BRITISH MZ RACING CLUB

MZ250 Race Preparation

for the financially challenged

second edition Sept 2002

Introduction

The aim of this guide is to give some practical advice on building an MZ250 for racing in the BMCRC MZ250 class. The regulations for 2002 season are used as a guideline. It is not intended as a tuning reference so the settings and timings are for example only, but are mostly workable – I have to say that because mistakes can be very expensive in this game! Some definitive theory books are listed at the end.

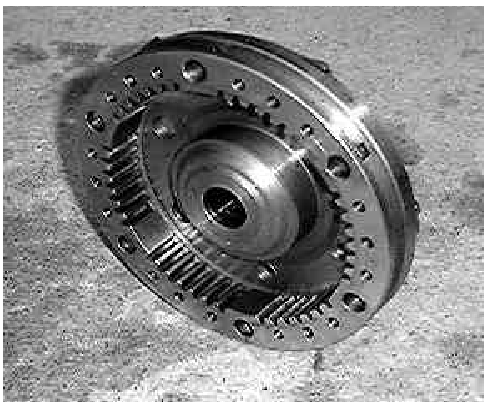
The MZ formula is simple - basically stock carburettor, stock exhaust header and diffuser cone, max diameter of expansion chamber no more than stock, and clutch must be crank-mounted as stock. Other standard parts specified, like barrel, head, cases, frame etc. but some parts are 'open' eg wheels, brakes and tyres.

Engine

Bottom end

Crank stays more or less standard - some people lighten and rebalance the crank wheels but it is lots of work for little gain in this class. The best place to spend the effort is making sure it gets assembled properly, perfectly true and check it for out-of-round.

Bigend needs to be replaced with a silver plated cage type for racing (£20), to a conrod that has been checked for damage. The standard (original MZ) rod has proved perfectly reliable, but the crankwheels can be modified to accept a japanese rod and bearing kit which some prefer. Fit new little end, main bearings and crankcase seals – take care not to overheat the seals when heating the cases to get the mains in and out, and take care not to 'nick' the seals on the step on the crankshaft as the spring can get dislodged.



Most people take a lot of weight off the clutch which is crank-mounted and very heavy – show it to a machinist or a tuner and ask them to shave it, which makes the engine more responsive. Simply turn a big recess on the outside of the main 'basket', remove the castellations which guide the pressure plate (it works fine without them), and take some of the excess metal from the surface and centre boss plate. Drill some holes, in pairs across the diameter for balance, right through the boss plate and the basket. Concentrate on removing weight from the outermost parts in this way as this gives the best effect (rotating inertia of a mass is proportional to square of its rotational radius ..) and the mods described make a substantial difference.

The clutch has a tendency to work loose from the taper, then ruin the taper in the boss (clutch centre) and the lightening might help this. Best prevention is to make sure the taper is perfectly clean and undamaged on assembly, and then tightened fully using a suitable locking tool to prevent the crank turning (see suppliers list). If it is scored then replace it. It can be modified to key the boss to the crankshaft which guarantees the thing stays put.

Change ALL the bearings (they really don't cost much), the oil seal, and check the thrust washers, selector forks and gear teeth for condition. Replace anything less than perfect because they get punishing stress in racing. The little layshaft bearing in the blind hole can be removed easily by heating the case evenly to about 150 celsius, when it will literally fall out: clean the case thoroughly, wait till the wife (or other likely objector) is about 5 miles away and put it in the oven, face down on a tray. Open the windows, give it 15 minutes at gas 5, and you will hear it hit the tray. Drop the new one in while it is hot. This goes for all the bearings in the ally cases, they need to be heated or the housings get damaged and the fit is lost.

Gearbox should be refurbished while the cases are apart - 3rd gear suffers from a slight design defect that can be rectified with some attention – see below.

Gearbox

Problems with 3rd gear selection stem mainly from the lack of 'undercut' in the 3rd gear pinion window. What this means is the sliding dog, which has slightly tapered tangs on it, should meet similarly tapered holes (windows in the pinion) so that under load the dog tends to 'pull' itself into mesh with the pinion.

