: (Bridges at 1,2,3,7 und 11)

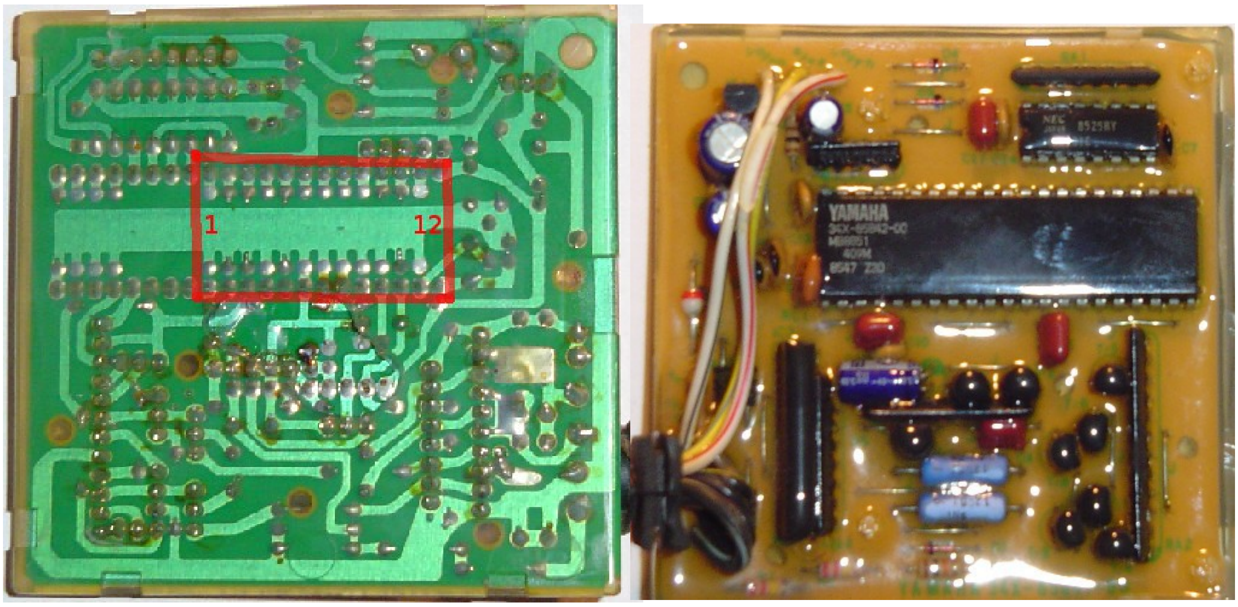


Figure 123: 1WW: (Bridges at 2,3,5 and 11)

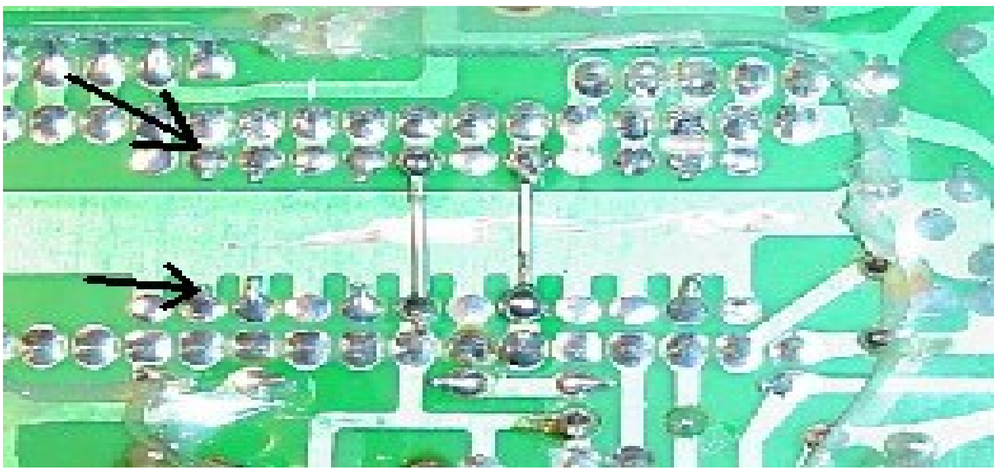


Figure 124: Modified bridges

To turn a “0” into a “1” I solder a piece of wire to the PCB as shown in the pic. The important detail is that “ground” (the wide path in the middle) is connected to the IC pin in the 1'st row.

The famous BDK PV chart is referring to the pins 1 to 12 on the main IC.

- Left column = pin nr.
- Green = bridge active
- Empty (white) = remove bridge

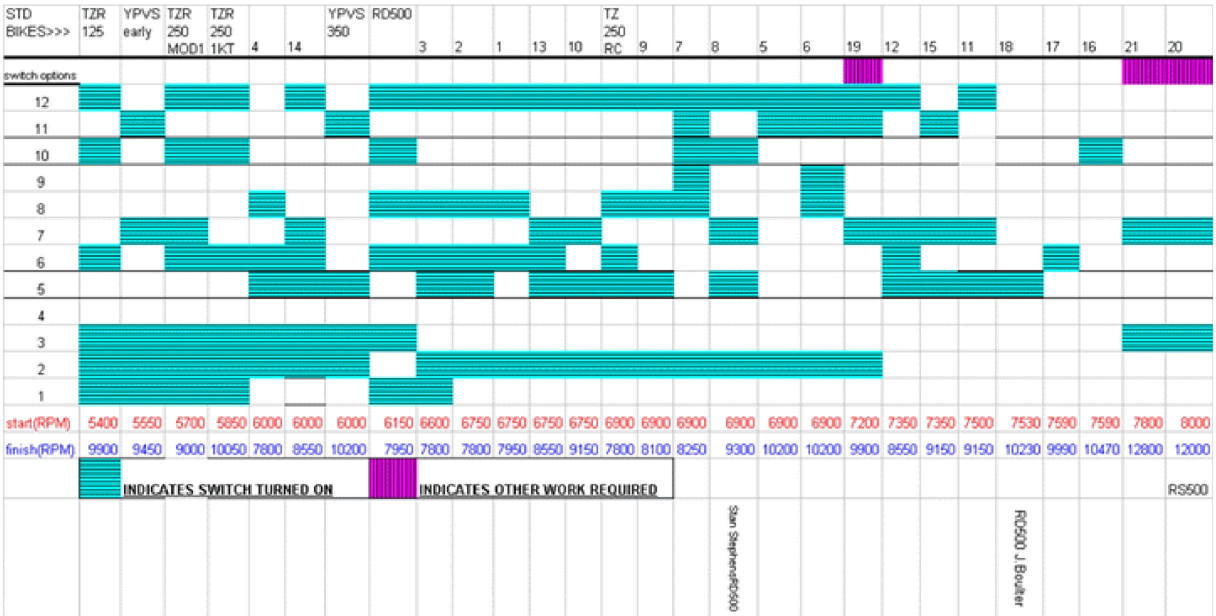


Figure 125: BDK table for PV modification

If you need that a bit more versatile, you can use a measurement from Stefan Rempfer (Germany).

He used a 12 pin DIP switch soldered to the IC pins and measured what the pins actually changed.
At the end he found that it's a binary representation of three 4-bit numbers (i.e. 0-15). Pin 1-4 controls the start rpm, pin 5-8 the end rpm and pin 9-12 the opening angle of the valve.

If you cross check that to the BDK table, you get good matches. For example the start rpm (pin 1-4) of the first few columns is a 1-1-1-0 (a 7 in decimal). That gives us a 5700 according to the Rempfer measurement and some 5400-5850 rpm according to BDK.
For the TZR125 and 250 the end-rpm is listed with 0-1-0-0 (a decimal 2). According to Rempfer that's 9951 rpm, according to BDK 9900 or 10050.

Figure 126: PV-Box 1WW converted to DIP switches

This was his result for each of the 3 4-pin blocks:

Bridge 1	Bridge 2	Bridge 3	Bridge 4	**Value**	**Start-rpm**	**End-rpm**	**Angle**
0	0	0	0	**0**	**7486**	**10457**	**30,6**
1	0	0	0	**1**	**7230**	**10204**	**31,6**
0	1	0	0	**2**	**6975**	**9951**	**32,7**
1	1	0	0	**3**	**6720**	**9699**	**33,8**
0	0	1	0	**4**	**6465**	**9446**	**34,9**
1	0	1	0	**5**	**6209**	**9193**	**35,9**
0	1	1	0	**6**	**5954**	**8940**	**37,0**
1	1	1	0	**7**	**5699**	**8687**	**38,1**
0	0	0	1	**8**	**5444**	**8435**	**39,2**
1	0	0	1	**9**	**5188**	**8182**	**40,2**
0	1	0	1	**10**	**4933**	**7929**	**41,3**
1	1	0	1	**11**	**4678**	**7676**	**42,4**
0	0	1	1	**12**	**4423**	**7424**	**43,5**
1	0	1	1	**13**	**4167**	**7171**	**44,5**
0	1	1	1	**14**	**3912**	**6918**	**45,6**
1	1	1	1	**15**	**3657**	**6665**	**46,7**

Table 12:Binary/Decimal conversion table

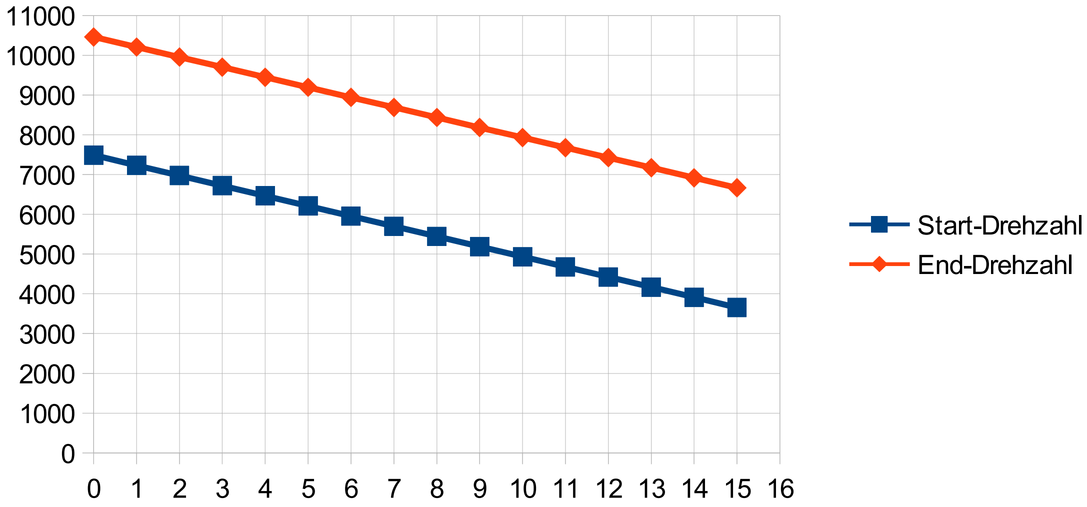


Figure 127: Graph for start/end rpm

As you see this both correlates within some measurement and also individual PV box tolerances and that's the reason why both measurements are not 100% identical.
I have a designated YPVS tester at home and checked the Rempfer table with an own DIP converted box. So I'm able to confirm that table with my own measurement.

Practical experiences:

- Solder with caution and let it cool down during your work.
  The IC does not like huge amounts of heat and I already destroyed one in trying a DIP conversion.
- The F2 (German 1WW) pipes have a peak rpm of 8500-9000 rpm (depending on the cylinders used). The most successful end rpms used were in the range of 8200 – 8500.
- The cigar-style 31K pipes have a higher peak. Here we used end rpms of around 8500-9000 rpm.
- The RD500 opens MUCH too early.
  With stock pipes you benefit from a higher end rpm in the 9-10000 rpm range.
  When using for example JL pipes I found that the “RD500 Boulter” setting from BDK was very beneficial to cure the giant midrange dip in the performance curve. That would be a start rpm of 7500 and an end rpm of 10.500.
- On the TZR250 BDK reported a earlier opening to gain performance (9000 instead stock 10000)
- If you use some unknown pipes on RZ based engines, I found that the end rpm should be some few hundred less than the peak performance rpm. For my DIY pipes they peaked at some 9300-9700 and thus I used PV end rpms of some 9000-9300.

- Personally I have not tested much with the opening angle. I have reports that there is a noticeable effect.
- In earlier applications I experimented with a deeper closing of the valve which was beneficial for low end torque. On the other hand it caused undesired effects like partial load bogging at low/mid rpm.

FAQ's:

- Is a fully programmable box worth the extra money ? (Ignitech STPS or Zeeltronic PPV, or even a CDI/PV combo-box)
  In any case yes, because the form of the opening curve can influence the engine characteristic very much. Adding ignition advance will enhance performance even more.
  You just need to be able to read a wiring diagram, solder cables and use a PC software to program the curves.
- If you fix the PV to fully open; is there a difference in peak performance compared to optimized PV start/end rpms ? Theoretically the peak HP should not be affected ?
  Funnily the answer is yes. In several measurements and simulations you can see an increased peak performance with optimized PV actuation rpm's even after the PV is already fully open.
  I cannot explain that effect, but it is existing!

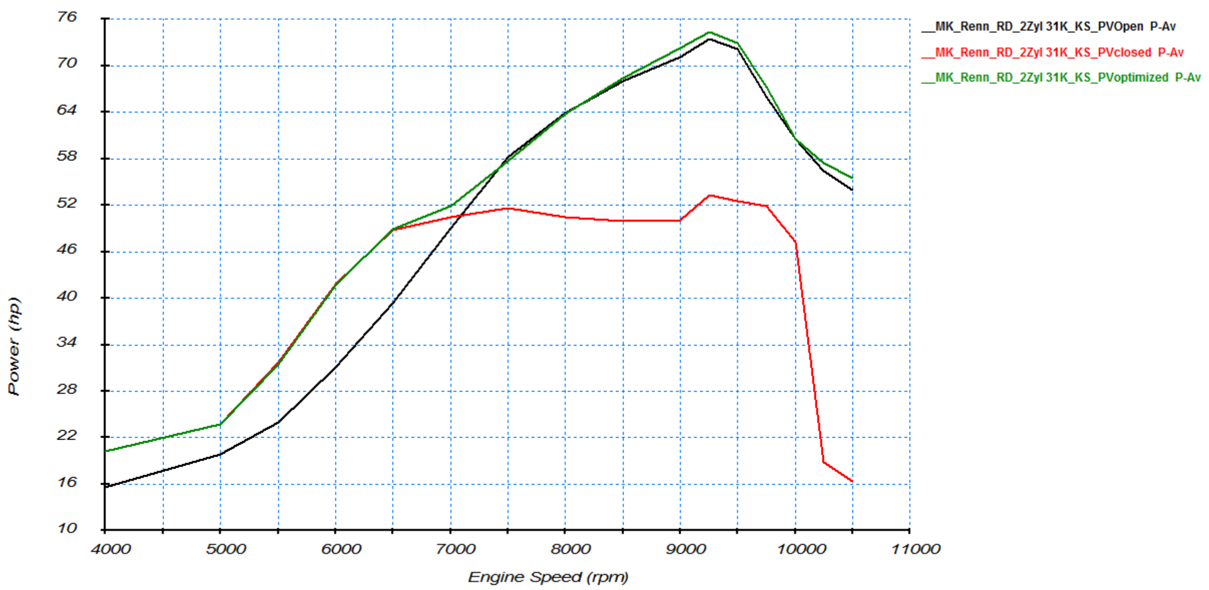


Figure 128: Simulation PV closed/open/optimized

The mechatronic side of the system is a simple servo motor that has a small gearbox with a position sensor (potentiometer) telling the controller box what angle the spool has.
It always has 5 cables (2 for +/- 12V and 3 for the potentiometer)

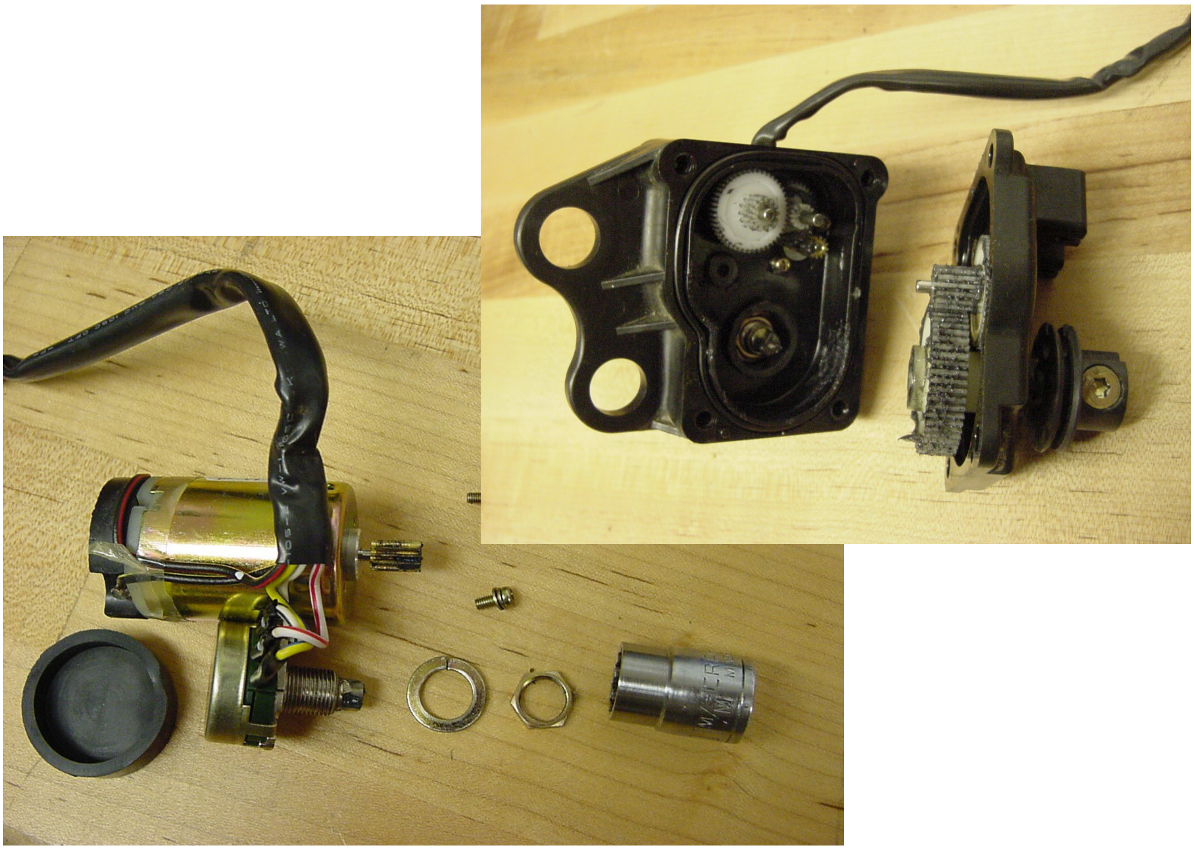


Figure 129: Servo motor surgery

If it fails then it's a

- Damaged graphite track on the potentiometer; especially around mid-position (= peaky signal for the controller, jerking operation when constant position required)
- Damaged motor (= dead system, does not turn at all)

If you need to replace yours or you seek some lightweight alternative you're not fixed to Yamaha parts. Every motor that follows that principle would do

- RD500
- TZR250
- RGV250
- RC-servos
- FZR1000 Exup
- Exhaust flap servo R1/R6
- Exhaust flap servo Ducati

For all the parts it's required to get the wiring diagram of the bike and measure which cable does what, because that can be different. As the spool diameter can be different it may become necessary to change the actuation angle.
On my race bike I use a RGV250 servo since my stock servo quit working.

Programmable Power-Valve controller

If you don't have a programmable ignition with an integrated PV controller, there is also standalone PV controller boxes that can be used independently from the ignition.
Zeeltronic.com offers the so called PPV. It holds a curve opening in % vs rpm.
The 0% and 100% position is adjustable, so you can realize any opening angle that is mechanically possible.
In my RD's for example a deeper close position turned out beneficial for low end torque (made 40 Nm @ 5000 and that's what a stock RD has as max value).
The programming work is done by the same handheld or PC cable that is used for the ignition.

In my own experiments I found a S-shaped curve (like Tuning 1 in the next pic) made the engine somewhat more “explosive”. The linear variant (Tuning 2) made the torque delivery also linear (= as dull as a 4 stroke).
For the F2 pipes I started at 5k and ended at 8.100 rpm.

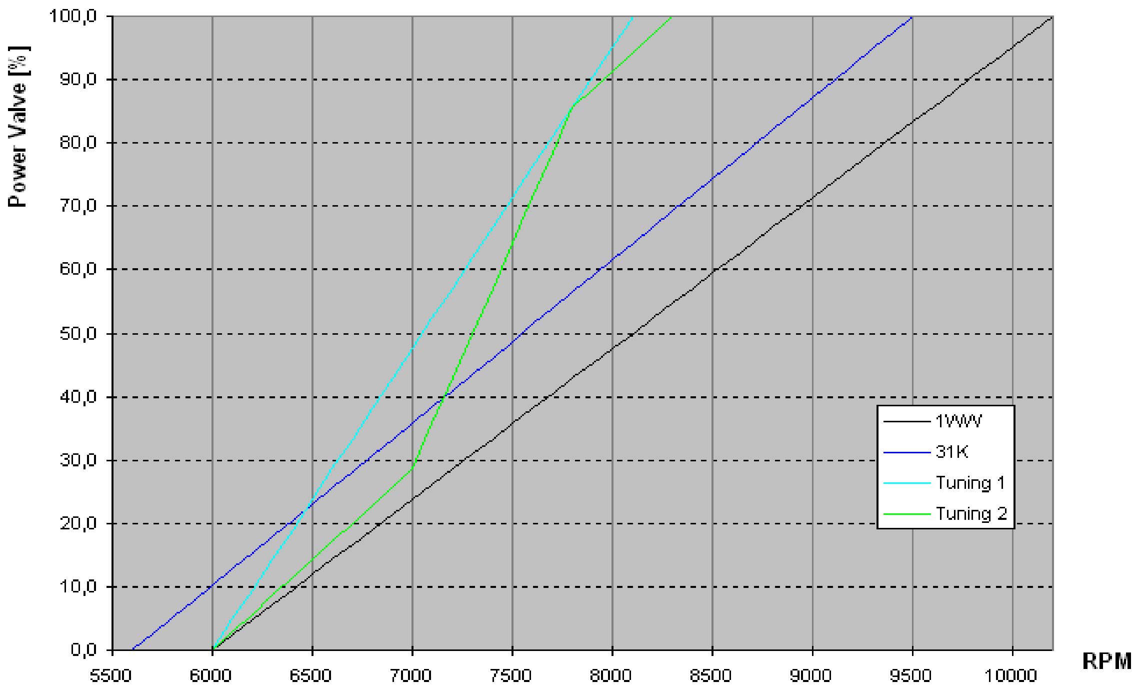


Figure 130: PV-curves (Source: Hans Krieger, Aachen)

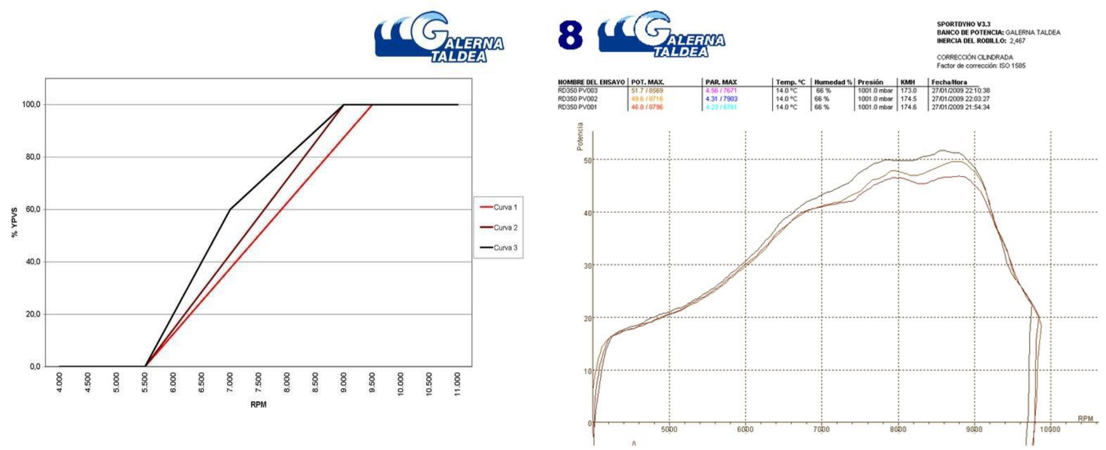


Figure 131: Dyno and PV curves using Zeeltronic PPV (Source: Galerna Taldea)

An alternative product is the STPS from ignitech.cz.
Here you can use an additional TPS input to control your PV with a map servo voltage vs. rpm vs. throttle position.
I tried to do things like opening the PV at high rpm and low TPS like you have it when braking if you approach a curve. It should put some heat in the pipe to be able to accelerate better after the apex but I couldn't really feel an effect.