Unfortunately MZ seem to have forgotten to put the taper into the windows, hence they have to be 'undercut' which is to grind them to shape with a suitable tool. It is very hard metal, and I have managed it with a Dremel fitted with a 2mm diameter diamond-faced cylinder shaped cutter. It is difficult to do accurately, so it's not for the faint-hearted. They need to be widened into the side facing away from the dog, so they have about the same taper as the dog tangs.

Check the condition of the 3rd gear selector fork before reassembly - if it has been jumping out, it tends to wear the sides and bend the fork so replace it if there are deep furrows in it, or it doesn't look straight.

Also pay attention to the condition of the 'detent roller' which is the indexing roller on a sprung lever arm in the primary drive case. It lives behind the driven primary gear. Replace it if it looks burred over. Another mod I have done is to grind a groove in the selector fork shaft, again using a dremel with a diamond disc, holding the shaft in a drill and turning it slowly against the disc - to fit a circlip to retain the detent arm, which has a habit of falling off and getting mangled in the primary gears.

Some other problems they have are too much endfloat on the selector drum, and same on 3rd gear pinion where it is mounted on the shaft. The drum can be shimmed, just to stop it floating around, but it makes sense to shim it away from the clutch side so it tends to drive the 3rd gear dog more into mesh. This requires some 30mm shims - I made them out of 10 thou (0.3mm) brass shim metal (bought it from a model shop) by sandwiching the sheet in some wood, with contact glue for grip, using a hole saw in a drill. Then cut out with scissors, 3 or 4 mm wide. Use as many as you need to give about 0.2mm endfloat (mine started 0.5 and my other gearbox has 0.8!). Test the endfloat by putting it in the cases, tighten the case screws up fully without the crankshaft or the neutral switch plunger (it pushes against the drum) and poke the drum back and forth. Use a vernier to measure the height of the drum end above the case at either extreme.

The pinion is best brought to tolerance (again, 0.2mm is good, no less than 0.1mm) not by shims but by remaking the 7mm wide spacer that sits between the 2nd and 3rd gear pinions. Shims would need to be very tough as a failure could lock up the gearbox if the shim got out and mangled in the gears. The spacer needs to be a reasonably hard wearing metal, like carbon steel or phosphor bronze - I got hold of an offcut of EN8 steel from a local machinist. I turned it on a lathe to 22mm i/d, 30mm o/d and the right length to set the endfloat - mine needed 7.5mm to give 0.1mm float. Mount it on the shaft with the standard thrust washer and circlip, and pay attention when reassembling to thrusting the output shaft bearing cap properly - the one behind the sprocket, should have shims behind it setting the endfloat of the whole shaft. The book specifies 0.4mm: tap the outer bearing and shaft fully home against the inner bearing circlip and splash plate then test the clearance with a bit of solder, like when measuring the squish band, by tightening the cap down with the solder sandwiched behind.

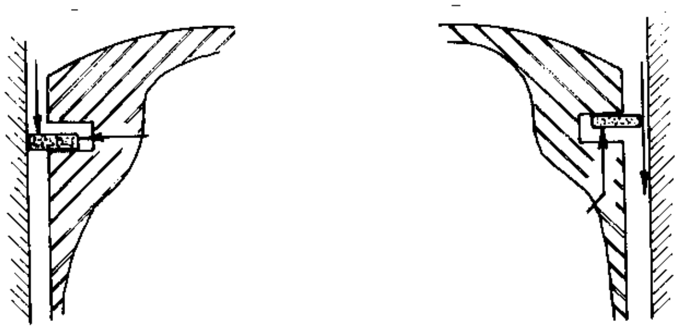
Don't forget the splash plate - a thin washer with a hole in it at the other end of the output shaft, with a baffle plate held in by a circlip. This collects a small puddle of oil that splashes behind the plate and directis it down a hole in the shaft to the 2nd/3rd gear pinions and spacer!

Top end

General

The MZ piston goes in the bin. It is far too heavy, has too many rings and is made of spat-out cardboard or something equally unsuitable for racing. The best piston material and manufacturers are Japanese but there are a number of patterns to choose: the type of piston depends on whether you go piston-ported or reed valve in your tune - whichever you choose you need a 70mm nominal size (69 is the MZ standard) with an 18mm gudgeon pin.

Get the barrel bored to match the new piston with a 0.08mm diametral clearance. Be fussy and state you want a careful job, ‘sparked off’ exactly parallel in the bore, exactly perpendicular to the cylinder bottom face (not the liner spigot) then honed to your specified clearance.



pictured left, piston ring with proper gas seal formed when ring is in contact with lower land and combustion pressure can reach behind it

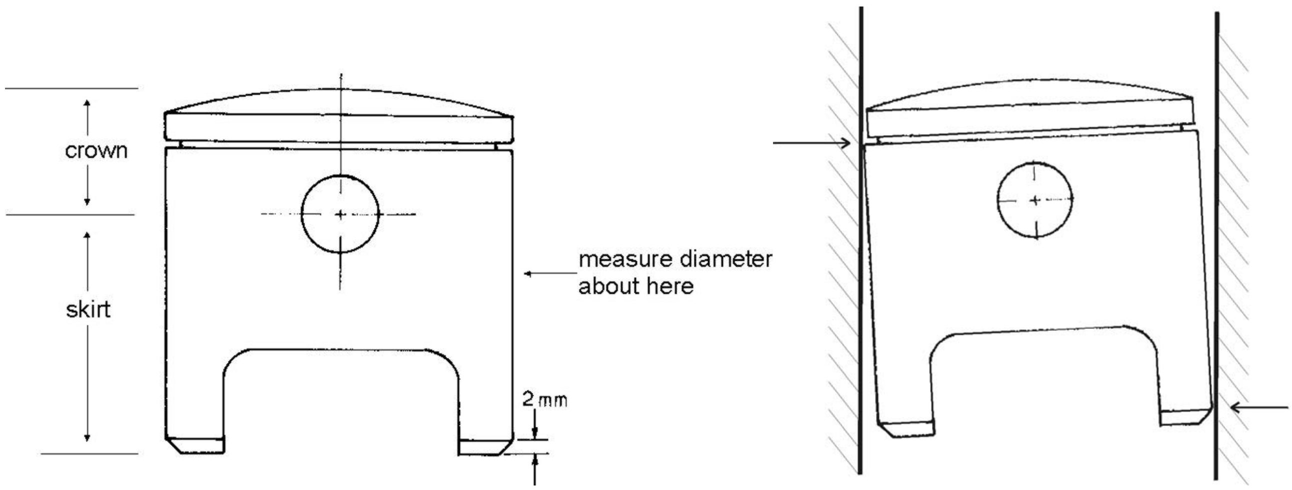
pictured right, ‘flutter’ condition is when acceleration forces at TDC exceed pressure forces and ring leaves lower land. Sealing thrust against bore is lost – pressure can escape .

The Suzuki TS250 piston has two rings, about 1.3mm thickness which is good for roughly 8000 rpm and has a long skirt for piston porting. The RM250E piston has a single 1mm ring which is good for 9500 rpm, has a shorter crown height and skirt length which is OK for reed valve use. One of the speed-limiting factors is ring thickness, which determines what speed 'ring flutter' sets in but 8k is fine (see below).

Both can be run with one ring to reduce friction, if 20:1 fuel/oil mixture is used to maintain good compression seal (this mixture is the subject of great debate). But the pipe and carb sizes allowed will not flow much more than 8500 rpm. I use the RM piston and a reed valve from a RD350 and I can get it to rev on to over 9000, without useful power up there but it makes the motor nice and flexible.