As the algorithm is controlling servo voltage a bit more thinking is required than having opening %.
As a compensation you save some $$ by being able to use a cheap USB2Serial cable to connect the box to your Laptop.

Koso dashboard

Koso offers several nice, small and lightweight dashboards with tach, speedo and gimmicks like water temp and shift light.
They're not exactly a bargain (150-350 Eur), but the really cheap Chinese copies are not electrically compatible and you'll need some more try and error.
Same applies for the EGT gauges. Unfortunately the Koso sensors are not of the best type, sou if you manage, just get the gauge and buy the K-type sensors separately (www.sensorshop24.de).

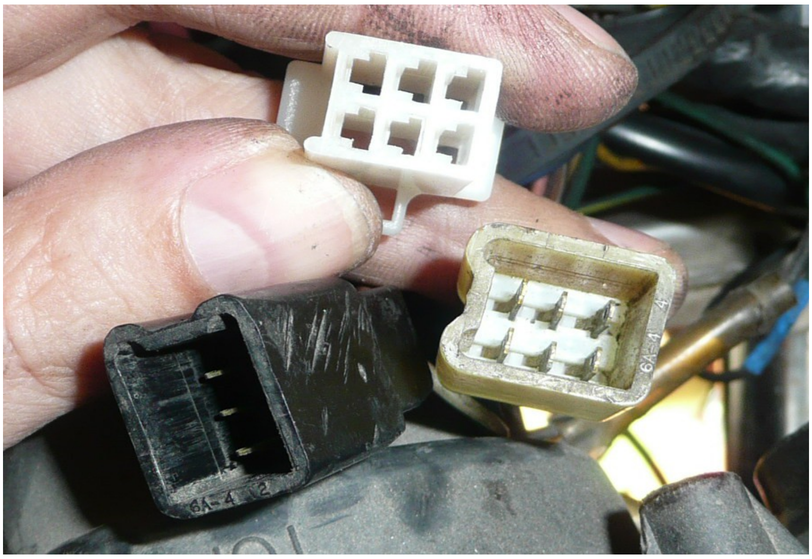
To connect the gauges with the RD harness you can get the plugs at louis.de (JAPAN-SYSTEMSTECKER-SET, 108-TEILIG, Order Nr:10003843).
The 31K dashboard has two plugs: 1 black and one white – the mentioned cables will be found mostly on the black plug.

Figure 132: Koso RX1N and EGT-gauges

Koso	**RD**
Red	Connect to + on battery
Brown	Brown (ignition +)
Black	Black (ground)
Yellow	Yellow (Hi – single bullet-connector)
Blue	Dark-Green (Signal R)
Orange	Dark-Brown (Signal L)
White	Sky-Blue (Neutral)
Grey	Black-Red (Oil)
Brown	White-Green (tach)

Table 13: Connection Koso RX1N to 31K harness

Figure 133: Connectors 31K and Louis (10003843)



If you connected the hardware, you need to program some settings.
In the tach area that's “2C 2P (2 Cylinder , 2 Piston) and impulse to “Hi”. This setting works with the a couple of tach signals: gray cable on the stock tach, black-yellow on stock CDI or purple on the Ignitech.

The most annoying problem if you fit any speedo to your bike is gluing some magnets and attach a sensor with a DIY bracket. Koso offers a very elegant solution: a speedo adapter that fits plug & play instead of the stock speedo cable.

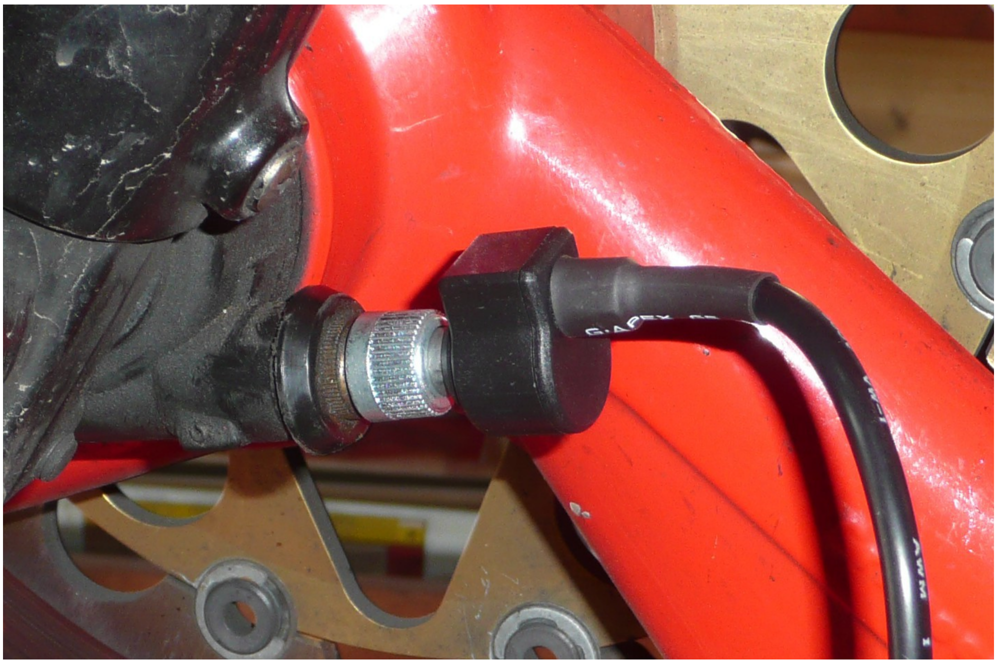


Figure 134: Koso adapter to create a speed signal

The adapter creates 6 signals per rotation of the internal shaft. You have to multiply that with the transmission ratio of the worm gear.
For example if one wheel rotation creates 3 shaft rotations, you end up with 6 * 3 = 18 Signals per wheel rotation.
Now enter the tire circumference (which was 1836 mm with a 110/70ZR17 on a 2.75 rim).
You can use a second vehicle for calibration, a GPS navigation system or simple smartphone apps that show just the current speed over ground. If the speed doesn't match, correct the number of signals and/or the circumference value.
I my case I ended up with 16 signals as the entered value.

The rest is simple mechanical work and the reward is a modern style gadget in addition with some ½ kg weight saved.

Driving Resistance

If you want your bike to run faster you can either increase engine performance or you can use the small amount of power in a more economic way.

If you put in a 100% of energy (=fuel consumption) there are only some 25% which you can use for moving your bike somewhere else. These 25% have to compete against the driving resistance which consists of:

- Drag resistance
- Mechanical grade of efficiency
- Rolling resistance
- Acceleration resistance

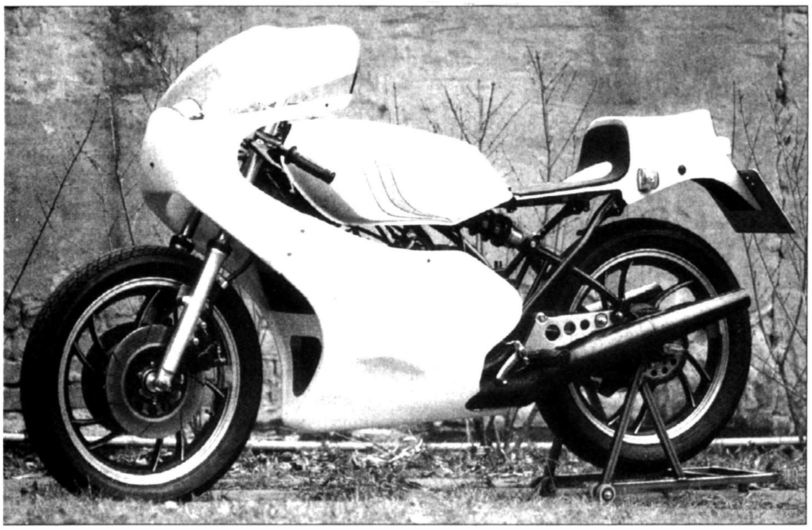
At each time you ride the sum of engine output equals the driving resistance. At lower speed the drag is low too so you can accelerate quite fast (great acceleration resistance). At high speed the drag eats up the whole engine output and the possible acceleration is almost zero.

To show you the potential which is hidden in this chapter I'd like to give you an example:
In an article in the German magazine "mo" (9/84) they presented the RD350LC of Bernd M. Hilla from Berlin. As I knew him I can confirm the given info.

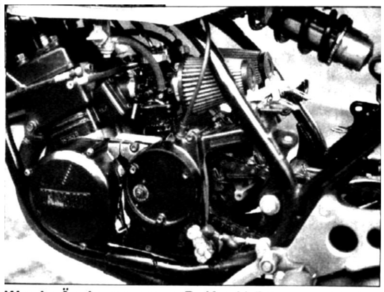
In stock condition a RD350LC is good for about 43 - 44 rear wheel HP and about 185 - 190 km/h. Bernd carefully (pedantic to be more precise) adjusted ignition, mixture and carb-setup which resulted in 53,86 HP at 8770 rpm (measured at the back wheel on a Mitsui dyno).

Despite the TZ fairing he managed to reduce weight from 165 kg to 137 kg. He used all tricks to reduce friction as a non-o-ring-chain or bearings without seals.
To reach a higher speed with low engine revs he had to use a quite long transmission ratio.

The result was convincing: Measured 220 km/h at the Berlin Avus motorway (10 km straight, three lanes, no speed limit).
Without the whole optimising he would have reached about 205 km/h with 54 HP or he'd have needed 67 HP for reaching 220 km/h.



Die Verwandtschaft zur Serienmaschine ist dieser Rennmaschine anzusehen, wenn sie auch mit Verkleidung, Sitzbank, Lenkerstummel und durch Abbau von Straßen-Teilen von 160 auf 137 kg erleichtert wurde. Ein Rennen kann man damit nicht gewinnen, aber viel Spaß haben – und genau darauf kam es dem Besitzer an



Wenig Änderungen, z.B. K + N-Filter, am Motor

Figure 135: Hilla-RD350LC (Magazine “mo” 9/84)

Drag Resistance

The drag resistance (in HP) is proportional to the third power of the vehicle velocity.
For better imagination I’ll give you an example: A motorbike of the make Yosukawonda ZXY750 has a drag resistance of 10 HP at 100 km/h. If you double speed you have an eight (2^3) times higher drag resistance! In this case you’d need about 80 HP for 200 km/h.
So it’s quite clear that if you want to reach high speed you’ve some work to do in the field of aerodynamics.

As anyone will know drag depends on the product of vehicle shape cross section and an aerodynamic value called C_w.
You can influence both by using a slim fairing but this is lot’s of work.
Many shops offer race fairings for several bikes, some even in carbon fiber. At Sebimoto for example you could get a Ducati 916 fairing for about 850,- DM in fiberglass or 1600,- DM in carbon fiber.
As the models from ’85 or later have the fairing mounts welded at the frame, it’s easier to fit fairing here.
The former TZ250/350 fairing is used quite often in Germany but it’s a race part and you’ve to clamp the handlebars very low. So the drivers position "upright" is cancelled and changed to the position “smell some fuel”.

If you have a fairing model you can modify it the following way:

- Smaller (or even no) mirrors
- Smaller (or even no) flashers
- Shorten the windscreen and lower handlebars

But: Don’t destroy the whole work by driving in jeans and fancy jacket. A good leather suit which fits not only protects you better from injury but also assists optimum top speed!

Driveline

Most of the losses here are caused by a dry chain. Missing lubricant can cost you up to 5 km/h at top speed.
All racebikes use chains without O-rings and mostly in a quite small dimension (520 for 250 cc and 500 cc). The difference with or without O-rings is about 1 – 1.5 rear wheel HP. If you have an old LC you can use the YPVS front sprocket and a custom made rear one to use a 520 chain.

I felt that the new X-ring chains have less friction compared to standard O-ring chains. This would be an alternative for those who want to maintain street use.

To optimise gearbox losses use the lowest possible amount of low-viscosity gearbox oil (I use Bel Ray MC-4).

Rolling Resistance

Rolling resistance is caused by the wheel bearings, the not 100% released brake pads and the tire rubber being deformed while the wheel spins under load.

The biggest share is held by the tires, but you can improve that point by using a harder rubber compound (bad for cornering!) or increase tire pressure about 0,5 to 1 Bar (obstructs tire warming during operation = bad for cornering!).
The rolling resistance is also reduced if you decrease wheel loads which means to get rid of some “unnecessary” parts of your bike (see next point).

If you have a look at modern 125 cc bikes like the Cagiva Mito you will see that these ones have no wheel bearing seals and even open bearings (without cover) in the race versions. If you let these wheels roll free they keep spinning for a very very long time ... .

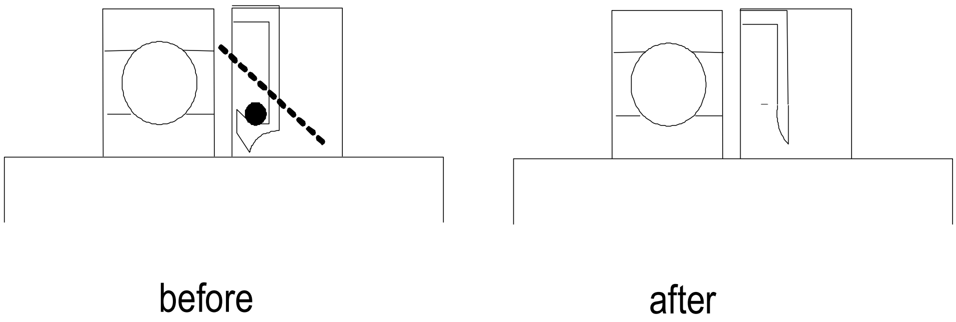


Figure 136: oil seal modifications

To copy this in your RD just use special wheel bearings and remove the stock oil seals. If you only ride in dry conditions and maintain it regularly you can also remove the bearing's integrated covers. Maintain means to lube it with some motor oil because if you use plenty of bearing grease it will be hurled out during rotation.

	stock (standard bearings)	low friction (larger clearance)
Wheel bearing front	6301 2RS	6301-C3
Wheel bearing rear	6302 2RS	6302-C3
Bearing sprocket holder	6304 2RS	6304-C3

As mentioned before the state of you brake system influences the rolling resistance. If the pads are not released 100% after braking you will have a residual brake torque of up to 10 Nm (this destroys about 3 HP at 230 km/h).

The stock '83 31K are very sensitive to bad maintenance because of the floating single-piston calipers. The floating slides can become tight which results in high pad wear, high disk temperatures and high rolling resistance.
If this occurs you have to perform a cleaning or overhauling operation.
To clean the piston in the caliper remove one at a time from the fork and press the brake lever slightly a few times to get the piston about 5 mm out of the caliper (not too much, because if it slips completely out you will have an awful mess and you must rebuild the caliper!)
Then clean the piston with brake cleaner spray or air pressure and push it back into the caliper with the help of two big pliers. Repeat this once or twice to be sure all the dirt is removed.
If you have the twin-piston calipers of the later models you can do the same proceedings but you may have to block one piston with pliers when pumping the other out.

Weight

For the purpose of race use the weight reduction is an essential part of the necessary modifications. On a stock street bike there is plenty of scrap to remove.
The first 15 – 20 kg are quite cheap but after that a rule of thumb says that every additional kg costs about 1000,- DM.

- For race use remove all street parts as: mirrors, flashers, lights, horn, ignition switch, main- and sidestand, plastic covers, coolant surge tank, …
- Use no instruments or just small ones like Koso
- Race fairings are much lighter than stock ones, especially if you use carbon fiber. In addition they improve aerodynamics.
- Change nuts and bolts which are not important to aluminum type. The suspension and main chassis ones can be made out of titanium.
- Replace steel mounts by aluminum or carbon fiber.
- The rear subframe can be cut off and replaced by an aluminum version (saves 1.5 – 2 kg)
- A simple DIY aluminum fuel tank saves about 2 kg
- Magnesium rims are a few kilograms lighter than stock rims
- Jolly pipes save 3 – 4 kg per pipe compared to stock material
- Getting rid of the oil pump and tank (use pre-mix 1:30) gives you another 2 kg and an additional good look (free sight below seat).
- If you use a DC CDI, you can get rid of rotor/stator and use a LiFePo battery with a total loss setup (saves around 4 kg, 4800 mAh last for around 1-1 ½ h of riding)
- If you keep the generator, you can scrap the lead battery and use a huge capacitor (30.000 microF)
- '99 R6 front fork/wheel/brakes save 6 kg over the same parts from the RGV250

Figure 137: DIY aluminum tank and subframe

Counting Sprockets

The transmission ratio should match the performance characteristic of your engine to the most common driving situations.

A shorter secondary reduction ratio is needed when you usually drive around town or you live in a region with nice small road or if you've got a speed limit to follow.
The Advantages are:

- Good acceleration / good draft to Vmax
- Can hold Vmax even with worse conditions (headwind/uphill)
- Very good for Wheelies

Disadvantages would be:

- High engine revs during long distance travelling (very bothering)
- Doesn't get faster with good conditions (tailwind/downhill)
- Rev's up to or more than redline on straights

The longer ratio is recommended when you usually drive on unrestricted motorways (or if you p..s on restrictions). If you do so you shouldn't bother to lay down quite often to reach (or to hold) top speed

The Advantages are analogously:

- Gets very fast with good conditions (tailwind/downhill)
- Moderate engine revs (convenient for long trips)

Disadvantages would be:

- Less acceleration (more work to spend on shifting gears)
- If awkward conditions occur you must shift down to 5.'th gear
- Obstructs Wheelies (My favourite KO criteria for undoing mods)

Figure 138 gives you an example of what the secondary gear ratio can do in an engine which has almost stock rev level.
In the diagram you can find the drag resistance for the "naked" RD's without wind and with head/tailwind next to the engine performance curve with long (18/41) and short (16/39) transmission ratio.
At the point of max. engine performance you reach 187 km/h at 9.900 rpm (Mark 3) with the short one; the top speed of 192,5 km/h is reached at 10.200 rpm (Mark 4).
The long one reaches top speed of 197 km/h (Mark 5) at 9750 rpm (nearly at the speed of max. engine performance).
If you got a 15 km/h wind coming from the front direction the short version descends to 181 km/h (Mark 2) whereas the long one falls dramatically to 176 km/h (Mark 1), which means you'll have to use 5'th gear!

If you make a U-turn to get the 15 km/h wind from rear direction the long version can push up to 203 km/h (Mark 6) at 10 grand, whereas the short one starves at 192,5 km/h (Mark 4) because it's the engines rev limit!

Naturally there are physical limits about the desired top speed. Don't expect your bike always to run faster when you make the transmission ratio longer. I've a good approximation formula which tells you how much performance your RD requires to get to a desired speed value.

$$V_{\max}(P_2) = V_{\max}(P_1) * \sqrt[3]{\frac{P_2}{P_1}}$$

P1 = performance before (stock); P2 = performance after tuning ; Vmax (P1) = Vmax with performance P1

Table 14 assumes that stock RD's have 59 HP and a top speed of 188 km/h naked and 191 to 192 km/h with fairing (average of several magazine tests). The 1WW is somewhat faster if you use the 18 tooth front sprocket. Top speed climbs to 197 km/h for the 63 HP engine.

Figure 139 displays the necessity of changed transmission ratio if you have major changes in the engine rev limit due to race pipe usage. I assumed a tuning which ended in 75 HP at 11.000 rpm and 3 – 5 HP loss in midrange
In the diagram you can also find the drag resistance for the "naked" RD's without wind and with head/tailwind next to the engine performance curve with very short and stock transmission ratio.
At the point of max. engine performance you reach 204 km/h at 11.000 rpm (Mark 4) with the short one. The stock sprockets result in a top speed of 201 km/h (Mark 3).
Imagine again some slight wind coming from the front: The short version descends to 187 km/h at 10.100 rpm (Mark 2) whereas the long one again falls dramatically to 168 km/h (Mark 1); you'll have to use this f....ing 5'th gear again!
If the wind comes from the rear direction (I always feel wind comes from the wrong direction) the long version can push up to a fantastic 219 km/h (Mark 6) at 11.000 rpm, whereas the short one also reaches quite a good 211 km/h at 11.500 rpm (Mark 5).

So you see that a shorter transmission ratio is essential if you use race pipes without dramatically tuned engines. With stock sprockets the acceleration in the lower gears seems to be good, but you'll say the bike rides a little bit tired in 6'th gear and doesn't reach max. revs.
With the short ratio it's all blown away. The acceleration will nuke your opponents out and the top speed is also higher than before!