Piston

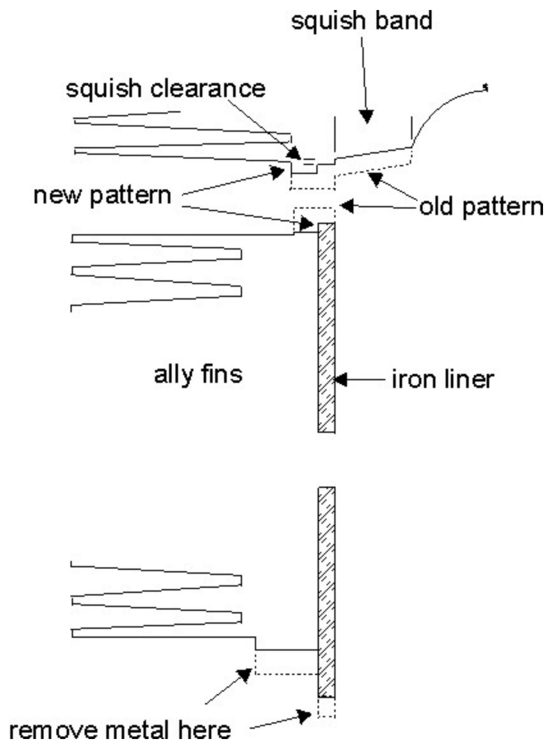
Prepare the piston by chamfering the edges of the skirt, 2mm deep (LH diagram, below). Very carefully stress-relieve the whole outer edge of skirt and pin boss, by filing smooth any nicks and sudden changes in section of the casting. Finish the worked areas with 1200 wet-or-dry using plenty of kerosene, white spirit or thin oil (WD40?) as a lubricant. Relieve the top ring land slightly also, at least along the exhaust-facing edge as it bears the thrust here (RH diagram) and can scuff up as the piston wears - the piston rocks forwards on the power stroke, and you need to make sure the pressure (thrust) is shared by the bottom of the skirt on the inlet side and the face just below the ring lands.



Pictured left, piston details. Pictured right, correct thrust points for a 'rocking' piston – crown must be relieved to allow this

Barrel

When the piston is chosen the barrel has now got to be shortened at both ends to make up for the different piston skirt and crown height. Machining the top of the barrel to set the exhaust port first will push the transfers up too far, making them open too early ie the 'Blowdown' period will be too short. So in order to get the transfer port opening point right the barrel top should be machined to set this first, then the bottom machined to correct the TDC position. The exhaust port is then enlarged to the new height and width setting, and finally the inlet port modified as described later.