For these high revs I'd strongly recommend pistons with thinner rings than stock. The stock rings are limited to 10000 – 10500 rpm due to max. tolerable acceleration values. At higher revs they can tilt in their groove and may break. I've seen this in several high revving engines with stock/Prox pistons!

V_{max} [km/h]	Performance without fairing [HP]	Performance with fairing [HP]
188	59	54,7
190	60,9	56,5
192	62,8	58,3
194	64,8	60,1
196	66,8	62
198	68,8	64
200	70,9	65,9
202	73	67,9
204	75,2	70
206	77,4	72
208	79,7	74,1
210	82,2	76,3
212	84,6	78,5
214	87	80,8
216	89,5	83
218	92	85,4
220	94,5	87,8
222	97,1	90,1
224	99,8	92,6

Table 14: Required performance for 31K/1WW without/with fairing

In Germany you can get front and rear sprockets in several sizes:

17, 18, 19 Yamaha
15, 16, 17 Hein Gericke
38 / 39 / 41 Schuh
40 AFAM / PVM
13, 14, 15, 16, 17 Götz
36, 37, 39, 41, 45

At several stores you can get sprocket ruffians without mounting holes for a 520 chain. At Götz they have 40,42, 44, ..., to 56.
At all YPVS you can use the TZR/TDR 250 rear sprockets, too.

A front sprocket should cost around 10,- to 15,- Euro , a rear one around 30,- Eur in steel and around 50,- Eur in aluminum.

By the way: The front sprocket is identical with the KAWASAKI KX500 (> 91). So if you're out for a very short ratio you should see you Moto-Cross dealer ...

If you change the total amount of teeth for more than two or three teeth, you may have to cut the chain or use a longer one. Anyway I'd recommend a 108 to 110 link chain if you use a 120/80 tire. A secondary effect is the longer wheelbase (1 to 1,5 cm) which gives slightly more high speed stability.

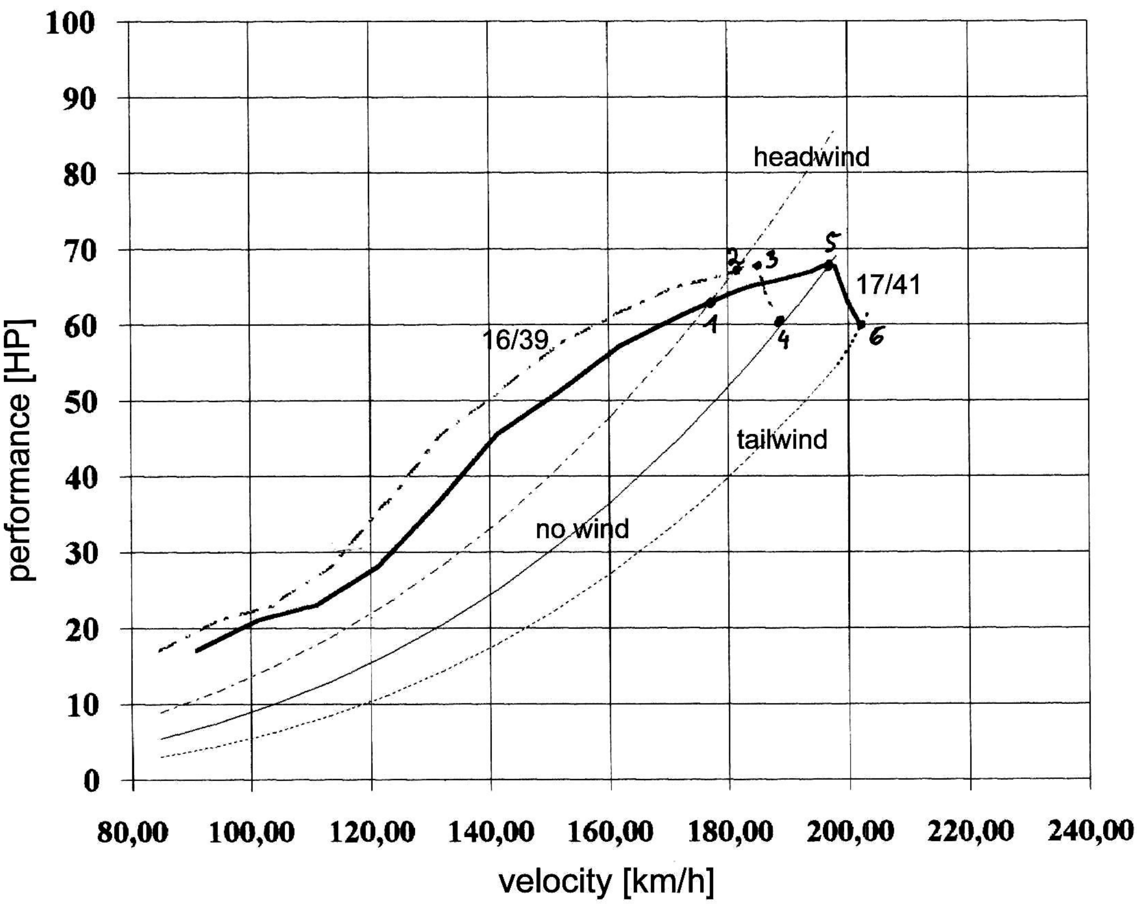


Figure 138: Ratios with stock rpm level

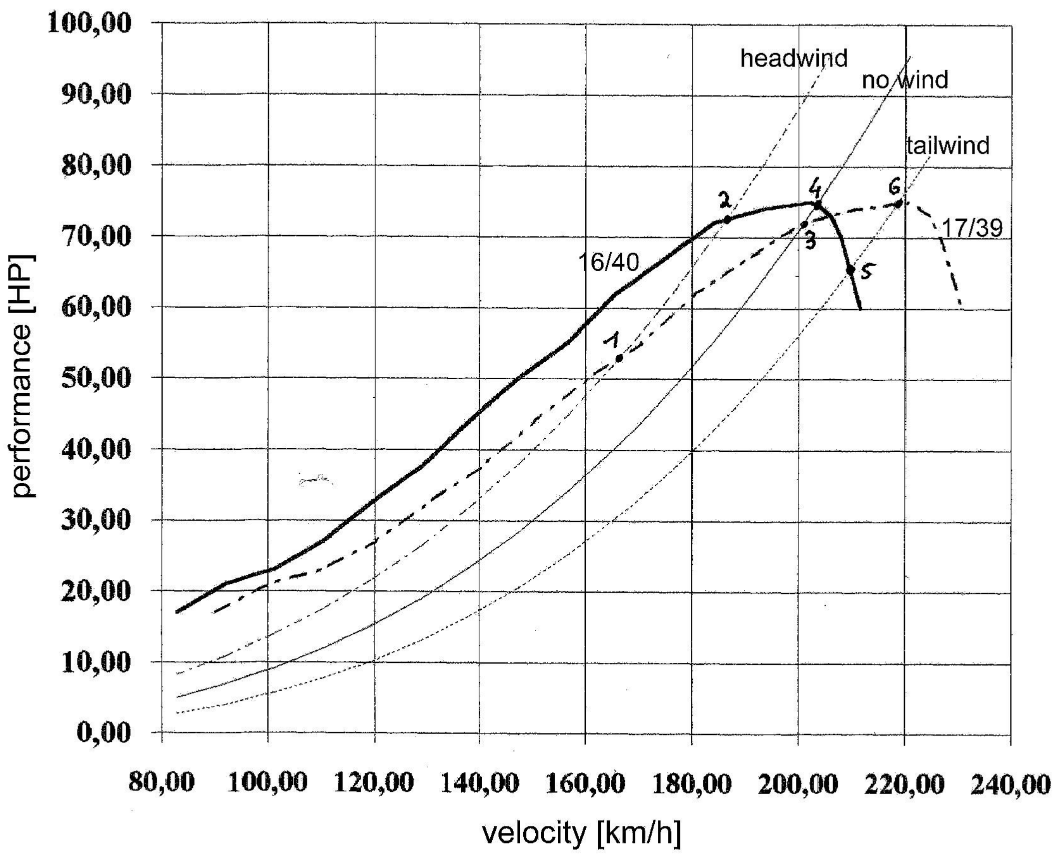


Figure 139: Ratios with much higher rpm level

Rpm	17/39 Stock	18/41 0,7% longer	17/38 2,5% longer	18/40 3,1% longer	18/39 5,5% longer
3000	60,2	60,6	61,8	62,1	63,7
4000	80,2	80,8	82,4	82,8	85,0
5000	100,3	101,0	102,9	103,5	106,2
6000	120,4	121,2	123,5	124,3	127,4
7000	140,4	141,4	144,1	145,0	148,7
8000	160,5	161,6	164,7	165,7	169,9
9000	180,5	181,8	185,3	186,4	191,2
9100	182,5	183,9	187,3	188,5	193,3
9200	184,6	185,9	189,4	190,5	195,4
9300	186,6	187,9	191,5	192,6	197,5
9400	188,6	189,9	193,5	194,7	199,7
9500	190,6	191,9	195,6	196,7	201,8
9600	192,6	194,0	197,6	198,8	203,9
9700	194,6	196,0	199,7	200,9	206,0
9800	196,6	198,0	201,8	202,9	208,2
9900	198,6	200,0	203,8	205,0	210,3
10000	200,6	202,0	205,9	207,1	212,4
10100	202,6	204,1	207,9	209,2	214,5
10200	204,6	206,1	210,0	211,2	216,6
10300	206,6	208,1	212,1	213,3	218,8
10400	208,6	210,1	214,1	215,4	220,9
10500	210,6	212,1	216,2	217,4	223,0
10600	212,6	214,2	218,2	219,5	225,1
10700	214,6	216,2	220,3	221,6	227,3
10800	216,6	218,2	222,3	223,7	229,4
10900	218,7	220,2	224,4	225,7	231,5
11000	220,7	222,2	226,5	227,8	233,6

Table 15: Longer ratios for RD's

Rpm	17/39 stock	17/40 2,5% shorter	16/38 3,5% shorter	17/41 5,1% shorter	16/39 6,25% shorter	15/38 10,4% shorter
3000	60,2	58,7	58,1	57,2	56,6	54,5
4000	80,2	78,2	77,5	76,3	75,5	72,7
5000	100,3	97,8	96,9	95,4	94,4	90,8
6000	120,4	117,4	116,3	114,5	113,3	109,0
7000	140,4	136,9	135,6	133,6	132,2	127,2
8000	160,5	156,5	155,0	152,7	151,0	145,3
9000	180,5	176,0	174,4	171,7	169,9	163,5
9100	182,5	178,0	176,3	173,6	171,8	165,3
9200	184,6	179,9	178,3	175,5	173,7	167,1
9300	186,6	181,9	180,2	177,5	175,6	168,9
9400	188,6	183,8	182,1	179,4	177,5	170,8
9500	190,6	185,8	184,1	181,3	179,4	172,6
9600	192,6	187,8	186,0	183,2	181,2	174,4
9700	194,6	189,7	188,0	185,1	183,1	176,2
9800	196,6	191,7	189,9	187,0	185,0	178,0
9900	198,6	193,6	191,8	188,9	186,9	179,8
10000	200,6	195,6	193,8	190,8	188,8	181,7
10100	202,6	197,5	195,7	192,7	190,7	183,5
10200	204,6	199,5	197,6	194,6	192,6	185,3
10300	206,6	201,5	199,6	196,5	194,5	187,1
10400	208,6	203,4	201,5	198,4	196,4	188,9
10500	210,6	205,4	203,5	200,4	198,2	190,7
10600	212,6	207,3	205,4	202,3	200,1	192,6
10700	214,6	209,3	207,3	204,2	202,0	194,4
10800	216,6	211,2	209,3	206,1	203,9	196,2
10900	218,7	213,2	211,2	208,0	205,8	198,0
11000	220,7	215,1	213,1	209,9	207,7	199,8

Table 16: Shorter ratios for RD's

I did my gearing calculations with a freeware called geardata. It has a submodule chaindata that can determine necessary chain length for the chosen sprockets.

The driving performance can be done with other Software like Dynabike! Here you could simulate for example the acceleration curve for a quarter mile and check what change in the engine hp would result in which difference in time.

Both could be found via a search engine.

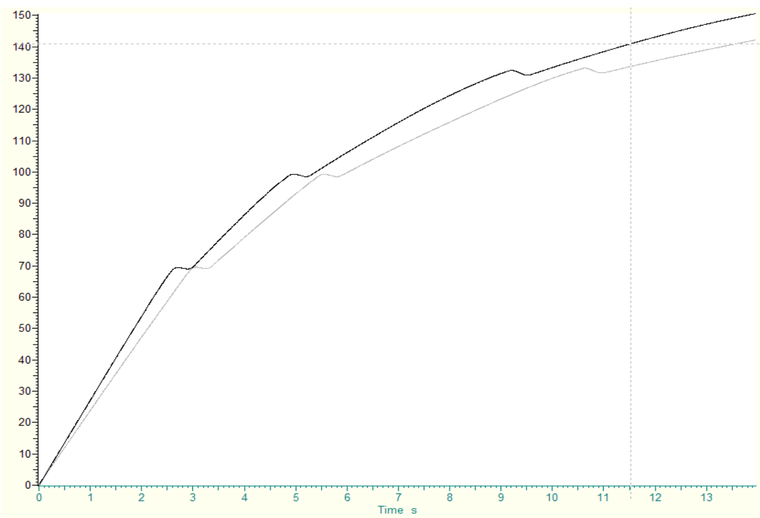


Figure 140: Dynabike quartermile simulation for 2 RD variants

Chassis

The RD's are most famous for two things: Being very fast on small roads where cornering is more important than top speed and having a severe high speed weave problem.

Both are true and in my experience high speed weave is mostly caused by too low weight on the front wheel combined with an excitation from the tire-to-road and/or wind-to-bike interaction.
As a consequence the fairing-models don't suffer as much as the naked ones. If you own an '83 model you should consider getting rid of the dead ugly steering-fixed fairing, because this is a very good excitation for high speed weaves.

But there are some other factors you should watch:

- Tire profile (especially at the rear below 3 mm) and pressure
- Steering head bearing (worn / too stiff/loose / wrong assembly) (special "zero-tolerance" bearings available from Emil Schwarz)
- Fork (oil-type and -level, pressure different left/right)
- Swingarm (worn bearings)
- Rear shock (worn, insufficient damping)
- Too little weight on the front wheel (running low fuel, upward driver position while high speed driving)

Figure 141: The author at tire testing (RD rally, Lichtenberg 2015)

Tires

In my opinion the stock YOKOHAMA/DUNLOP tires are not worth a single penny and they wear faster than you can watch them. Meanwhile there are only few manufacturers that sell the small 18 inch tires suitable for the RD. Most German RD riders use Bridgestone BT 45.
You can use the stock dimensions 90/90-18 and 110/80-18 if you use it for everyday riding and you are not going that fast.

In Germany other tires have to be approved by the TÜV; you can get the necessary papers directly from Bridgestone. The sizes are:

Front	Rear
BT45 F 100/80-18 53H	BT45 R 120/80-18 62H
BT45 F 100/90-18 56H	BT45 R 120/90-18 65V
	BT45 R 130/80-18 66V

My tip for sporty/race drivers: Use 100/80 and 120/80. The 100/80 improves handling compared to the 100/90.

I'd dissuade from the 120/90 or 130/80 dimensions, because they won't get up to temperate during riding. If you have a fluent driving style they offer a quite good grip but they have a tricky to cope with sliding characteristic. If they lose grip, they lose it in an instance and the rear wheel performs the slide of your life. This occurs when the tires are cold and/or you try to perform hard acceleration during cornering.

Suspension

The stock suspension doesn't offer many opportunities for adjustment.
At the rear end I was always running on hardest position, because of missing cornering clearance. For the fork's I used self-made spring adjusters which were variable from zero to 50 mm (you can use spacers, too). If you want it harder, do not use heavier oil types, but increase the oil level in the fork. The reduced air chamber gives you a better progression at the end of the spring travel.

If you didn't spend all your money on tires you should get yourself some White-Power (Technoflex, Öhlins, ...) stuff.
The fork springs don't need air support in the fork, if you combine it with the required oil levels of 150 mm (31K) and 140 mm (1WW) with SAE10 WP-fork oil. The oil level (actually the length of the air chamber above the oil level) is measured when it's pressed completely down with removed spring.

As the stock shock is scrap after 20.000 km I prefer the rebuildable White Power EMU shock. This is the road-use type which can only be adjusted in pre-load (bolt nuts on thread) and rebound damping (11 steps). To adjust the spring pre-load you have to determine the negative wheel travel (35 mm difference between unloaded state and with driver in normal position). The damping varied from click 2 to 9 in road use.

Brakes

The stock YPVS brakes are one of the stronger features of the RD’s, especially the dual-piston types used after ’85.
I used several brake lining makes and all were more or less usable. Meanwhile I’d recommend using race types (available from several manufacturers like Ferodo, EBC, Girling, Brembo, ...) because they improve brake efficiency (at the cost of reduced life-cycle).
In long-term average my linings lasted between 20 and 25.000 km at the front and between 6-12.000 km at the rear. Race pads wear much quicker, they can be down after only 1000 or 2000 km!

Compared to the stock rubber hoses, steel braided ones significantly improve brake actuation accuracy. Prices vary very much on quality (aluminum, stainless steel, adjustable or anodised banjos) and quantity (2 or 3 hose kit). If you trust your own work, you could make them on your own. Some companies offer universal kits which have to be screwed together (the other kits were pressed).

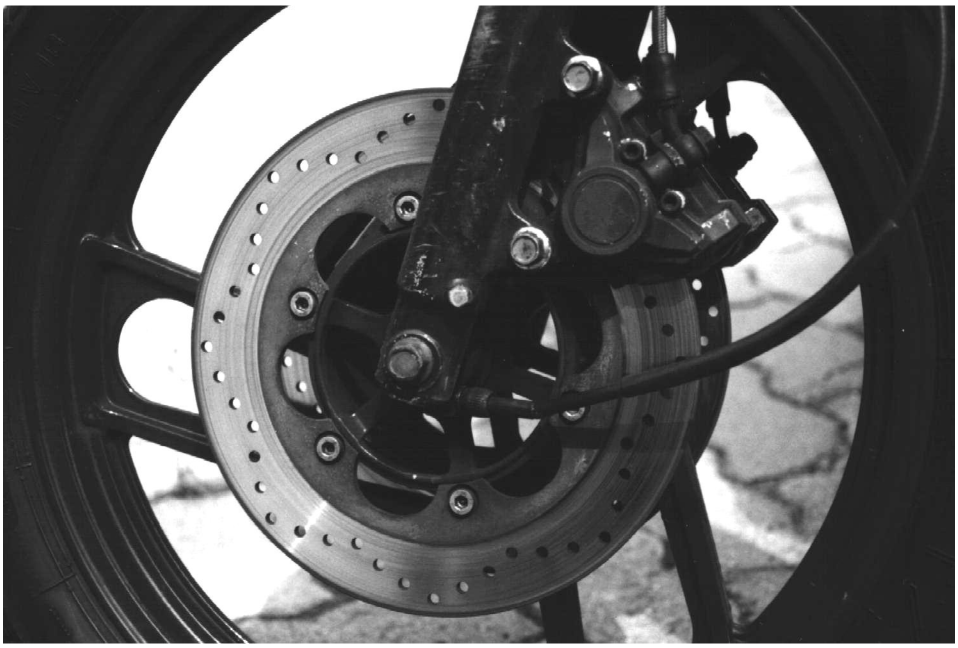


Figure 142: Brembo cast iron disks

If you are about to replace worn stock discs you should use the Brembo or Spiegler cast-iron disks for the RD's. They offer better high temperature fading resistance and they are delivered with special high-friction brake pads (Price: approx. 320,- DM a set).

If you prefer using the best, choose the ABM floating discs for the RD (about 800,- DM a set). I'd only recommend them if you undergo extensive racing activities, otherwise the Brembos are the better choice

A very cheap possibility to improve brake lever actuation force is to use the RD500/XJ900 calipers. Mostly they are easy to get, because many RD500 owners swap their fork to FZR or other 17 inch rimmed types. They have a bigger piston diameter (42,85 mm instead 38,18 mm) which reduces the actuation force by 10 %. These calipers only fit to the '85 31K and 1WW (which already have dual-piston calipers).

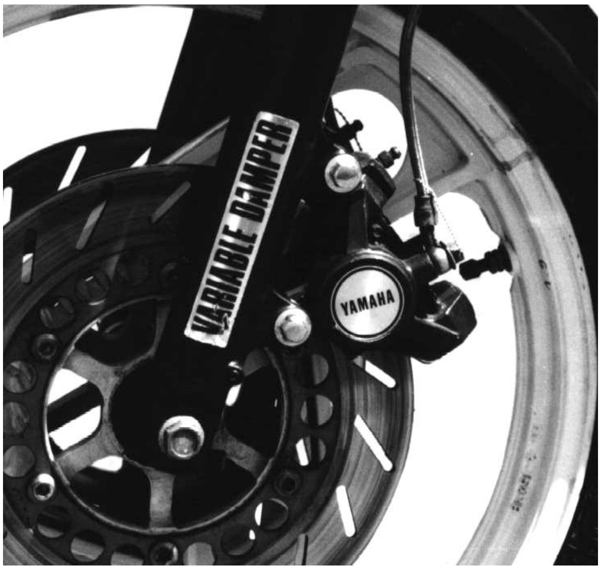


Figure 143: RD500 caliper on 1WW

Miscellaneous

Stock RD's often lack some more cornering clearance when you want to go fast. For this reason most drivers scrap the main stand because it's the first part coming in ground contact. You may keep it on the bike if you just shorten the stopper rubber. This gives you plenty of clearance; maybe sometimes you will hear some scratching noises at the right.

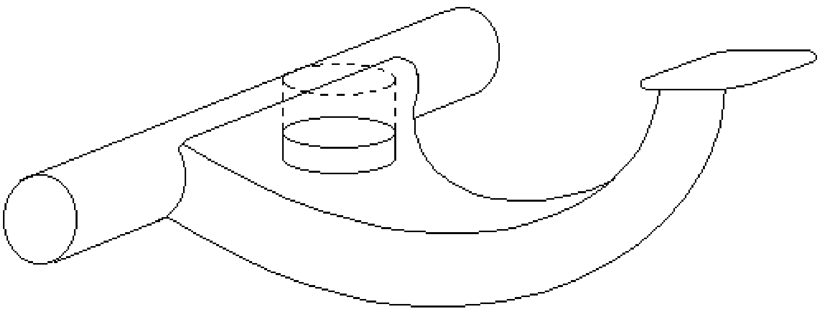


Figure 144: Main stand rubber

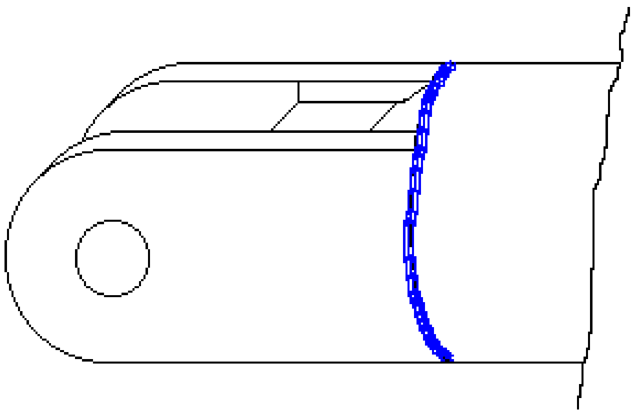


Figure 145: Side stand groove

If you have done this, the side stand will be the next obstacle at left cornering. I modified the endstop between stand and frame. If you mill a 1 or 2 mm groove in the stand it can stop in a higher position. It may be necessary that you bend the shift lever slightly to avoid contact to the side stand.