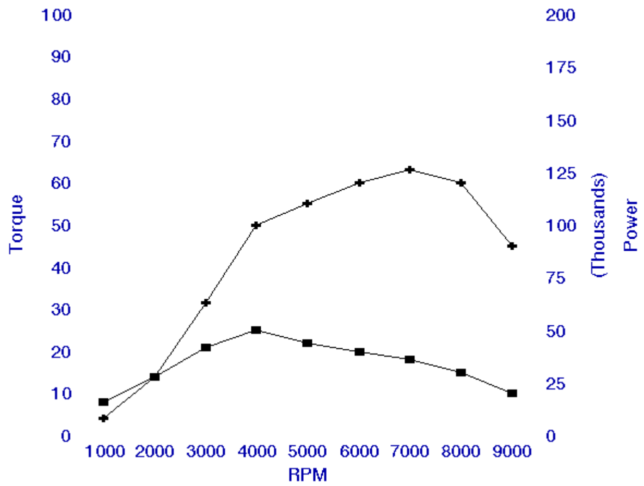


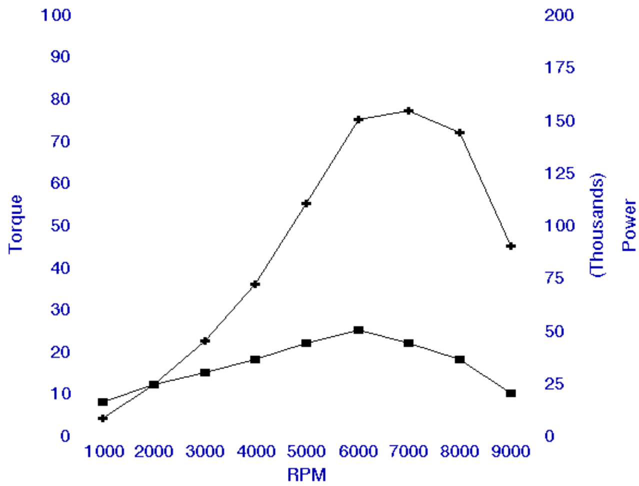
The liner spigot (the part of the iron cylinder liner that locates in the crankcases) must be shortened also to match the cases - decide whether to use a gasket, and what type, and account for this in the measurement. Personally I don't use any gaskets at all, just a good quality sealant like Wellseal and carefully prepared surfaces. These measurements have to be exact so spend a good deal of time over it, using modelling clay to take moulds of clearances etc. Make a spigot at the top of the barrel for mating to the head by machining so the liner protrudes by 1-2mm or so from the top face - see head preparation later.

Inlet port

Then the inlet port needs to be modified - it will need moving upwards - using metal epoxy (eg Devcon 'F' aluminium putty) and a metal spacer screwed to the port floor to build up the floor to give your chosen port timing, and a die grinder or a Dremel (a flexible shaft in a drill doesn't really go fast enough) to remove metal from the roof. There are arguments about whether to leave some of the cylinder liner 'tongue' in place, which serves to improve the piston thrust-face contact with the liner on the road machine as it passes the port which of course is on the thrust side of the barrel for a forward-rotating engine but I am of the opinion that the pistons wear too fast on a racing machine for this to be of much benefit, though some of the cheaper pistons tend to break at the skirt. A reed valve modification does not require the port floor to be built up, so skirt support is much reduced across the port and leaving the tongue will be beneficial. A forged piston (Wiseco) will help here as they are stronger.

For a piston-controlled inlet port the usable range for timing is probably 155 to 175 degrees total ‘open’ duration.. There are many schools of thought, but the setting affects the cylinder filling efficiency as a function of speed, and increasing the duration has the effect of moving the torque peak up the speed scale. As power itself is the product of torque and speed, the shape of the power peak (and thus the tractability of the engine) is directly affected by the port timing. The diagrams below illustrates this (with kind permission of John Wood and Rob Carrick, ‘Villiers Singles Improvements Handbook’) – note the maximum torque has not changed in magnitude between the diagrams, but its changed position has affected the power delivery markedly.





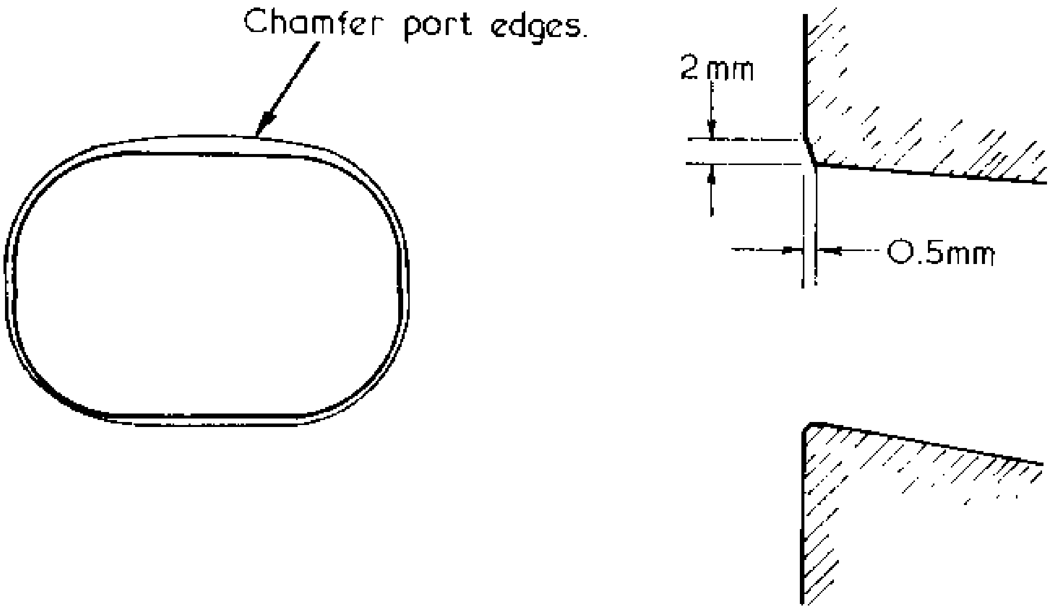
As with most tuning parameters, the relationship between torque and port timing is not simple, and other factors need to be considered as the carburettor, inlet tract, port and crankcase space act as a resonant cavity with the pulses of air movement in the system. It really does warrant some extra reading. All this also affects the jetting requirement – for example I use a 240 main in my reed-valve engine, but some of Tony Holmshaw's piston-port tunes use 200 and some Burwin's use less than 150 – one factor that causes this is an effect in the carburation called 'loading-up' or 'triple-carbing' at low speeds .. reed valves don't do it so the fuel delivery requirements are totally different.