Now you’re quite near to the maximum tire grip, but sometimes the pipes come in contact with the tarmac. You can cope with it if you mount them a little higher and tighter to the bike.
You only have to modify slotted holes in the brackets with a file and use some three or four washers when you mount it on the bike. When you’ve mounted them check for enough clearance to the swingarm during full spring travel.
Some pipes have a notch to avoid contact with the wheel spindle/nut, you may tailor one with a hammer.

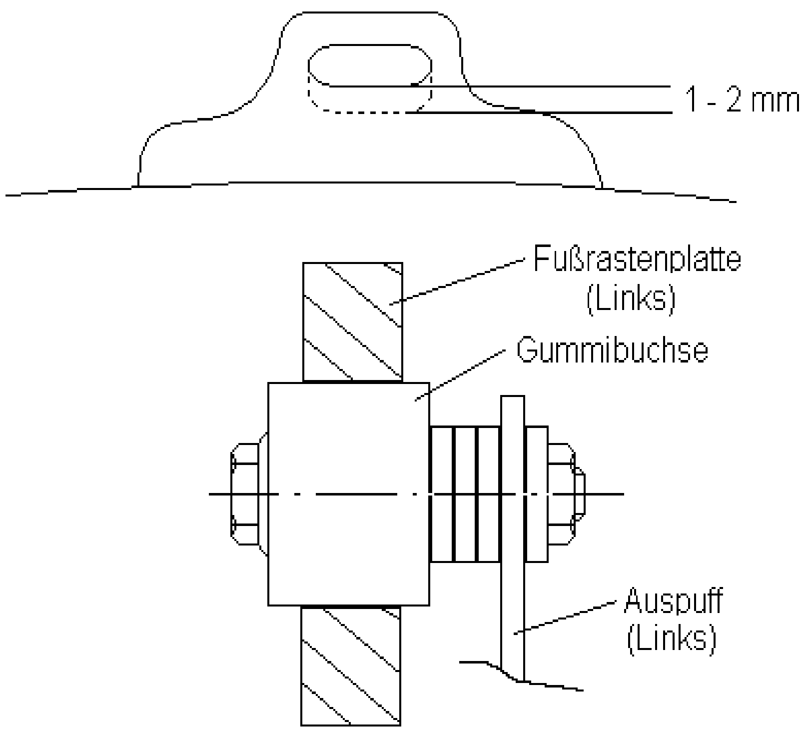


Figure 146: Pipe mounting

Figure 147: Steering damper

On my RD a steering damper is doing a really good job especially on my favorite small roads. After mounting it to the bike I went to my “test track” where it improved the maximum cornering speed from 140 to 150 km/h combined with a fabulous feedback of stability and security.
Originally I used it because of some very nasty kickback effects during hard acceleration on uneven road (sometimes it kicked the handlebars from end position to end position!). As expected this was totally eliminated. Unfortunately it has almost no effect on high speed weaving.
The main disadvantage is the high price and the poor range of available kits (in Germany). The cheapest kits begin at 300,- DM (LSL, but they’re sold out since 10/97). You can try to get used ones and have them rebuilt or you’ve got to make your own brackets using a new damper (about 100 mm stroke).

Models with catalytic converters

USA

Figure 148: RZ catalyst pipes

The catalyst is a device to complete the combustion process begun in the cylinders but left incomplete by the nature of the twostroke engine.
In the application on the US-RZ models a reed-valve opens when pipe pressure falls below atmospheric, admitting filtered air to each pipe. When unburned hydrocarbons (HC) and carbon monoxide (CO) encounter oxygen on the platinum-coated surface

of the catalyst, they combine just as in burning; turning these smog-producing compounds into harmless water (H2O) and carbon dioxide (CO2).

It works only with unleaded fuel from 750°F (400°C) to 1650°F (900°C). If temperature exceeds this value, warning light & buzzer alarm turn on and the bike must be stopped.

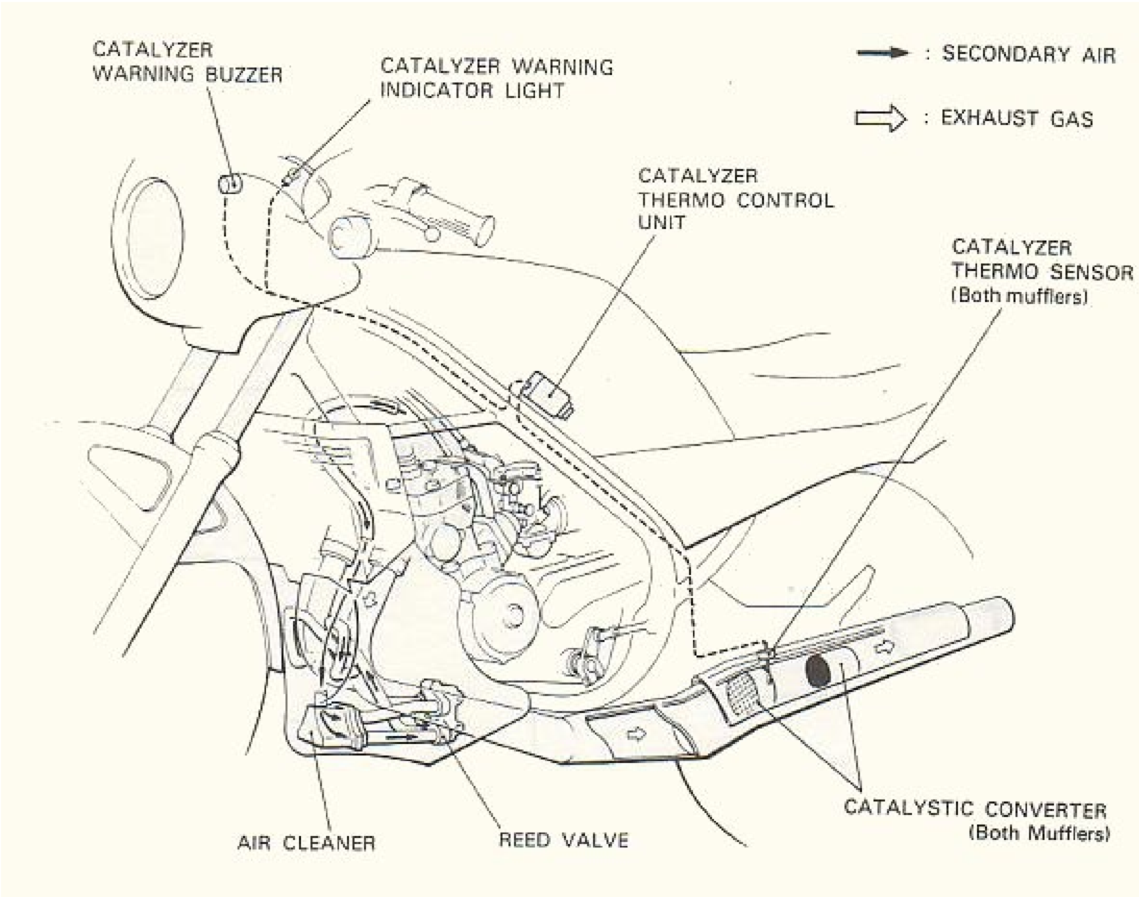


Figure 149: System overview

Carburetors are specific, too: They have non adjustable jet needles, and only the genuine needle jet is available in order to prevent owners from “adjusting” carb setting. The reason is that the catalyst system works best a certain setting. The bike has to respect the pollution level authorized by the EPA (Environmental Protection Agency) which you can see on a sticker on the bike.

The '85 NC & NC2 ("C" like California) models have a third catalytic element in the headpipes and, an internal venting of the gas tank and carbs via an active-carbon filter system (sticker on the bike) which reduces the fuel tank capacity because emissions laws are different in California.

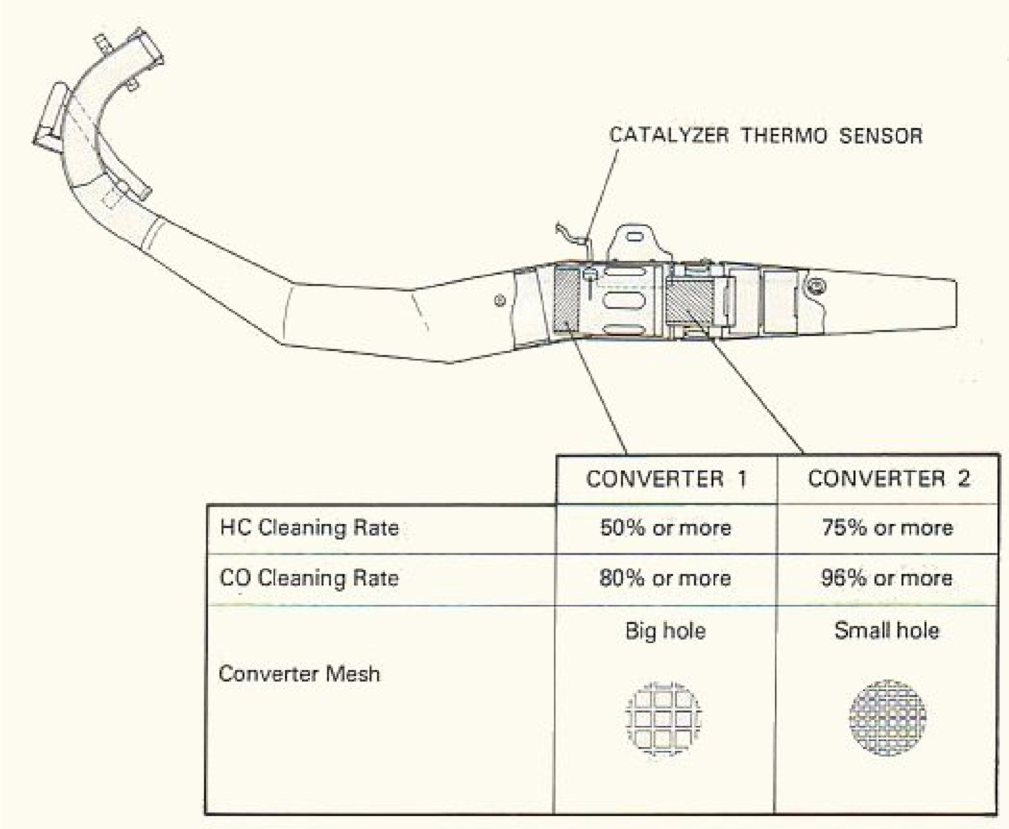


Figure 150: RZ Pipe cross section

Switzerland

In Switzerland the emission laws are not that hard to meet as in California, but they have a different problem: Noise emission. The bikes were measured in first gear at highest RPM's so the usual result is that Swiss bikes are heavily restricted in order not to rev that high!

You can see it at the pipes which have a smaller diameter at the end. The advantage is that these pipes just contain the catalyst without a separate valve system to get additional air into the pipes.

The carbs were also different and so they require different jetting.

Type	RD350YPVS (1WW)	RD350YPVS (1WU)
Carb No.	1UA-00	1WU-00
Main Jet	#185	#210
Idle Jet	#27,5	#20
Needle & clip pos.	5L20 2. Clip	5CK2 3. Clip

Table 17: Carb data for Swiss RD (1WU)

Stages

At this point it's time to summarize and put together single mods which make sense to be carried out together. The numbered costs are German prices and they assume that you do the work on your own, except crank rebuilding and cylinder rebore.
Don't take the stages too seriously, they should only be a kind of proposal for people who are not sure what to do and what to leave out.

Stage I

For those who don't want to put too much work into their bike or who are just too lazy, I'd recommend at least to perform the following points:

- Power Increase up to 10% (dependent on starting state!)
- Charge: a few hours work and max. 400 Eur costs for parts.
- Optimum adjustment of Power-Valve System (look inside or feel with finger) after removing pipes.
- Optimum carb synchronization.
- Jetting 31K #230, 1WW #185
- Power-Valve control box modification (use BDK Curve 14)
- 1 – 3 ° more ignition advance via slotted holes or using a degree key.
- Fiber reeds (Banshee).
- Bridgestone tires 100/80 and 120/80 dimension
- Remove main stand or modify stopper rubber

Stage II

For those who are anyway rebuilding their engine and who know how to use a file or die grinder. Just add the following points

- Power Increase about 10 - 20% (estimation)
- Charge: about several days up to some weeks work and up to about 2000,- Eur for parts/labor costs.
- TZR or Vforce reeds
- Porting: exhaust, intake and transfer ports.
- Piston: Skirt sharpened, bottom polished.
- Programmable ignition; use high advance curves with stock compression
- Chassis: Steel braided brake lines
- Bigger radiator (R6, RGV)

Stage III

Those who drive quite crazily and who own a second RD for everyday driving (I use my RD500 for touring) but who still want to keep their bike for road use should add the following points:

- Increase of power to about 20 - 30% (estimation)
- Charge: about several weeks of work and up to some thousand DM for parts/labor costs.
- Open stock air filter or K&N type filters
- Race pipes (SoniX, DN, TSA, Jolly, DIY).
- Crankcase modification.
- Bigger carbs: Mikuni TM30-6
- Maximum radiator (GSXR1100W, ZZR1000,ZX6/7/9R, NC57)
- Straight cut primary gear, 8 Plate clutch
- Complete conversion of rims, fork, brakes (e.g. R6, RGV, TZR, FZR 600, ...)

Stage IV

For those who use their RD only on race tracks:

- Increase of power about ? (Record: measured 238 km/h for a 31K without fairing, Spec II, USA)
- Charge: Rob your local bank and prepare for a long, long winter ....
- Leave lower piston ring out or use TZ pistons
- Modification of transfer port height and radius
- Big carburetor (34-38) with big single air filters
- Cheetah Cubs & Matoon Machines crankcase
- Race pipes (DIY suited to engine mods)
- Max. weight reduction
- Reduction of driving resistance’s
- Get rid of the oil pump and use mixture 1:25 - 1:35

Nice ones

As I regularly participate in two stroke meetings I've seen many nice RD's and captured them on celluloid. For some of you these are rather boring, as in other countries people are less restricted concerning swapping bike parts.

What you can see quite often is the RGV250 front end, because it fits without problem in the RD frames and offers both good look and excellent brake performance.

This one from the 1995 RD meeting in Bockelskamp had a slightly modified Kawasaki GPZ 600 R swingarm with a FZR 600 18 inch rim at the rear.

Figure 151: 31K with RGV fork, GPZ 600R swingarm

It had 100/70-17 and 140/80-18 radial tires which improved handling very much. All conversions were approved by German TÜV and the total costs were around 5.000,- DM (3.000 $ or 1.600 £).

Next page:

The RGV front and back was used in the RDV350 from Marco Böhmer. This was not that easy as you have to cut and re-weld a frame tube. In addition he used the Jolly-Moto pipes, Mikuni TM30 carbs and a modified upper RGV fairing.

The next one comes from the Performance Bikes readers special series. It also used RGV250K ('89) front end, rims, seat and fairing combined with a beautiful Spondon frame.

Figure 152: RDV 350
(for more see appendix)

Figure 153: Spondon RD

The LCR-RD is also from the Performance Bikes. It was tested several times in different versions. This one used the RGV gullwing swingarm with GP-style pipes. It was measured with a 199 km/h top speed and 58 rear wheel HP (32 mm RGV carbs, porting and race pipes)

Figure 154: LCR-RD

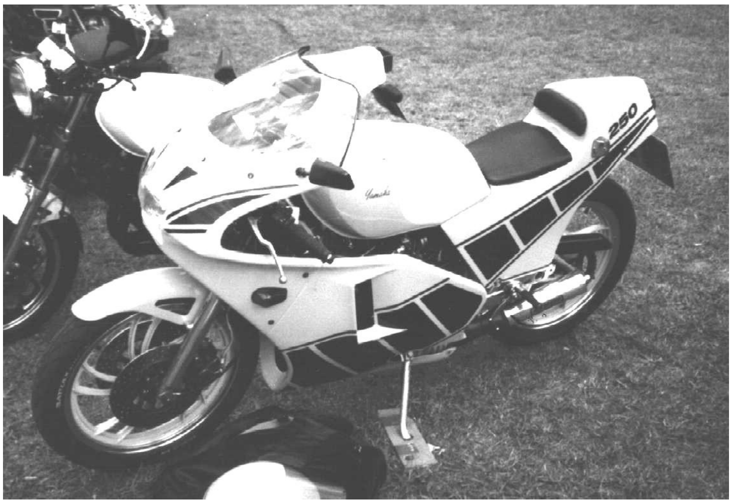


Figure 155: "Classic" RD conversion

This RD250LC had the classic full job done: 350cc cylinders, 34 mm carbs, Micron pipes, Kröber tachometer, self made fairing and TZ-style seat.

What looks also very nice is the English twin lamp style RD. This one is not available in Germany, so you can make use of British/Dutch parts to convert your fairing model to an old FZR style. I think you will need the holder, the lamps and the upper fairing (Info from Glenn v. d. Geld, e-mail: siegers@hotmail.com).

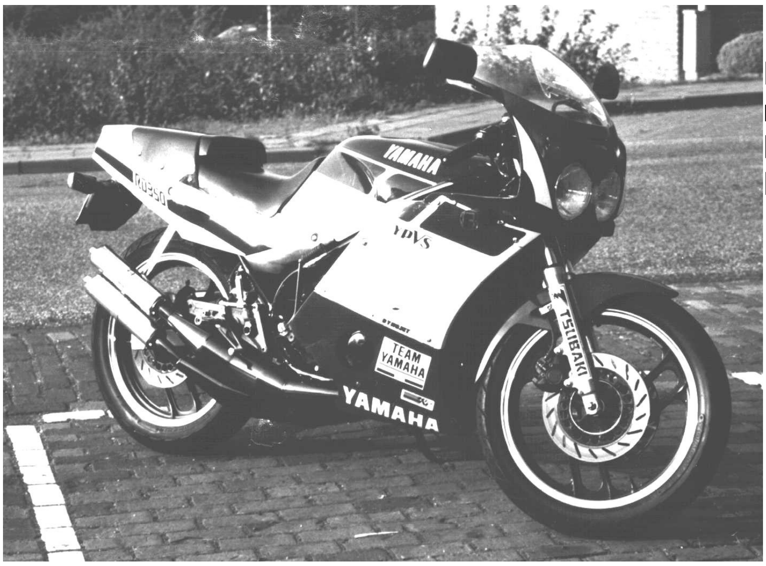


Figure 156: RZ350 English model (seen in the Netherlands), exhaust Micron Hypower

For the classic freaks there is a possibility to use the TDR/TZR250 front end and swingarm. The TDR spoke rims fit beautifully to classic style RD's. If you want to use stock fork and swingarm you can use the SR500 hub at the front and the TDR250 hub at the rear. With appropriate spokes you can use some Acront rims (proposal: 3"x17 or 3.5"X17 with 110/130 tires).

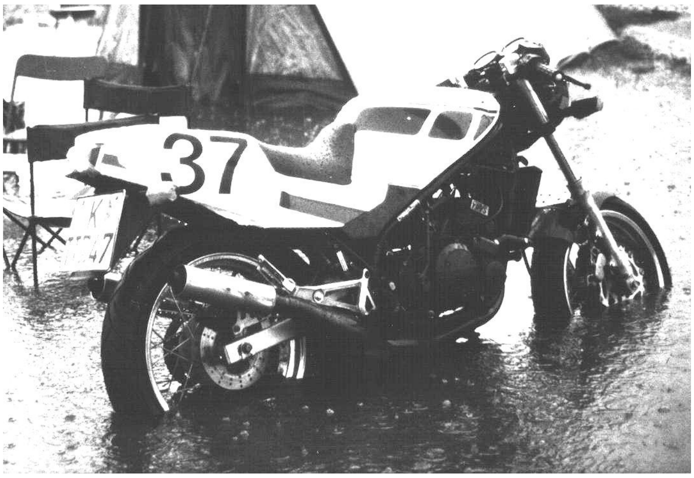


Figure 157: RD with TZR-TDR parts (seen once upon a time on a rainy, rainy day in Zandvoort)

In 1997 I participated in a German race series (MuZ Skorpion Cup) where I tested the METZELER MEZ1 race tires. They performed that convincingly that I decided to use them on my RD. Another reason was that they were even cheaper and better to get than the 100/120 18 inch Metzelers. The only problem are the smallest available sizes 110/70ZR17 and 150/60ZR17. This meant at least other rims but as the swingarm is too narrow to bear the 150/60 tire I had to look for an easy, cheap and TÜV approved solution.

My first thought was to put the RD engine in a Cagiva Mito 125 ('91) chassis which I got as a bargain from my former girl friend (I already tried earlier to fit the engine in this bike).

The problem in Germany is that it's impossible (restricted by the enforced emission laws) to use such an engine in a frame that is younger than October 1. 1989, so I had to use only the front end and the rims combined with a Honda NS400R swingarm.

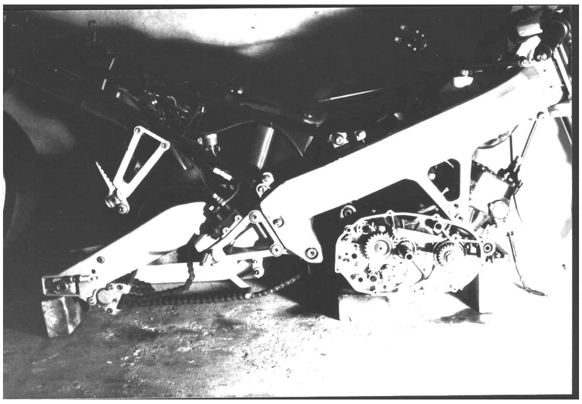


Figure 158: Mito with RD engine


Figure 159: RD350 – YAMITO (1998) (see appendix for more)

Since early 2000 you can get an RGV conversion-kit from Marco Böhmer. The kit contains all necessary parts like bushes, plates, bolts, steering bearings and front sprocket to get the RGV swingarm and fork without any try&error into the RD frame.
The front sprocket already contains the required side-offset to match the 160/60 tire and rear RGV sprocket. But the best thing is: The kit enables you to use the stock RGV linkage (aluminium) and fully adjustable shock. So from the saved money for buying a new shock you can almost afford the whole kit ....

Figure 160: ’86 RD350 with RGV-swingarm, fork & fairing and Soni-X GP-pipes

Addresses

Here are some addresses of the German RD-scene, naturally without claiming to be complete. As far as I am concerned I've made my own experience with most companies and products, so I've added a very subjective rating

- 👍👍 very good product, you **must** have this
- 👍 good thing, but quite expensive
- 👉 ok, but not needed urgently; for people with too much money
- 👎 too expensive, negative effects
- 👎👎 total crap

Yamaha Deutschland GmbH Hansemannstr. 12 41468 Neuss http://www.yamaha-motor.eu/de	Technical data for all YAMAHA models	
Emil Schwarz Daimlerstr. 8 73660 Urbach ☎ +49 (0)7181-995290 http://www.emilschwarz.de	Zero clearance steering bearings special power-valve-bearings needle bearing conversion for swingarm and linkage	👍 👍👍 👍
Wilbers Products GmbH Frieslandstraße 10 48527 Nordhorn ☎ +49 (0)5921-727170 http://www.wilbers.de/Technoflex products	Technoflex products fork springs rear shock steering damper	👍👍 👍👍 👍 👍👍
BRC-Brockhausen Racing Beverstrang 17 48231 Warendorf ☎ +49 (0)2584-358 http://brc-racing.de/	Prox pistons crank rebuild	👍
Alne Lederbekleidung Hansaring 7 63843 Niedernberg ☎ +49 (0)6028 -8402 http://alne-leder.de/	protective leather wearing (quality as good as Schwabenleder) from 650,- € upwards tested it myself more then once and it worked very well	👍👍

Großewächter
Racing-Parts
Soar 25
32139 Spenge
☎ +49 (0)5225-859256
http://www.gw-racing-parts.de

Prox pistons
Wiseco pistons
(company only deals with other companies)
Prox crank rebuild parts
engine rebuild
aluminum welding, reboring and plating of cylinders

RM Product Line
Gradnerstr. 185
8054 Graz (Austria)
☎ +43 (0)316-281565
http://www.rmproducts.at/

race accessories, tuning parts

GL-Motorradtechnik
Truchtelfingerstrasse 110
72458 Albstadt
☎ +49 (0)7431-9485868
http://www.gl-motorradtechnik.de/

Jolly-Moto-Import Germany
RD350 & RD500 pipes

Micron-Systems GmbH
Boxdorfer Str. 13
90765 Fürth-Sack
☎ +49 (0)911-93674-0
http://www.micronsystems.de

RD350-pipes in grand-prix-style (both silencers on the right side)
Dynojet-carb-kit RD 350 LC

A. Sieker
Im Krummen Kamp 12
32547 Bad Oeyenhausen
☎ +49 (0)5731-796360
http://www.sieker-rohrbiegetechnik.de/

Pipes for RD500, RGV250

Gimbel Motorradtechnik GmbH
Kesslerstr. 7
79206 Braisach
☎ +49 (0)7667-7014
http://www.gimbel-motorradtechnik.de/

150/70 ME99 / 120/80 ME 33 approval f. RD500
130/80 ME99 auf PVM rims f. RD350

Götz GmbH
Walter-Simon-Str. 14
D-72072 Tübingen
☎ +49 (0)7071-6399488
http://www.motorsportgoetz.com/

GFK and CFK reeds
Spiegler brake disks

Trinity Racing 29370 7TH, Suite B. Rancho Cucamonga, CA 91730 ☎ (909) 987-4213 http://trinityracing.com/	Specialised on Quad Banshee (350 cc, similar to RZ) Big Bore Kits 420/500/570 cc (!) Nitrous kits, race ignition Two Stroke Tuning
Lance Gamma P.O. Box 681 Leicester NC 28748 ☎ +1-828-777-4076 http://www.lancegamma.com/	Air filter kit (around 300 US$) RD500-pipes
LStan Stephens Motorcycles Potobello Parade Fawkham Road West Kingsdown Kent ☎ +44 (0)1732-760337 http://www.stanstephens.com/	pipes, cylinder tuning, Nicasil-plating, chassis tuning Big-bore-kits (375 ccm for RD350) (catalogue is very interesting)
Brune GmbH Wöste 6 48291 Telgte ☎ +49 (0)2504-7344 - 0 http://www.brunegmbh.de/	Mikuni carbs and spares (jets, needles,...) Brembo disks f. RD 350/RD500
Stephen Topham Zur Quellge 11 32351 Stemwede-Dielingen ☎ +49 (0)5474-9011 http://www.mikuni-topham.de/	Mikuni carbs and spares (jets, needles,...) Consulting for setups and tuning
PSR Motorräder und Zubehör Holsteinstr. 6 23812 Wahlstedt ☎ +49 (0)4554-2994 http://www.psr-motorrad.de/	Technoflex suspension parts Suspension repair & tuning Conversion kit for adjustable damping f. RD500
Spiegler Bremstechnik Krummholzstr. 5 79206 Breisach ☎ +49 (0)7667-90664-0 http://www.spiegler.de/	Brake disks and calipers Steel braided lines

Zupin-Moto-Sport GmbH Trostberger Str. 26 83301 Traunreut ☎ +49 (0)8669-8480 http://www.zupin.de	Boyesen reeds f. RD250/350 LC Boyesen Rad Valves (Banshee)	👍 ☜
Motorrad Weihe Koblenzer Str. 247 32584 Löhne ☎ +49 (0)5731-78640 http://www.motorrad-weihe.de/	Yamaha dealer 3G3 – TZ pistons	👍 ☜
WIWA Rennsporttechnik Nord-West-Ring 54 32832 Augustdorf ☎ +49 (0)5237-1061 http://www.wiwa-racing.de/	Crank rebuild Kart-Tuning RD-pipes	👍 ☜ ☜
DIMO Kunststofftechnik Franz-Wenzel-Str. 3 53474 Bad Neuenahr-Ahrweiler ☎ +49 (0)2641-4653 www.dimoonline.de	Replica fairings / bodywork f. RD500 and others	
Jamparts Friedenstrasse 2 71282 Hemmingen ☎ +49 (0)7150-970565 http://www.jamparts.com	Custom aluminum swingarms	☜
Sebimoto GmbH Goethestr. 12 63179 Obertshausen ☎ +49 (0)6104-74632 www.sebimoto-germany.de	Replica fairings: Ducati 916, Cagiva Mito, CBR 600, ... Carbon plate material	 👍
RD500LC Club de France Didier Daumin 53 BIS Rue de la Fosse aux Loups F-5800 Nevers, FRANCE http://rd500lc.free.fr/	Annual Meeting on race track in the middle of France Highly recommended !	 👍👍
LSL Motorradtechnik GmbH Heinrich-Malina-Str. 107 47809 Krefeld ☎ +49-(0)2151-55590 http://www.lsl.eu/	Floating disks f. RD Superbike handlebar Steering damper kits	☜ 👍

Sonic Speed	Soni-X pipes for most 2 strokes
	Crank repairs / stroker cranks
Marco Böhmer	ProX-, Wiseco-, Vertex pistons
Max-Planck-Straße 15	Technoflex, White-Power
95233 Helmbrechts	Mikuni TM30 Kit for RD500
☎ +49 (0)9252-7371	finding setups on own dyno as a sercive
☎ +49 (0)171-6194475	aluminum/stainless welding service
	custom radiators
info@sonic-speed.net	
http://sonic-speed.net/	
www.moto-boehmer.de	

Martin Kieltsch	Tuning manuals RD 350 / RD 500
Vor dem Stadtberge 33	Wartungsbuch RD 350 YPVS (31K/1WW)
38300 Wolfenbüttel-Wendessen	
☎ +49 (0)5331/77584	
(Anrufe 17:00 bis 21:00)	
maki500@gmx.de	
http://rd350.gmxhome.de/	

Interesting internet pages:

http://www.rzrd500.com	The US RD page. (RZ/RD500 Owners Club, Bulletin Boards for RD350/500 and other twostrokes
http://rd500lc.free.fr/	Homepage of the french RD500 Club Info's for annual meeting in France
http://forum.rd350lc.de	DIE deutschsprachige RD-Seite. Interessantes RD Diskussions-Forum
http://www.rd350lc.net	French RD site with history and all model codes
http://rdlccrazy.proboards.com/	THE UK RD page ! Bulletin Boards for RD350/500 and other twostrokes

Appendix

As some of you won’t be used to metric units, I’ve compiled several conversions for bike relevant units.

Length					
mm	**inch**	**m**	**ft**	**km**	**mls**
0,10	0,0039	1	3,28	1	0,6
0,20	0,0079	2	6,56	5	3,1
0,30	0,0118	3	9,84	100	62,1
0,40	0,0157	5	16,4	1000	621,5
0,50	0,0197	10	32,8	5000	3107,5
0,60	0,0236	20	65,6	10000	6215
0,70	0,0276	30	98,4		
0,80	0,0315	50	164		
0,90	0,0354	100	328		
1,00	0,0394	200	656		
2,00	0,0787	300	984		
3,00	0,1181	500	1640		
4,00	0,1575	1000	3280		
5,00	0,1969				
10,00	0,3937				
20,00	0,7874				
30,00	1,1811				
40,00	1,5748				
50,00	1,9685				

Velocity	
km/h	**mph**
30	18,6
50	31,1
80	49,7
100	62,2
130	80,8
160	99,4
170	105,7
180	111,9
190	118,1
200	124,3
210	130,5
220	136,7
230	142,9

Volume	
litres	**gallon**
1	0,22
2	0,44
3	0,66
5	1,10
6	1,32
7	1,54
8	1,76
9	1,98
10	2,20
12	2,64
15	3,30
20	4,41
25	5,51

Pressure	
Bar	**PSI**
1	14
2	28
3	43
4	57
5	71
6	85
7	100
8	114
9	128
10	142
11	156
12	171
13	185
14	199

Temperature	
°C	**°F**
0	32
10	50
15	59
20	68
25	77
30	86
38	100
50	122
60	140
70	158
80	176
90	194
100	212
110	230

Weight	
kg	**lb**
1	2,2
2	4,4
3	6,6
4	8,8
5	11,0
10	22,1
15	33,1
20	44,1
30	66,2
50	110,4
100	220,7
150	331,1
200	441,4
250	551,8

Torque	
Nm	**lbft**
1	0,738
2	1,476
3	2,214
5	3,69
10	7,38
20	14,76
30	22,14
40	29,52
50	36,9
60	44,28
70	51,66
80	59,04
90	66,42
100	73,8

Exchanging ignition parts

The YPVS-model family has three different generators, rotors and CDI-units, which do not all fit together.
Theoretically you can create 27 (3^3) different assemblies by combination. The following chapter should help to solve problems of getting used parts from other bikes. If markings are given they may vary in other countries. I'd guess the shape of the parts is as it's shown on the photos.

If there is no spark in most cases the generator is to blame. To be sure you have to measure the coil which suppliers the CDI (red, green, brown).
This coil has a resistance of 5.3 Ω (red to brown) and 225 Ω (brown to green). If the wire is broken in most cases the 5.3 Ω coil has an infinite resistance.
For the newer types of generator the higher value is 130 Ω (31K 1985) and 160 Ω (1WW 1986).
Sometimes the missing spark or faulty ignition is a result of poor contact in the electric connectors, especially those which are related with the ignition system. Just unplug them and put them together a few times. In most cases it's the black or red (red/white) one which has a bad contact.

The CDI of 1983/84 carries the marking 29 K – 50. The generator (marking 1CY), can be identified easily by the shape of the ignition supply coils. There is a thick one in the middle and on both sides there are two smaller ones which look like horns.
Another hint comes from the connectors. This generator has one square shaped connector (3 x white, blue), one T-shaped connector (red, green, brown), a flat connector for the pick-up (white-green, white-red) and a black earth connector.
The fitting rotor bears the marking 29L - 50 and it has two round and two slotted holes.

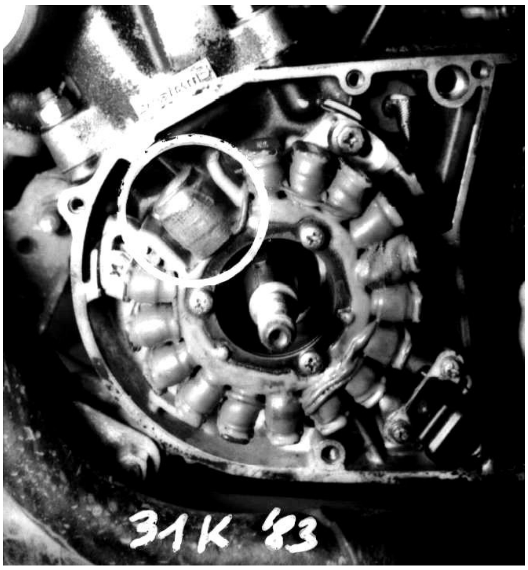


Figure 161: Generator 31K ('83-'84)

In 1985 the generator and CDI were changed. The CDI marking altered to 52 Y - 50 and the generator marking to 2EZ or 8DX. The ignition supply coils were now two thick ones.

The 52-Y-CDI has only 8 instead of 9 connecting wires; black/white (engine stop) is missing.

Figure 162: Generator 31K '85 (with '83 connectors)

The fitting rotor bears the marking 51L - 50 and it also has two round and two slotted holes, but they are somewhat shorter compared to the ’83 model.

The 1WW-CDI is marked 1UA - 50; the corresponding generator looks like the '85 one, but has other connectors. One square shaped connector (3 x white, blue), one flat shaped connector (red, green, brown), a flat connector for the pick-up (white-green, white-red) and a black earth connector. The marking on the generator was 1FX.
The rotor is marked VCD 88 and has got six drillings (no slotted holes).

Figure 163: Generator 1WW

The usable combinations are at first the stock ones. The 1WW generator only runs with the corresponding rotor (VCD 88), the other rotors (29L and 51L) are interchangeable

The CDI of the 1WW (1UA - 50) can be used without changes to the '85 31K. The black/white cable at the CDI can remain unused, as the '85 31K uses the red-white cable to shut off the engine.

You can also use the 1UA-50 CDI in the 31K '83/'84 with the old generator (1CY/2CY). You just have to change the colours red and green. If you connect colour to colour, it won’t work.

The '85 CDI can be used in the 1WW and the 31K '83/'84.
For the 1WW connect colour to colour and the black-white cable of the stop switch with black/yellow on the CDI (Another possibility is to use the red one at the CDI)
At the 31K '83/'84 you have to change red and green and additionally connect the black-white to black-yellow (or red) at the CDI. If you don't connect black-white you cannot shut off the engine via the stop switch.

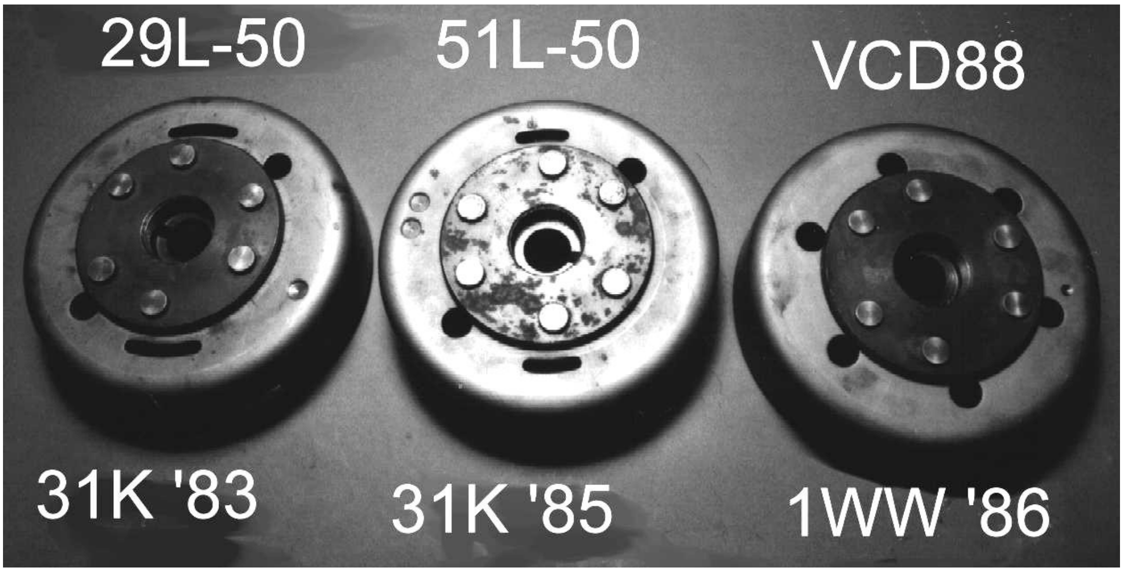


Figure 164: The RD rotors from '83 to present

As an example of how to read the following table you could check whether you can use a 29K-50 CDI with the old stator (1CY/2CY) and the 1WW-rotor
The header indicates the CDI so you've got to use the first table. Then the crossing between generator row and rotor column leads to a symbol. O means: doesn't work!

Please note that this table was done by a simple but time consuming experiment: I mounted all combinations to my bike and just tested if it would start and rev up. A test ride would have been required as it turned out afterwards that some of the combinations flagged "working" do not fully work. They may have issues at higher rpm and under load.
Since DC CDI's are on the market it's also obsolete to waste time and money on sourcing old parts. If your stator is broken get a DC-CDI and with that box you can combine whatever rotor and stator you want.

There is even explicit stators that come without source coils and thus only work with DC-CDI's.

CDI	29K - 50		
Rotor	31K 83/84 (1CY / 2CY) 29L - 50	31K 85 (2EZ / 8DX) 51L - 50	1WW (1FY) VCD 88
Generator			
31K 83/84 (1CY / 2CY)	X	X	O
31K 85 (2EZ / 8DX)	O	O	O
1WW (1FX)	O	O	

CDI	52Y - 50		
Rotor	31K 83/84 (1CY / 2CY) 29L - 50	31K 85 (2EZ / 8DX) 51L - 50	1WW (1FY) VCD 88
Generator			
31K 83/84 (1CY / 2CY)	X (change R/Gr, B/W to B/Y)	X (change R/Gr, B/W to B/Y)	-
31K 85 (2EZ / 8DX)	X	X	O
1WW (1FX)	O	O	X B/W to B/Y)

CDI	1UA - 50		
Rotor	31K 83/84 (1CY / 2CY) 29L - 50	31K 85 (2EZ / 8DX) 51L - 50	1WW (1FY) VCD 88
Generator			
31K 83/84 (1CY / 2CY)	X (change R/Gr)	X (change R/Gr)	O
31K 85 (2EZ / 8DX)	X	X	O
1WW (1FX)	-	-	X

X : works fine
O : doesn't work
- : works, but not properly (poor top revs, misfires)

Table 18: Combination options for the ignition parts

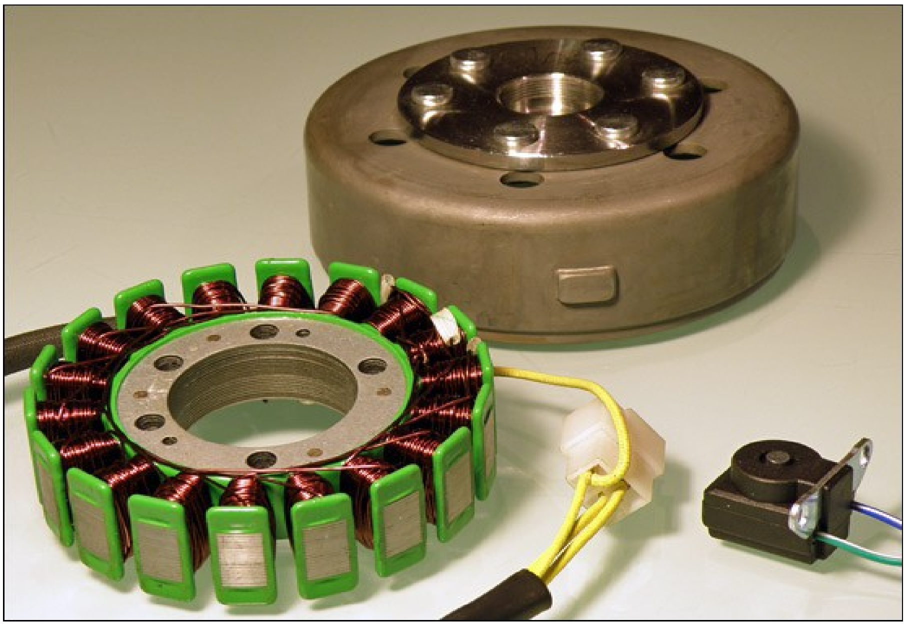


Figure 165: TSS rotor/stator/pick-up kit (for DC-CDI with no source coils)