The exact shape of the inlet port tract is down to how much work you can put in to it, regarding the above, but as a guide it needs to point downwards for good flow, and the port opening wants to be no less than 90% of the cross-sectional area of the carburettor, but no more than 120%. Theoretically, if an air passage such as the inlet tract is 'necked' slightly at a transition, like the opening at the cylinder wall, the velocity is increased and the turbulence is less detrimental, which can give good flow but at the same time a gradual taper outwards along the length increases the flow capacity (reduces the effect of turbulence at the walls of the passage). Ideally the two should be combined but make sure the passage does not have any sudden changes of shape, nor bulge out unnecessarily as the stream velocity will drop at the wide spots causing fuel ‘drop-out’ (basically it condenses onto the walls, coming out of the mixture) and further turbulence, which is bad for the gas flow.

Necking at a bend will help to keep the path length along all sides the same, hence keep flow laminar (non-turbulent) if the 'neck' is formed on the inside radius of the bend. Also, a slightly rough finish to the walls of the inlet tract will improve flow by causing micro-turbulence along them, which actually reduces drag at the boundary – it is like a cushion of already-moving air – so don't polish them finely, just use rough emery paper in small circular movements.

Exhaust and Boost port

Again a subject for further reading, but reasonable 'book' values for Exhaust Port timing are 190 - 195 degrees open duration (32 to 34 mm TDC-to-opening) for these speeds with no mods to main transfers, except some cleaning of the casting burrs, and the addition of a seventh ('boost') transfer port at the back of the piston. This gives extra transfer time-area needed for top speed, and helps piston crown cooling. It has the form of a little trough in the back of the barrel, pointing upwards fairly steep - 15 or 20 degrees from vertical - and a matching hole or slot in the piston below the rings, about 12 - 15mm wide. Make sure it stays a few millimetres clear of the ring ends or there could be trouble. With a reed valve this can connect down to the reed chamber on the cylinder side, and I have done this myself but for the sake of crankcase compression I think it might be better not to.



Be careful when machining the boost-port window into the piston, the material is brittle and I find it best not to drill but use a 6mm or smaller end-cutting mill mounted in a drill press. It can cut an angled slot without dancing about on the curved surface of the piston which risks cracking the skirt. And pay attention to the position of the bottom of the slot – too far down the skirt and it risks blowing into the inlet port at BDC, depending how high you have made your inlet port and how much of the skirt-support tongue is still there. The last one I made is very close because I forgot to check! It is way past the bottom of the liner cutout, but this can't be made to line up with a TS piston.

Exhaust port shape is a matter of preference, depending on which tuning book you have read but it should look vaguely like the sketch. It helps the smooth flow of gas if the port floor is matched to the BDC position of the piston, or just below it, and will increase ring life if the perimeter is well rounded at the corners to help 'ease' the ring back into its groove as it passes the port.

Finally all the port edges need to be chamfered but the machinist should do this when it is rebored – see diagram.