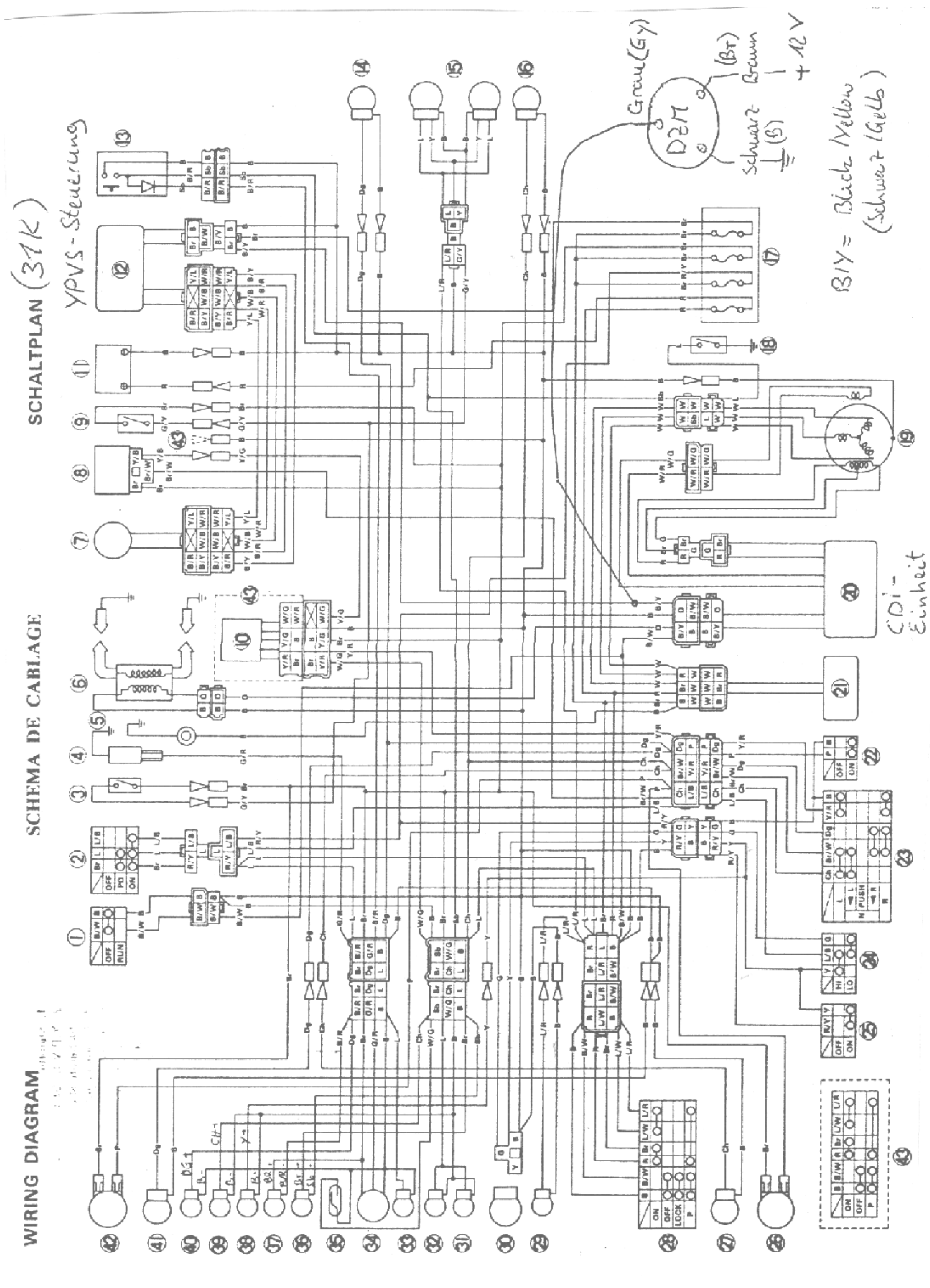


Figure 166: Wiring diagram for 31K (with electronic tach)

Data for dyno test May 13. 1993

Tire:	120/80 H 18 ME99, worn, rolling radius approx. 315 mm
Transmission:	18 / 41
Carbs:	Stock (31K); Main Jet: # 230; Needle: 5K1-Position 3
	Air screw: 2/3 turn out
Air Filter:	Stock (31K)
Cylinder:	Bridge width 4 mm, polished, TZR reeds (fiber type)
	Exhaust height 25,5 mm, Power Valves fitted to port shape
	Polished, Transfer ports: bridge as plane wing
Crankcase:	removed edges
Pistons:	Prox 0,75 mm oversize, skirt milled, holes
	stock, upper surface polished
Cylinder Head:	milled 0,6 mm, reworked squish area, combustion chamber
	polished
Pipes:	1WW
Fuel:	premium unleaded (98 Octane)
Oil Pump Setting:	min. pump stroke 0,1 mm, Full throttle: Align to dot on pump
	Wheel, Castrol Biolube XTS
Dyno:	Dynamic type
	measured acceleration of rotational mass inertia
	Computer calculates torque and performance

Changes for dyno test on Feb. 2/3. 1995

Reference Bike:	100%-Stock 1WW (except tires 120/80 ME1)
Tires:	120/90 H 18 ME55
Transmission:	17 / 41
Carbs:	Stock (31K), Ledar intake kit, main jet: # 290
	needle: 5K1-Position 5, idle mixture screw: 1/2 turn out
Air Filter:	cover perforated, special curtain air filter, with lower inlet
Cylinder:	TZR-125 carbon fiber reeds (Götz)
Pistons:	Wiseco 1 mm oversize, modified
Fuel:	premium leaded (98 Octane)

Compilation of possible stock carb setups:

To complete the carb section I've listed some setups I tried (bold font) and from people I know by myself (regular font).
These are partly uncompleted or may be corrupted due to transmission faults.
Neither is there given any guarantee that your special engine will survive these jettings!
Just take them as an orientation and try on your own.

Stock carbs Mikuni VM26SS:

Bike	Main jet	Needle position	Other mods
31K	#200-#230	2-3	Stock
31K	***#230***	***3***	***engine tuned, 1WW pipes***
31K	***#290***	***5***	***engine tuned, air filter cover perforated, "high flow air filter" made from old curtain, Ledar intake kit, 1WW pipes***
31K	#280	4	*air filter cover perforated*, stock filter element, all inlets removed, direct intake, modified 31K pipes
1WW	#185	2	stock
1WW	#195	2-3	WIWA pipes
1WW	#210-#220	3	K&N filters
1WW	#225	3-4	K&N filters & Jolly-Moto pipes
1WW	***#290***	***3***	***engine tuned, Power-Jet deactivated Ledar intake kit, K&N filters, Jolly-Moto pipes***

TZ race bike data

Model	**TZ 250**	**TZ 350**
Mix (Oil/fuel)	1:15	1:15
Carb type	VM34SS	VM38SS
Main jet	#230-#270	#280-#380
Idle jet	#60	#70
Nozzle	N-8	Q-0
Needle	6DH3 (3. Pos.)	6F13 (2. Pos.)
Slide cutaway	2,0	3,0
Idle mixture screw (turns)	1,0	1,0
Swimmer height	21,9 mm ± 1 mm	21,9 mm ± 1 mm

Data for bigger carbs on heavily modified RD engines

(Main source: Thomas Fried, address in appendix)

Don't take these too seriously. All setups are listed just to give you an idea how your engine ***could be jetted initially****.* ***After that you must do your own testing.***

Setup 31K, mildly tuned:

Cylinder 31K; porting as described; compression ratio 7,35; TZR-reeds; Jolly-Moto pipes, Mikuni TM34 flat slide carbs bored to 36 mm, K&N filter mounted with 60 mm spacers; adapter plate for fitting the carbs to the cylinder (with fittings for stock oil hoses); modified stock carb cables (outer cable shortened 10 mm + adapter for cable distributor to enlarge max stroke by 10 mm)
Dyno test: +18 HP at 11.500 rpm; theoretical top speed with optimum circumstances approx. 215 km/h.

Carbs	**TM34 bored to 36**
Main Jet	**#320**
Idle Jet	**#30**
Nozzle	**Q-2**
Needle	**6-FP 55, Pos 1.**
Slide Cutaway	**4,0**
Idle Mixture Screw	**1**

Setup 1WW ('86), heavily modified:

All ports altered 1 mm via second gasket, cylinder milled 1 mm at the top, porting similar to described version, outer transfer port area welded and ports heavily modified (radius as TZ models), reeds TZ 750, TZ 350 pistons (fits only in stock bore ∅64 mm!), modified Dörr pipes (∅ 22 mm end pipe instead of ∅ 20 mm), head milled 0,5 mm, stock air filter case without upper cover and inlets, dry foam filter element, intake manifolds TZ 750, oil pump removed, pre mixture 1:40, gas petcock on PRI position (no vacuum hose), performance: with 17/39 aprox. 220 km/h at 11.000 rpm without fairing.

Carbs	**TM34-Power-Jet race carbs(TZ 350) bored to 35 mm**
Idle/Chokesystem	**No idle adjustment screw, Choke at carb**
Lubrication	**1:40 pre mix**
Main Jet	**#320**
Idle Jet	**#60**
Nozzle	**N-8**
Needle	**6-F 22, Pos 3.**
Power-Jet	**disabled**
Idle Mixture Screw	**1**

Setup RD350LC ('82) race bike:

All ports altered 1 mm via second gasket, cylinder milled 1 mm at the top, porting similar to described version, outer transfer port area welded and ports heavily modified (radius as TZ models), TZ 350 pistons (fits only in stock bore ∅64 mm!), Speed Products F-1 pipes, head milled, no air filters, intake manifolds and reeds TZ 750, oil pump removed, pre mixture 1:40, TZ-fairing and seat, weight: 135 Kg, race tires 5.00-18 Dunlop KR124 medium, performance: with 17/37 approx. 225 km/h at 10.800 rpm, with another bike ahead up to 240 km/h.

In the beginning this scary monster was used on Bavarian roads:

Carb	**VM38 (round slide)**
Idle/Chokesystem	**present**
Lubrication	**1:35 (Castrol TTS)**
Main Jet	**#330**
Idle Jet	**#60**
Nozzle	**Q-0**
Needle	**6-F 8, Pos 1.**
Idle Mixture Screw	**1**

After increased modifications the setup was no longer suitable for road use (no idle, engine running like choke is out in lower revs)

Carb	**VM38-Power-Jet race carbs (TZ 350)**
Idle/Chokesystem	**no idle speed adjustment screw, Choke knob**
Lubrication	**Pre mix**
Main Jet	**#340**
Idle Jet	**#90**
Nozzle	**N-8**
Needle	**6-F 13, Pos 4.**
Power Jet	**#75**

Setup TM28 flat slide carbs, mildly tuned 31K:

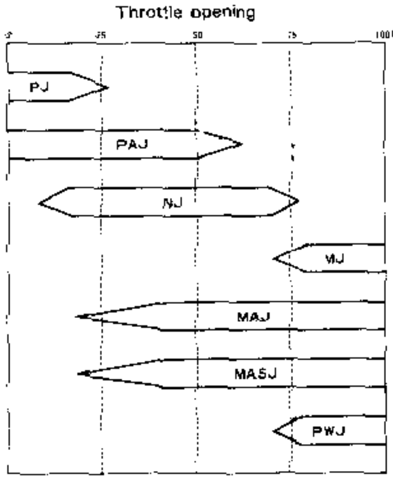
Cylinder 31K; porting as described; direct intake, shortened 31K pipes; open air filter.

Carbs	**TM28 (TZR250 1KT)**
Main Jet	**#260**
Idle Jet	**#25**
Nozzles, Needle, Power-Jet	**Stock**

•

Jetting specs for the RGV race kit

CARBURETION BY DIFFERENT JETS



This diagram indicates were each jet affects the carburetion throughout the throttle opening range.

- PJ (Pilot Jet): With 15% of throttle opening, carburetion is affected in the entire revolution range and with 25% of throttle opening, in the range over 9,000 rpm.
- PAJ (Pilot Air Jet): With less than 50% of throttle opnning carburetion is affected in entire revolution range.
- NJ (Needle Jet): With 15 – 25% of throttle opening, carburetion is affected in entire revolution range; with 35 – 50% of throttle opening, over 9,000 rpm; and with 75% of opening, over 11,000 rpm.
- MJ (Main Jet): With 75% of throttle opening, carburetion is affected in the revolution range over 9,000 rpm, and with 100% of throttle opening, in the range over 7,000 rpm.
- MAJ (Main Air Jet): From 15% of throttle opening, carburetion begins to be gradually affected, and with more than 50% of opening, it is affected in entire revolution range.
- MASJ (Main Air Solenoid Jet): With approximately the same throttle opening range as MAJ, it can affect carburetion. However, due to the duty solenoid control, carburetion influence is limited to within 5,000 – 9,000 rpm and over11,000 rpm.
- PWJ (Power Jet): With 75% of throttle opening, carburetion is affected in the revolution range over 10,000 rpm, and with 100% of throttle opening, in the range over 8,000 rpm.

– 17 –

MJ Increment of #10	#320 ~ #450	Leaner ↕ Richer	PJ Increment of #2.5	# 20 ~ #40	Leaner ↕ Richer
NJ	O–6 ~ P–2	Leaner ↕ Richer	PWJ	#50 · #60	Leaner ↕ Richer
JN	Clip position (1st–5th) 1st ~ 5th	Leaner ↕ Richer	PAJ MAJ MASJ PWJ II Increment of #0.1	0.5 ~ 0.9	Leaner ↕ Richer *

- * Because PAJ, MAJ and MASJ are air metering jets, the larger the number, the more air will flow, resulting in richer mixture.
- * Do not change the JN clip position but leave it in the 3rd groove.
- * Do not change the MAJ number from 0.5.
- • Basically, it is not necessary to change PAJ, MAJ or MASJ for tuning carburetion. Instead, replace PJ, NJ or MJ for different carburetion. Only when time is limited and changing carburetion in the pilot or main system is desired, PAJ or MASJ may be replaced as an alternative tuning. However, such a tuning method is not recommended because at times loss of total carburetor balance may result.

CARBURETOR JETTING EXAMPLE

For Stage I (With racing gasoline)

	#1	#2
MJ	#370	#360
NJ	O−9	O−9
JN	6FL-84-50, 3rd	6FL-84-50, 3rd
PJ	#27.5	#27.5
PAJ	#0.7 (0.8 when raing)	#0.7 (0.8 when raing)
MAJ	#0.5	#0.5
PWJ	#35	#35
PWJ II	# 0.5	# 0.5
MASJ	# 0.5	# 0.5

Circuit with straight: Approx. 500 m.
Temperature: 12°C;
Barometric pressure: 760 mHg

If circuit has the straight longer than this, then increase the MJ number by #20 – #30.

If replacing racing gasoline by aviation gas-soline, smaller jets may be used:
For MJ, smaller by #20 – #30;
and for NJ, smaller by 1 – 2 lower rank.

(with aviation gasoline)

	#1	#2
MJ	#350	#340
NJ	O−8	O−8
JN	6FL-84-50, 3rd	6FL-84-50, 3rd
PJ	#27.5	#27.5
PAJ	#0.7 (0.8 when rainy)	#0.7 (0.8 when rainy)
MAJ	#0.5	#0.5
PWJ	#35	#35
PWJ II	# 0.5	# 0.5
MASJ	#0.5	#0.5

For Stage II (With racing gasoline)

	#1	#2
MJ	390	380
NJ	P−1	P−1
JN	6FL-84-50, 3rd	6FL-84-50, 3rd
PJ	#27.5	#27.5
PAJ	#0.7	#0.7
MAJ	#0.5	#0.5
PWJ	#50	#50
PWJ II	None	None
MASJ	# 0.5	# 0.5

Circuit with straight: Approx. 500 m
Temperature: 12°C;
Barometric pressure: 760 mHg

If a circuit has a straight longer than this, then increase the MJ number by #20 – #30.

(With aviation gasoline)

	#1	#2
MJ	370	360
NJ	P−O	P−O
JN	6FL-84-50, 3rd	6FL-84-50, 3rd
PJ	#27.5	#27.5
PAJ	#0.7	#0.7
MAJ	#0.5	#0.5
PWJ	#50	#50
PWJ II	None	None
MASJ	#0.5	#0.5

When operating in a short circuit using a partial throttle opening frequently, a combination of smaller MJ with larger NJ may be suitable. On the contrary, in a large circuit with long straight, use comparatively larger MJ.

CARBURETION WITH DIFFERENT CLIMATIC CONDITION

Condition	Result	Required adjustment
Cold	Lean	To make richer
Hot	Rich	To make leaner
Dry	Lean	To make richer
When hot	Rich	To make leaner
High altitude	Rich	To make leaner

CARBURETOR TUNING BY DIFFERENT FAILURE SYMPTOM

SYMPTOM	ADJUSTMENT	REMARKS
With full open throttle; • Rev peak too low • Doesn't rev up quickly • Poor power output (Rich)	• Decrease MJ size. • Decrease gradually by 1 — 2 sizes while observing piston crown color.	• Check if choke is on. • Check if not overflowing.
With full open throttle; • Hesitates • Pings or knocks • Revs up but power not sufficient.	• Increase MJ size. • Increase gradually by 1 — 2 sizes while observing piston crown color. • Increase PWJ size.	• Check if air not leaking in. • Check if ignition timing not too fast.
Performs dull or intermittent in range 1/4 — 3/4 throttle opening.	Decrease NJ size to make mixture leaner.	(Rich at a partial opening)
Hesitates in range 1/4 — 3/4 throttle opening and torque is poor.	Increase NJ size to make mixture richer.	(Lean at a partial opening)
Responds to gradual but not to quick throttle opening.	Decrease MJ size because of too rich main system.	
Responce too sharpe to control.	Increase PJ size.	
Performs dull when throttle opened from full close.	Decrease PJ size.	

Setup table KTM 360 SX (39mm Keihin)

KTM SX360 '97 Europa							
		-20°C bis -6°C	-6°C bis 5°C	6°C bis 15°C	16°C bis 24°C	25°C bis 36°C	37°C bis 49°C
2300 m bis 3000 m	CO-Schraube LL-Düse Nadel Hauptdüse	1,5 # 45 NOZH 3. # 175	1,75 # 42 NOZH 2. # 172	2,0 # 40 NOZH 1. # 170	2,25 # 40 NOZI 1. # 168	2,5 # 40 NOZI 1. # 165	2,75 # 38 NOZI 1. # 165
1500 m bis 2300 m	CO-Schraube LL-Düse Nadel Hauptdüse	1,25 # 48 NOZG 3. # 178	1,5 # 45 NOZH 2. # 175	1,75 # 42 NOZH 1. # 172	2,0 # 42 NOZI 1. # 170	2,25 # 42 NOZI 1. # 168	2,5 # 40 NOZI 1. # 165
750 m bis 1500 m	CO-Schraube LL-Düse Nadel Hauptdüse	1,0 # 48 NOZG 3. # 180	1,25 # 45 NOZG 2. # 178	1,5 # 45 NOZH 2. # 175	1,75 # 45 NOZH 2. #172	2,0 # 45 NOZH 2. # 170	2,25 # 42 NOZI 2. # 168
300 m bis 750 m	CO-Schraube LL-Düse Nadel Hauptdüse	0,75 # 50 NOZG 3. # 182	1,0 # 48 NOZG 2. # 180	**1,25** **# 45** **NOZH 2.** **# 178**	**1,5** **# 45** **NOZH 2.** **# 175**	**1,75** **# 45** **NOZI 2.** **# 172**	2,0 # 42 NOZI 2. # 170
n.N. bis 300 m	CO-Schraube LL-Düse Nadel Hauptdüse	0,5 # 50 NOZF 4. # 185	0,75 # 48 NOZG 3. # 182	**1,0** **# 45** **NOZG 3.** **# 180**	**1,25** **# 45** **NOZH 2.** **# 178**	**1,5** **# 42** **NOZH 1.** **# 175**	1,75 # 42 NOZI 1. # 172

Figure 167: Allspeed advertising

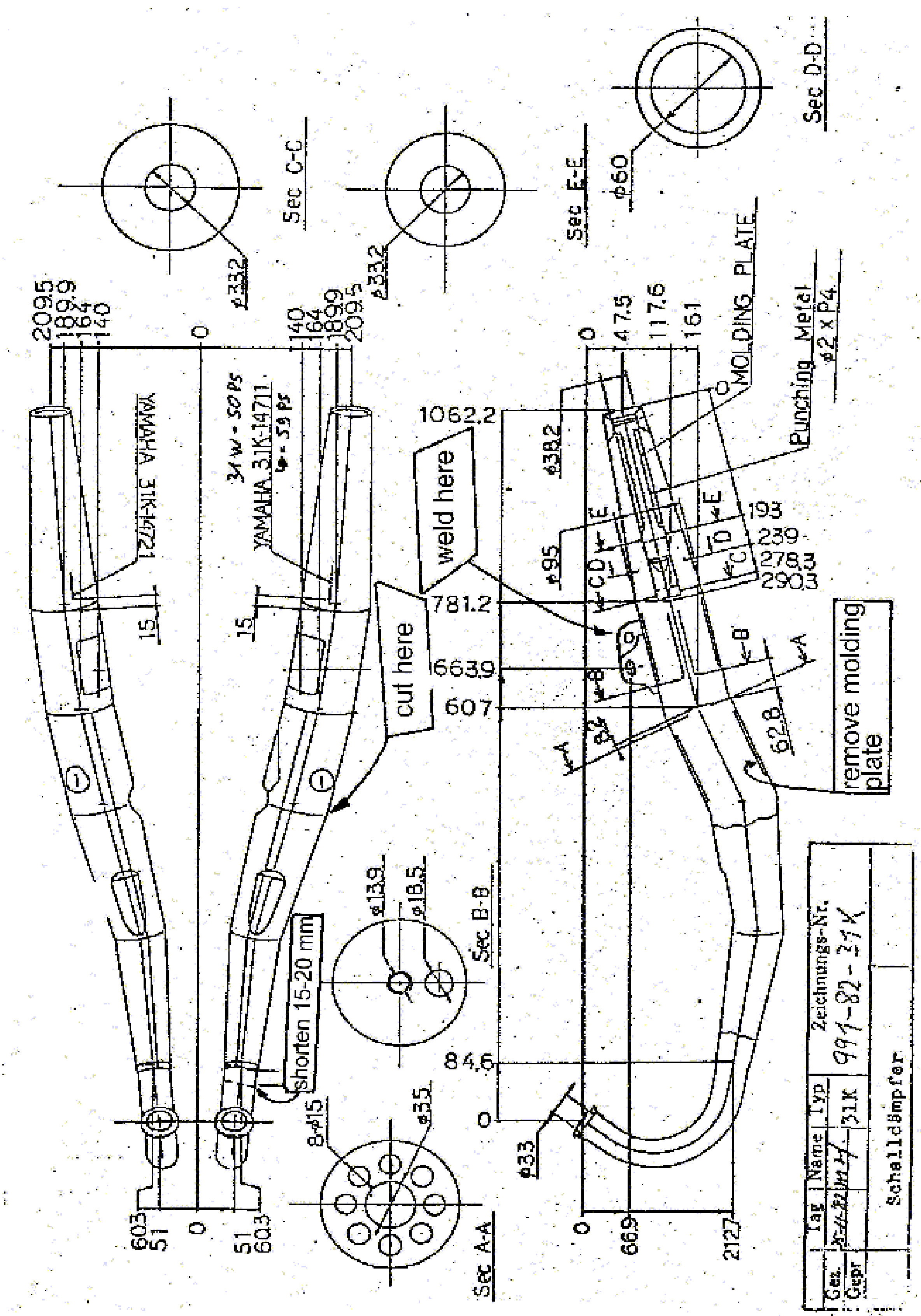


Figure 168: 31K pipes with possible modifications

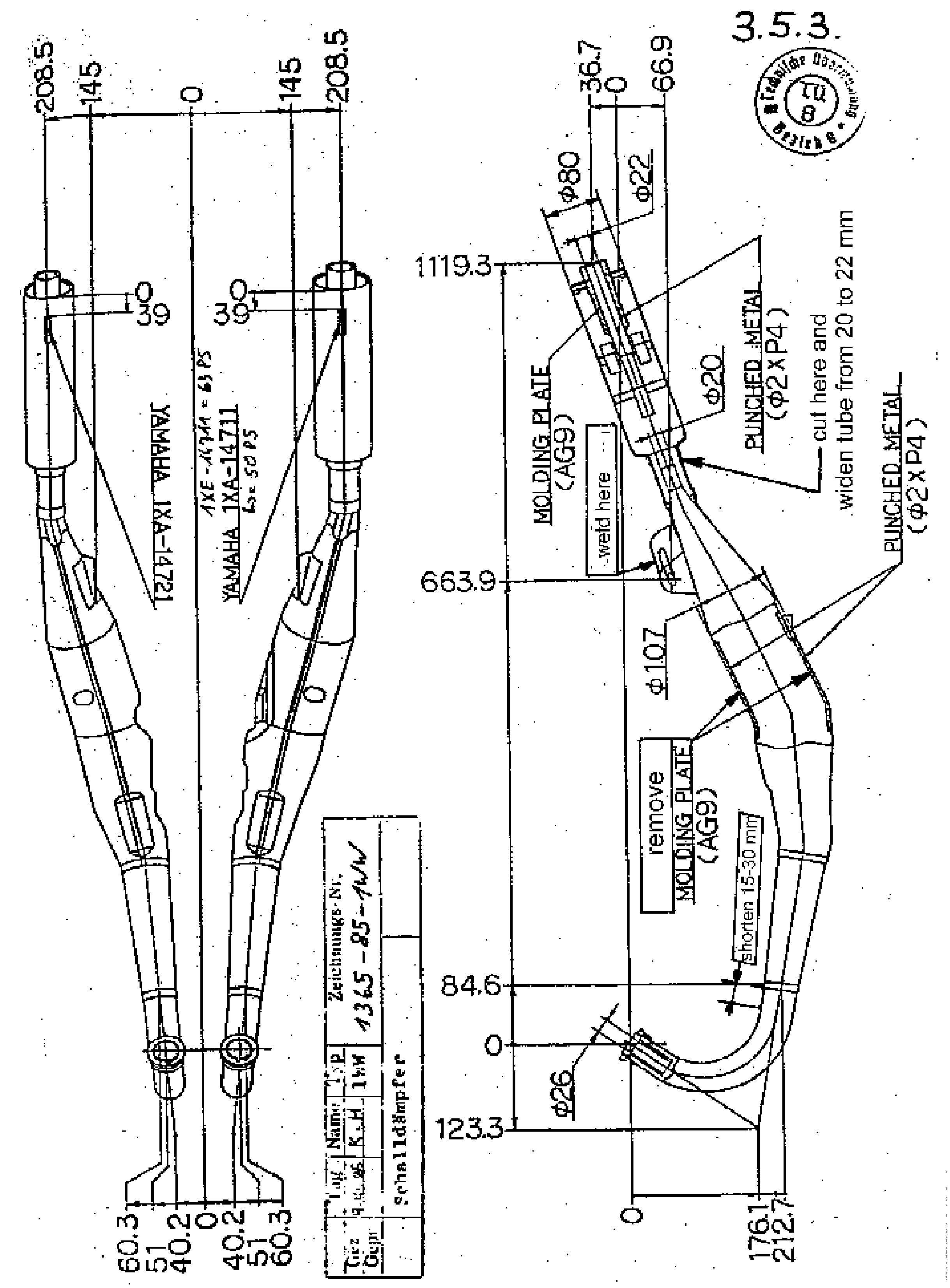


Figure 169: 1WW pipes with possible modifications

Adapter for the cable distributor (longer carb slide stroke), All dimensions in mm