More on Port Timing

Regarding timing values, Tony Holmshaw's recommendations, for a TS250 piston, are to take 8mm from the barrel base, add 5mm to the inlet floor, raise the top of the inlet port by 8mm working around the 'tang' so it supports the piston skirt as it passes the port. That leaves nominally 4mm to be removed from the barrel crown, pushing the main transfers to 46.8 in my example (142 degrees) and the exhaust to 31.4 (198 degrees). Then he recommends raising the exhaust to 30mm (but no more) which gives 203 degrees duration. The inlet opening point becomes 34.8mm (173.5 degrees).

Tony's motors regularly win races so there is little argument that they are sound figures, but they are pretty radical compared to what you might calculate. Now, I don't have the benefit of his vast experience and success in tuning these engines (though mine are recently getting top 10's) but I chose my timings by working through various formulae, trying out the measurements and pitching for something a little more conservative, but potentially less aggressive and easier for the novice rider to manage: main transfers at 48mm (137 degrees) exhaust at 31mm (199.5 degrees) and inlet at 33.8 (170 degrees). So for my porting, on my example barrel measurements you would remove 9.2mm from the base, 2.8mm from the top, and add 6.2mm to the inlet port floor. Inlet and exhaust port roofs would need further raising as before.

In all cases the auxiliary transfers (second, smaller ones) will open 1mm earlier than the mains and the boost port should be set to open 1mm before that.

Measurements:

- MZ piston: Crown to pin centre 46; skirt base to pin centre 41
- TS250 piston: Crown to pin centre 34; skirt base to pin centre 29
- Original porting (mm from TDC): Deck 0.1; Exh 35.4; Main Transfer 50.8; Aux transfer 49.8; Inlet 29.9

It is a good idea as I mentioned before, to leave the rebore until after the port rework has been done in order to avoid accidental damage to the bore. But it would be more accurate to make all the height measurements for the machining with the new piston in place – which of course you can't do without having first rebored to fit it. What you can do, however, is remove the base gasket, reassemble the bottom end and make all the port measurements with the old piston, and provided you carefully measure the new one and the old one regarding crown height and skirt length then you can allow for the differences. Use a good quality vernier or better still a calibrated height gauge and a surface plate if you can borrow the use of one for a few minutes. Your machinist will probably help you out. Personally I use an old marble slab as a surface plate in my workshop, and a dial gauge on a magnetic stand (not that marble is particularly magnetic …). First I measure the total skirt length, then the height to the top of the gudgeon pin with the pin sticking out one side of the piston. Then subtract half the pin diameter (18mm dia) to get the measurements to pin centre – crown height to centre is total length minus skirt length to centre. You need to do it this way because the small end is the datum for the measurements, ie the only thing that doesn't change during the retuning!

You need the crown height measurements to determine how much to take off the total barrel length – the difference between this measurement in the old and the new piston, because that's how much TDC is going to move by. Take this difference (12mm in my case for the TS250 piston in the piston-ported motor), and subtract how much you removed from the top of the barrel (to set the transfer ports – in my case 2.8mm) to give the amount to remove from the bottom of the barrel (my measurement gives 9.2mm). Now, add the new piston skirt length (total length from top to bottom along one side) to the inlet port opening point setting to give the required height of the inlet port floor, as measured from the top of the newly machined barrel to the lowest part of the port.

Settings were arrived at as follows:

From Bell – for 9000 rpm:

Transfer 128 degrees = 50.0 mm
Inlet 165 degrees = 32.5 mm (measured at piston crown)
Exhaust 192 degrees = 33.0 mm

These figures are derived from his own experiments, where a fully developed exhaust (typically 44mm at the port, tapering into a 110mm chamber) and bigger carburettor (36 or 38mm) are allowed. We don't have that luxury, and the best 'simple' explanation I can come up with for the fairly big difference in our similarly arrived at settings is that we are fighting a restrictive exhaust flow, and need to tune for a higher target horsepower than is actually available – however, our settings stack up well against modern time/area analysis targets (this was not the model for tuning that Bell is quoting against).