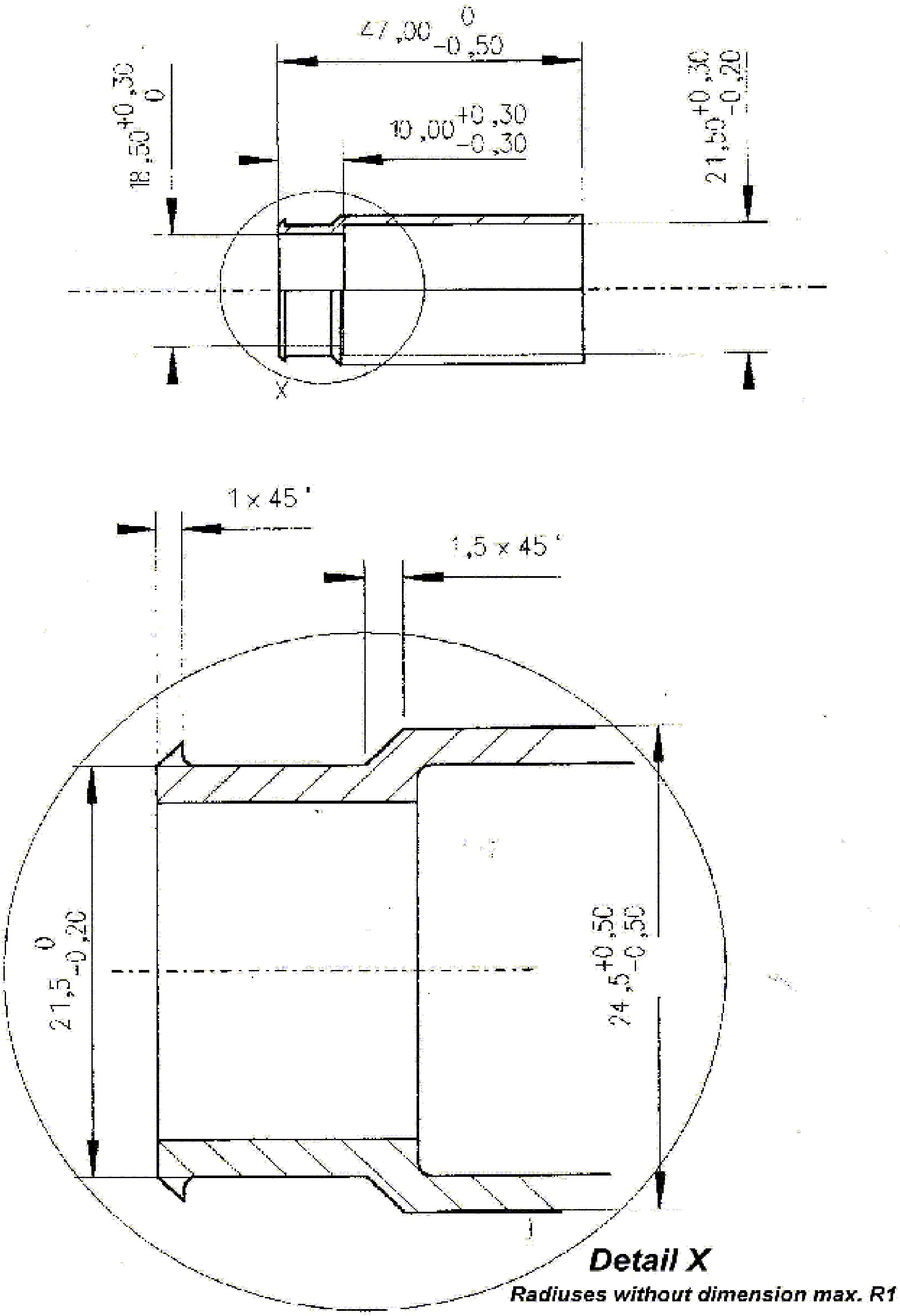


Figure 170: Adapter for cable distributor

Adapter plate to fit really big carbs (TM or VM 34 to 38) to the stock cylinders (without oil hoses), (All Dimensions in mm)

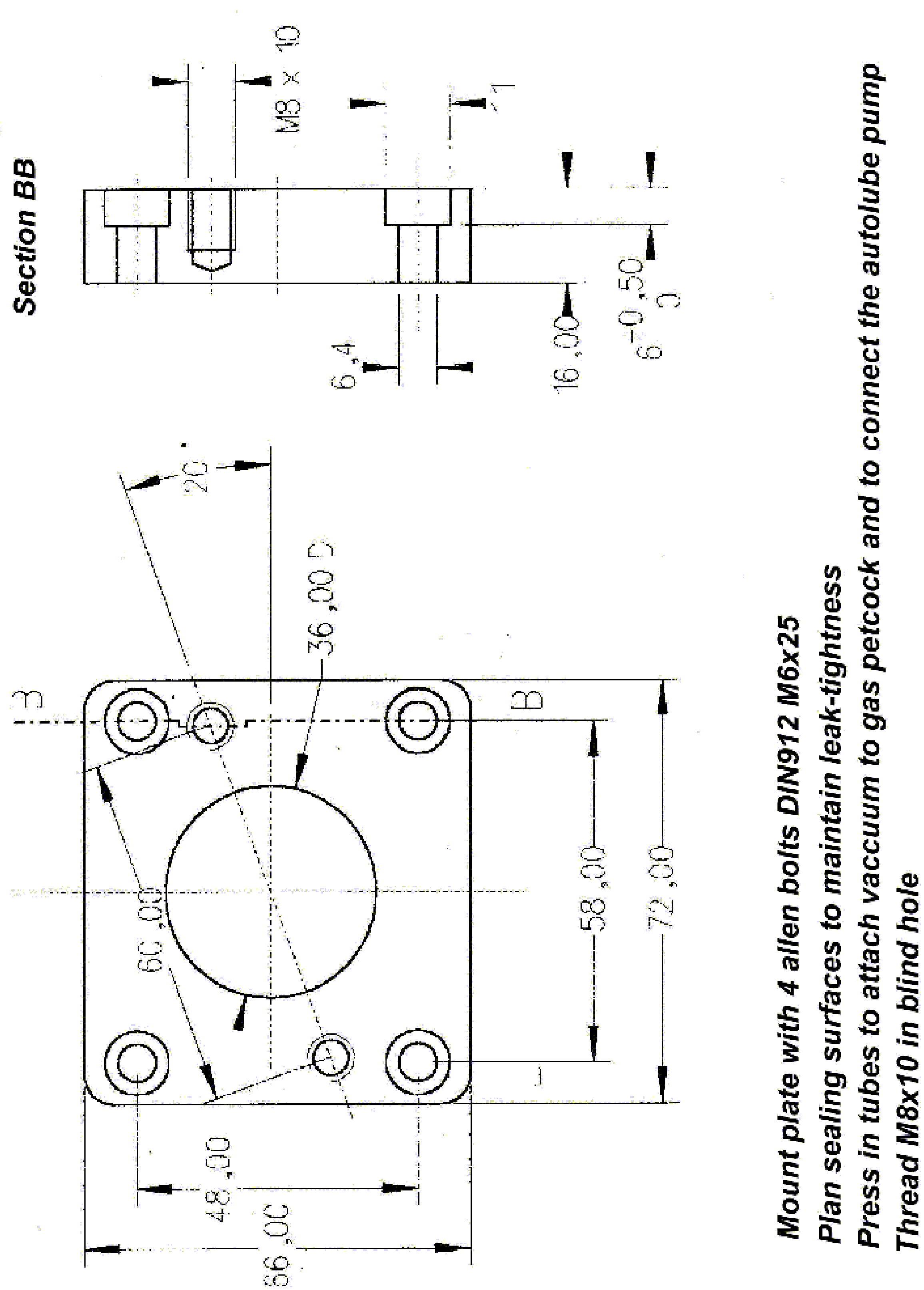
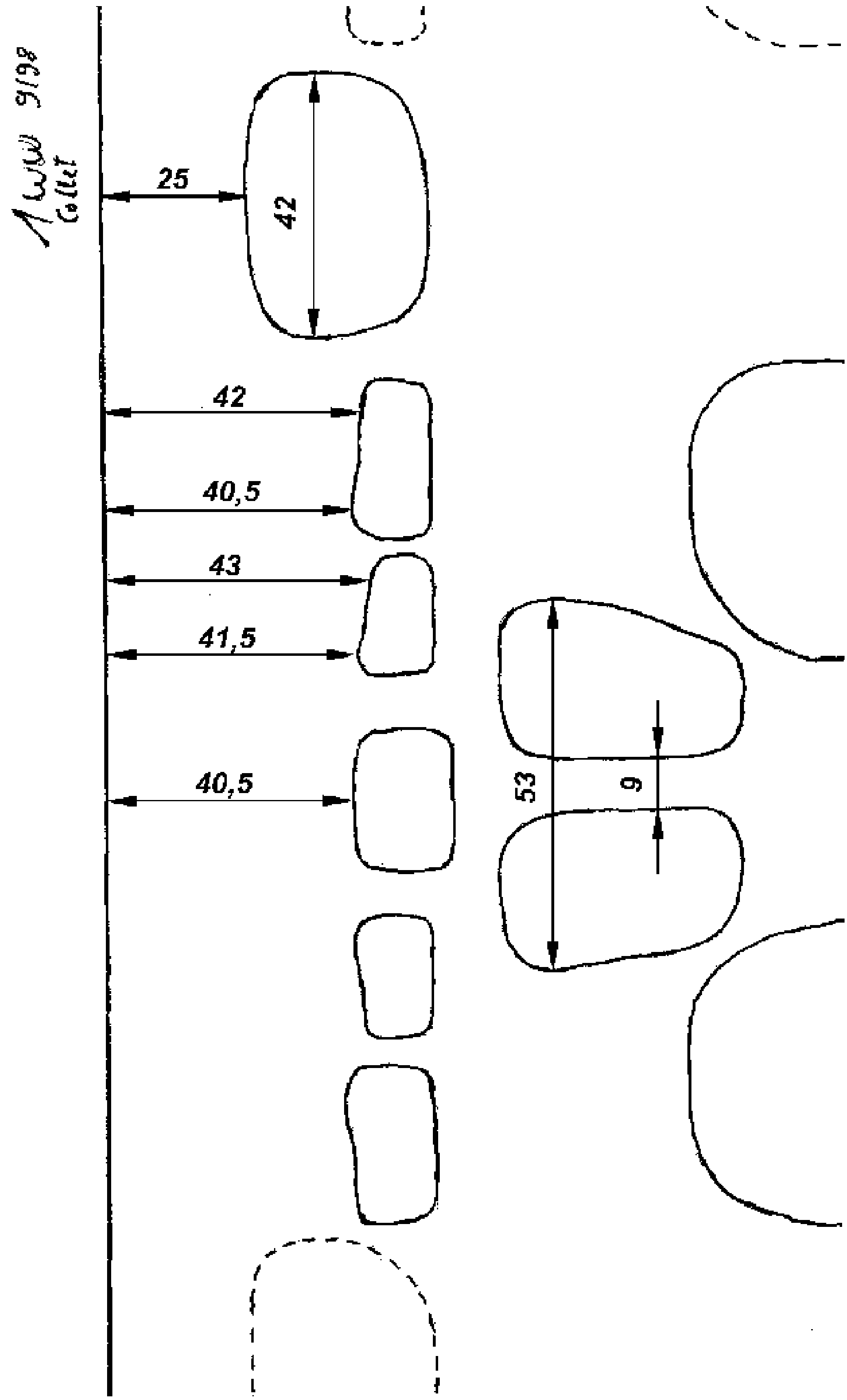


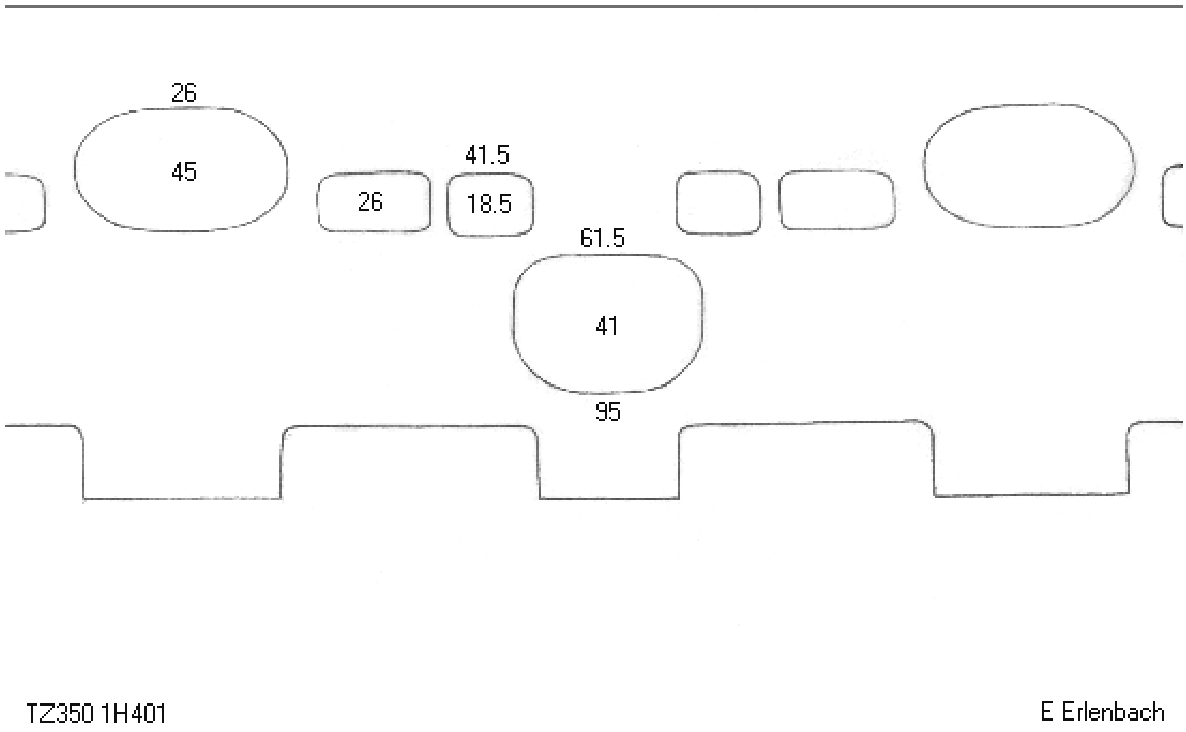
Figure 171: Adapter to fit huge carbs

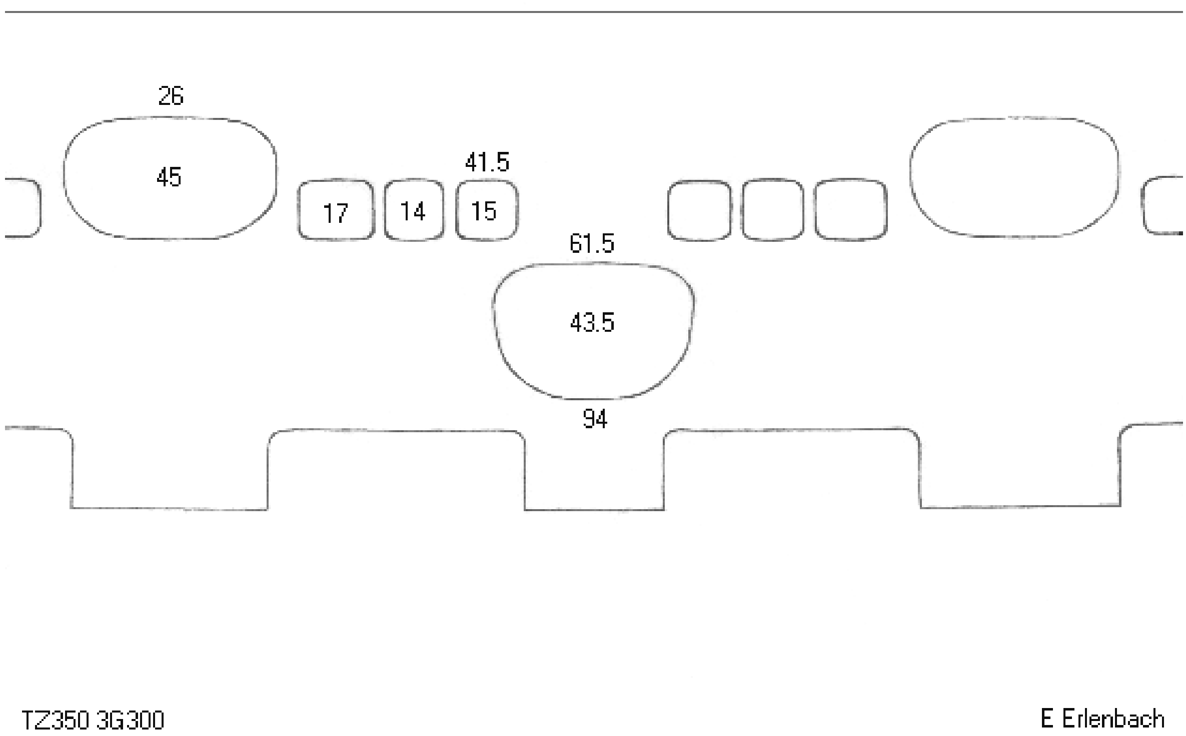
Port layout of my current pair of cylinders
(Collet style transfer ports)
(Approximate port dimensions in mm)



Port layout of TZ cylinders

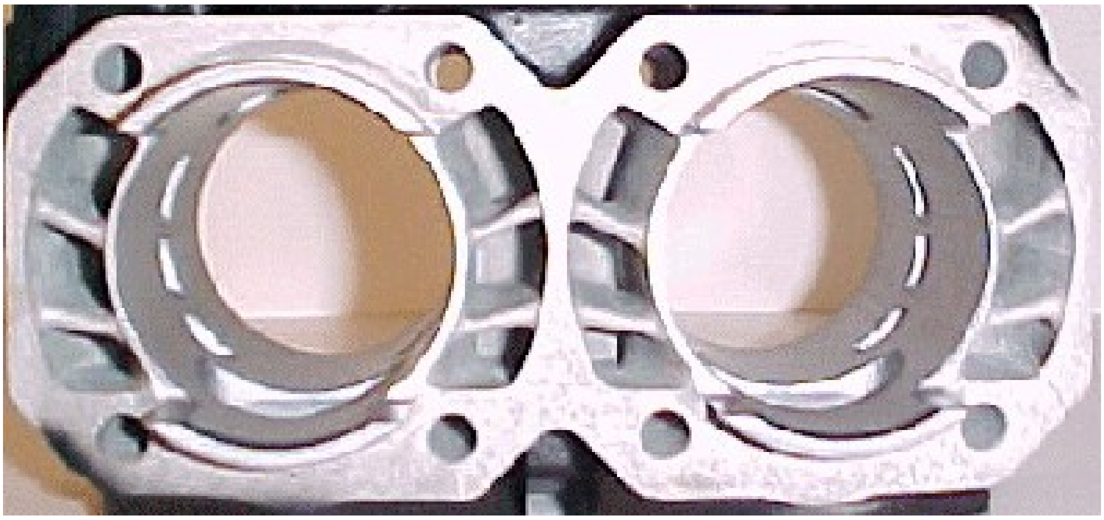
(Approximate port dimensions in mm)



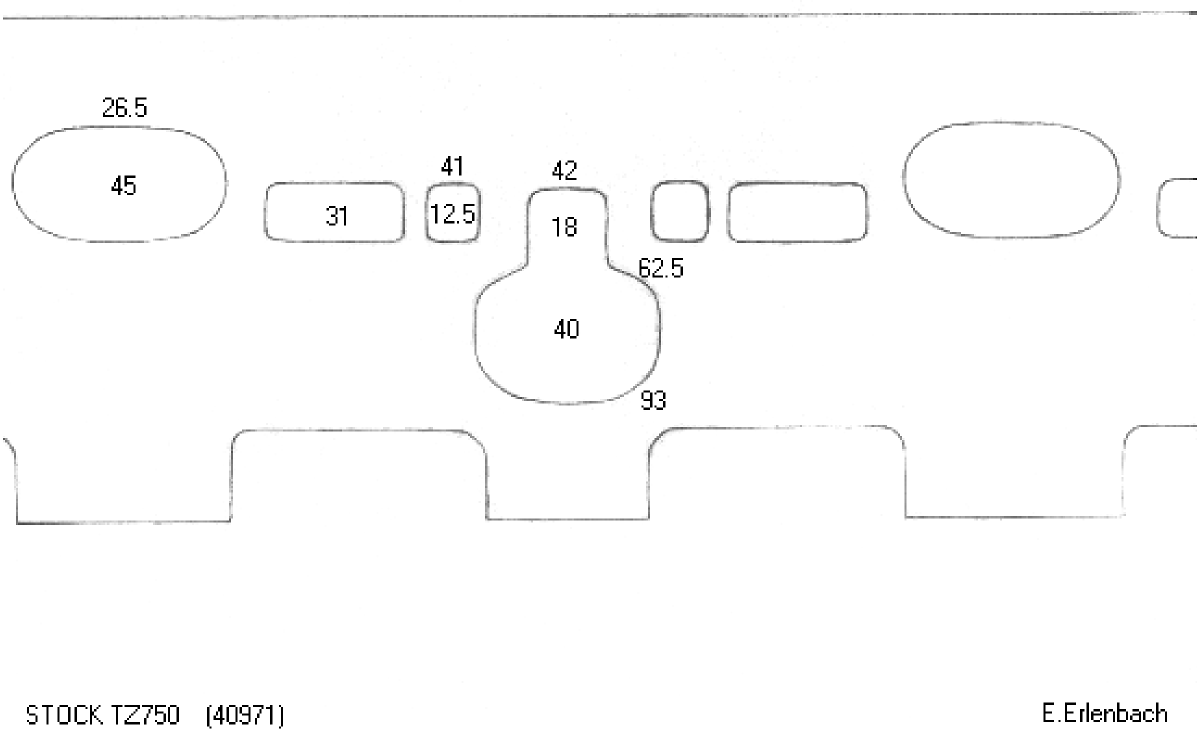


Port layout of TZ cylinders

(Approximate port dimensions in mm)

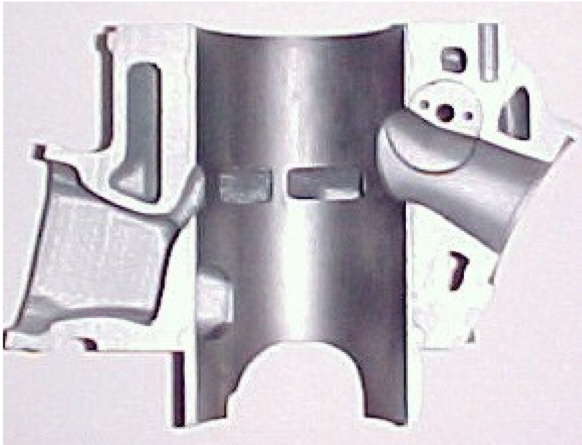


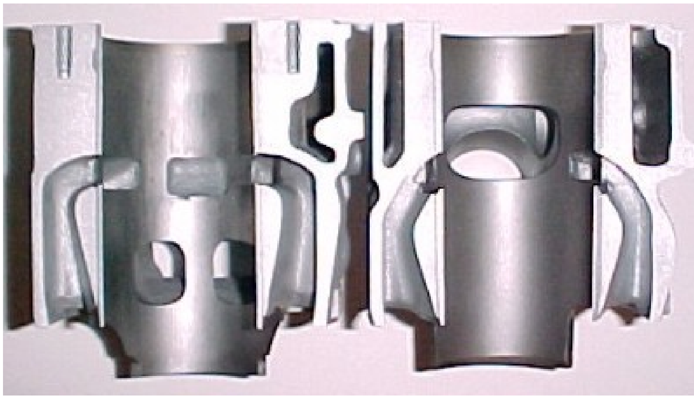
Zylinder View: TZ350 (6 transfer ports, type 3G3)

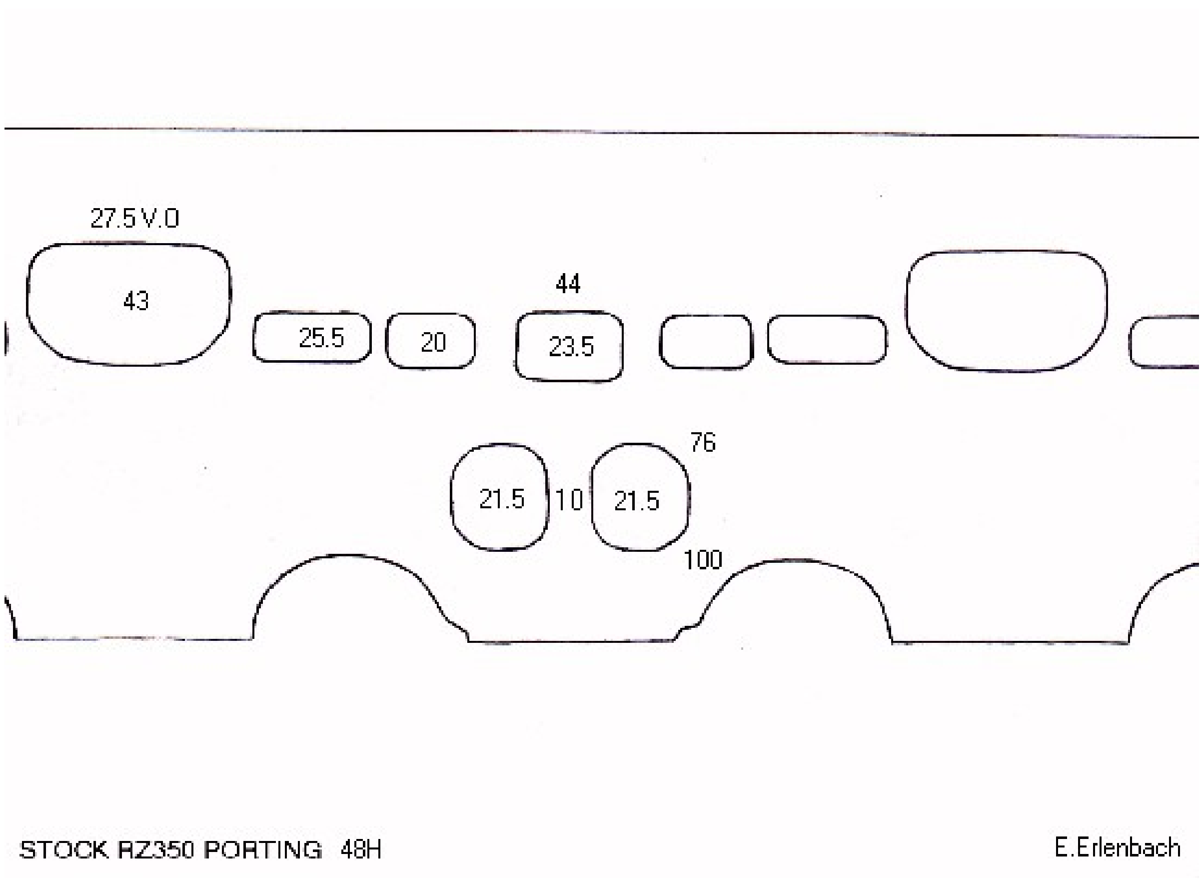


Stock RZ cylinders

(Approximate port dimensions in mm)







Short reference for RD250/350LC (4L1/4L0) mods

Carbs: K&N type air filters (multiply main jet by 1,2 , for example if jetted #140 take #170 and reduce if necessary)

Porting: Use YPVS reed cages, broaden port on right and left side
Exhaust height approx. 27 mm, broaden slightly, do not grind lower port edge, polish
transfer ports: proceed as described

Pistons: Proceed as described (max. diameter: 66,5 Prox for RD350YPVS fit, YPVS-pistons have bigger holes than stock LC)
DT175 pistons are 2mm higher, but can be milled to obtain optimum squish clearance (bore: 66 mm)

Compression: Measure volume and alter to 7,3 - 7,5 as described, (in another LC manual there was mentioned a head milling of 0,8 mm in version b) with an angle of 15°)

Pipes: Everything else other than stock (for example 31K pipes)

Radiator: Can stay stock for mild tuning, otherwise use RGV

Driving resistance: Can be used for LC, additional possibility of using a smaller 520 chain by using a 31K/1WW front sprocket and a tailored one at the rear end (use aluminium sprocket)

Oil: Synthetic race oil for pre-mixture of 1:25 to 1:40

Ignition: Zeeltronic or Ignitech

Chassis: Dunlop K181 TT100 in stock size, some use the 90/90-18 and 110/80-18 Bridgestone BT45 with YPVS rims and swingarm (Tip: cut off the cantilever bar from the stock swingarm and weld it to a stock YPVS one and you can use it as it was tailored for you. Models later than 85 have needle bearings, TZ-swingarm fits, too), use bronze or needle bearings WP-springs and shock, TZ-seat and fairing fit quite well

In the Performance Bikes magazine they published an article about an LCR RD with 58 rear wheel HP and 199 km/h top speed. It had 32 mm RGV250K carbs (#240 main, #160 power jet) with some kind of race pipes, porting work done and K&N filters with a 60 mm filter spacer (see Figure 85).

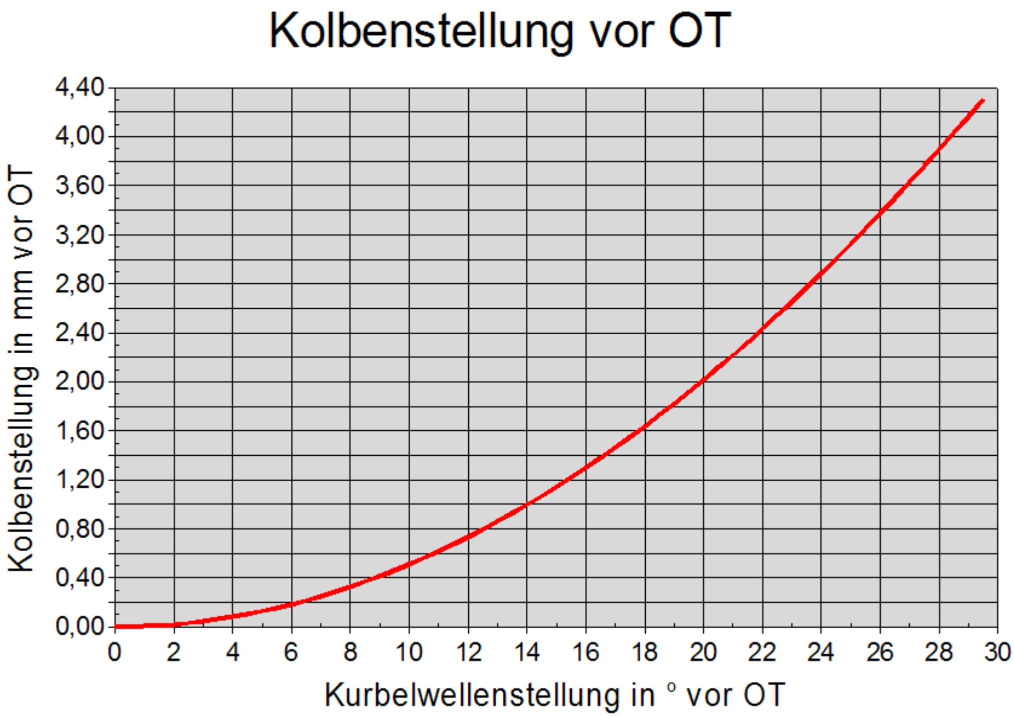
Other way: Use the whole YPVS engine completed with ignition and YPVS control unit.

Carb settings for RD250/350LC (4L1/4L0)

Type	RD350LC (4L0)	RD350LC (4L0)	RD250LC (4L1)	RD250LC (4L2)
Year	1980	1981 to 83	1980 to 83	1980 to 83
Stock Performace	49 HP	46 HP	38 HP	27 HP
Carb No.	4L0-00	4L0-01	4L1-00	4L2-00
Main Jet	#160 later changed to #140	# 210 - #230	#190	#170
Idle Jet	#27,5 - #25	#22,5	#20	#22,5
Needle & clip pos.	4H16 2. Clip	5K1 3. Clip	4N10 4. Clip	4N10 4. Clip
Needle jet	O-6 345	P-2 345	O-6 345	O-6 345
Slide cutaway	2,0	2,0	2,0	2,0
Mixture screw	1-1/2	1-1/4	1-1/8	1-1/8

Ignition data: piston position vs. crank angle

If you want to check ignition timing you need to know the crank position in degrees before top dead center (BTDC). Usually you measure that with piston position in mm BTDC and calculate the crank angle with that value.
Here's the result for all stock RD250/350 LC, Banshee and YPVS (54 mm stroke, 110 mm conrod)
(Kolbenstellung = piston position mm BTDC, Kurbelwellenstellung = crank position deg BTDC)



Calculating mm to deg or vice versa:

Vorzündung in Grad vor OT	α = ignition advance in degrees
Vorzündung in mm vor OT	T = ignition advance in mm
Halber Hub in mm	R = engine stroke divided by 2 in mm
Pleuellänge in mm	L = conrod length in mm

$$P = R + L - T$$

$$\alpha = \cos^{-1}\left(\frac{P^2 + R^2 - L^2}{2 \cdot P \cdot R}\right)$$

$$T = L + R \cdot (1 - \cos\alpha) - \sqrt{L^2 - (R \cdot \sin\alpha)^2}$$

If you have a stroker crank or use different conrods, you need to use this formula

<u>Example - calculating mm to deg:</u> Beispielrechnung für RD400

Bike: RD400E
R = 31mm (engine stroke divided by 2)
L = 115mm (conrod length)
T = 4mm (ignition advance in mm)

$$P = R + L - T = 31 + 115 - 4$$

$$P = 142$$

$$\alpha = \cos^{-1}\left(\frac{P^2 + R^2 - L^2}{2 \cdot P \cdot R}\right) = \cos^{-1}\left(\frac{142^2 + 31^2 - 115^2}{2 \cdot 142 \cdot 31}\right) = \cos^{-1}(0.8973)$$

$$\alpha = 26.19\,\text{deg}$$

Simulation Software

There's a lot of software available that can do single parts like head or pipe design. Freeware is often done by enthusiasts and only covers small parts of the whole engine.

The Freeware „Toms Tuning Tools“ can do head and exhaust port design:
http://atom007.heimat.eu/tmt/tomstuningtools.html
In addition it contains GSF Dyno: A program that can calculate the engine performance from a recorded audio-file of a full acceleration test. Not exactly perfect, but very much suited for checking before/after states.
The Software is also available for Apple/Android and there it's called MicroDyno – SIP HorsePower Dyno.

On the commercial side Mota and EngMod2T are the most common.
As I know more people using EngMod2T, I have a license on my own.
The license does not expire and can be ported “life long” to your PC's. You can purchase it directly from the developer Neels van Niekerk from South Africa: http://vannik.co.za/EngMod2T.htm

A couple of successful tuners use it and helps reducing testing as shows the weakest points and gets you into the right direction.
For me it revealed that base plates for stroker cranks are not as good as a head rework and lower port timings.
The sims later proved to be right on the dyno.

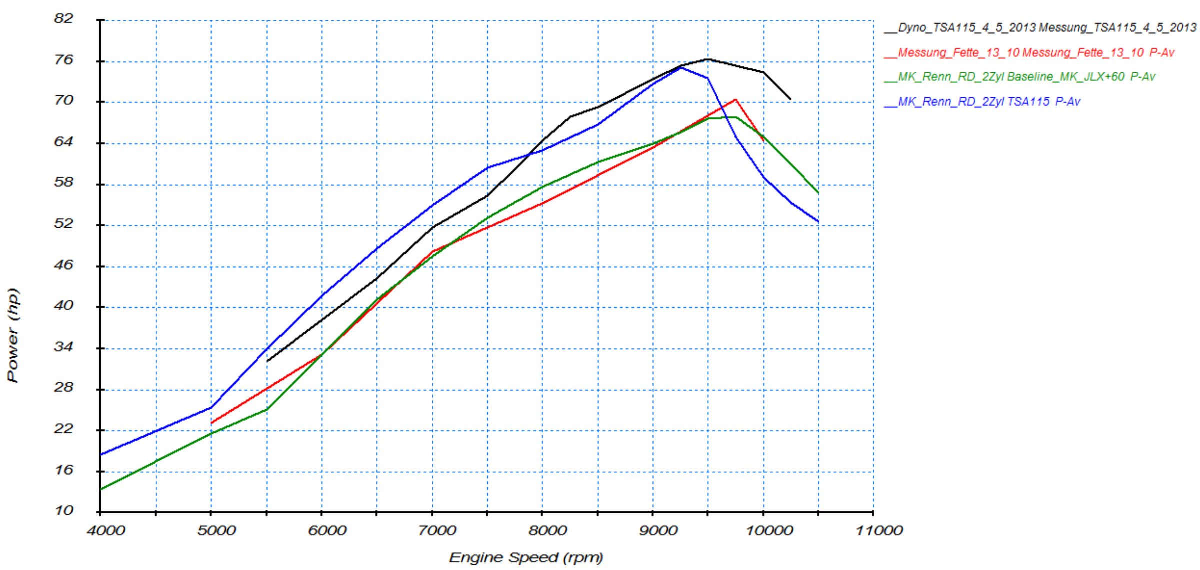
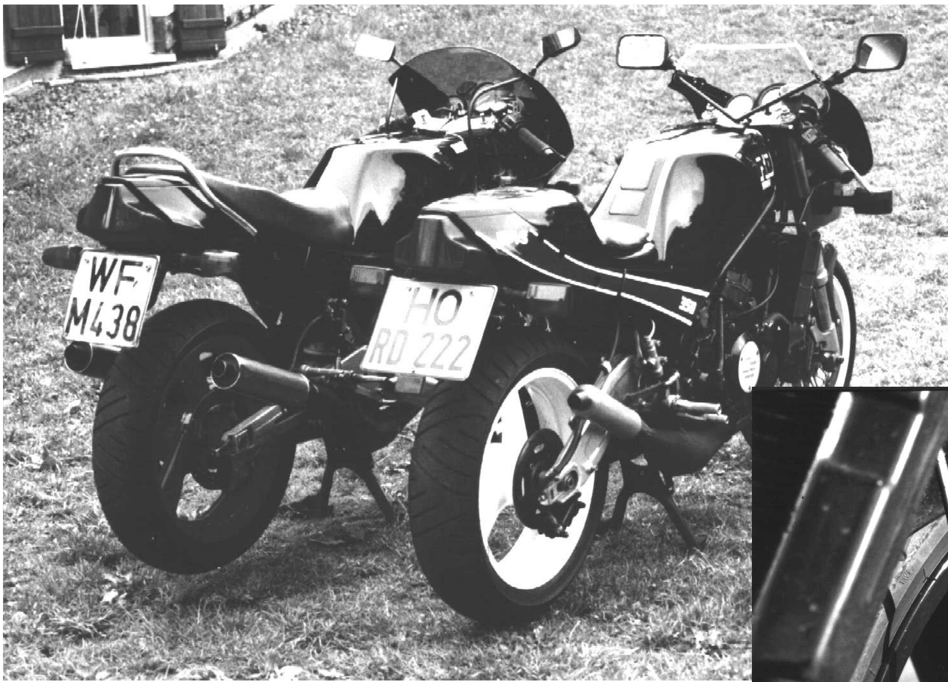


Figure 172: Comparison simulation/dyno

Marco's RDV350

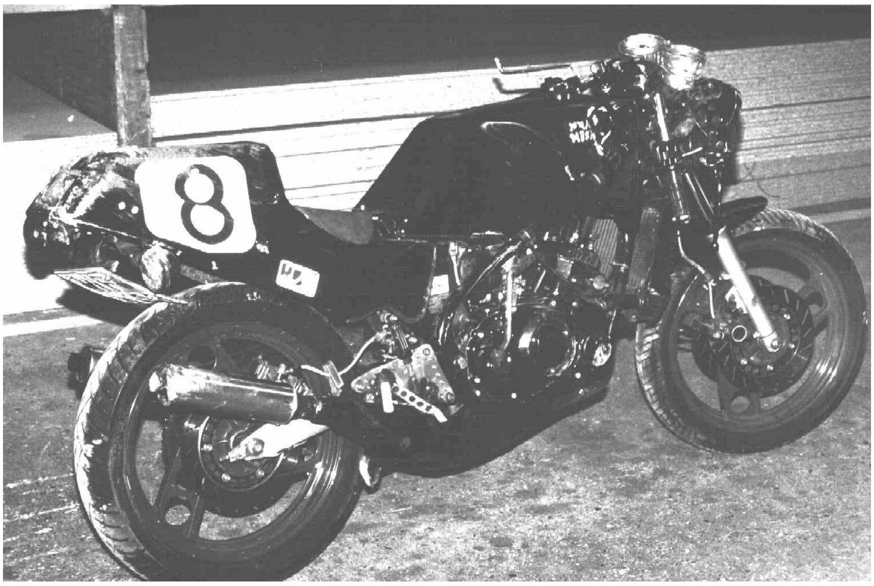
Fork, swingarm, brakes, rims, radiator, fairing: RGV250 '91 (VJ22B)
All mods approved by German TÜV (incl. Jolly-Moto and 30 mm carbs).
If you're interested, Marco does this and similar conversions. Price: depends on degree of modification (Info: +49/9252/7371 16:00 to 21:00 CET or sonic.speed@gmx.de)

YAMITO: Fork, rims, cockpit: Cagiva Mito 125 ’91, brakes: Yamaha YZF 750 (6-piston caliper), Swingarm: Honda NS400R ’88, Fairing: MuZ Skorpion Sport, DE-headlight: FZR 1000/600, Mikuni 30 mm carbs, All mods approved by German TÜV



Last page

Always remember: Stay on your bike whilst riding ....



Upper: My RD in April 1991 (crashed with an NS400)
Middle: The Author in May 1991
Lower: My RD in June 1989 (crashed with some trees in the Harz mountains)