My settings are:

Transfer at 48 mm = 137 degrees
Exhaust at 31 mm = 199.6 degrees
Inlet at 33.8 mm = 170 degrees (measured at piston crown)

The time/area figures are approximately:

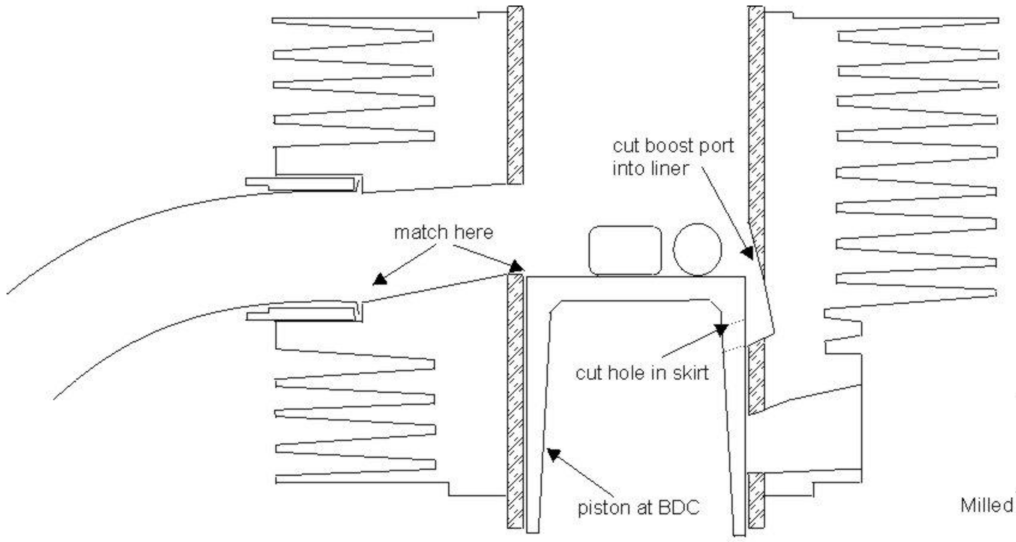
totals s-mm^2/cc	
0.01499	Exh
0.01148	Transfer
0.00084	Blowdown
0.01250	Inlet

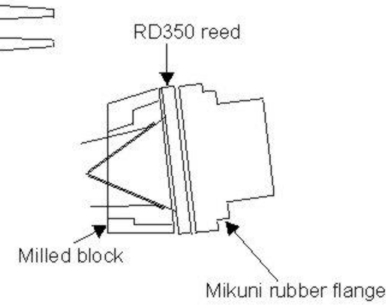
This was modelled on a spreadsheet, by chopping the ports horizontally into segments and summing segment areas in 1mm increments over the piston motion – incremental dwell times for each segment are worked out against the trigonometric function of piston displacement (this is *not* sinusoidal). It is quite hard to do, and I'm not sure how accurate it really is but the purpose in this exercise was just to show how the figures might compare to 'book' values of that method, for the piston-ported motor.

Carburettor mount

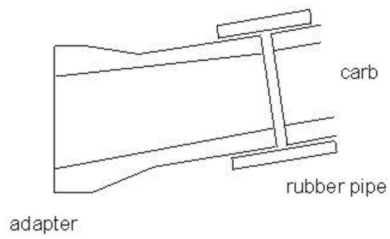
Now you need a means of attaching the carburettor. It needs a short pipe and some sort of flange: some people use the original connector and chop it down, re-angling the carb at the same time because now it won't clear the crankcases (the barrel has been shortened!) or weld a pipe to a flat plate, bolt up and glue this to the barrel and use a hose to attach the carb to the pipe. It needs to be bored out to match the bored-out carb (see later) and carefully matched to the barrel opening.

This is where the reed block goes if you are using one - it needs to be mounted close up to the barrel so as not to leave a large chamber behind the piston, so pick a reed cage that is not too wide or you will end up breaking into the stud drillings when machining out the cavity for it to fit into. Best of luck if you are doing this, it is not easy to get it to fit *and* not leak!

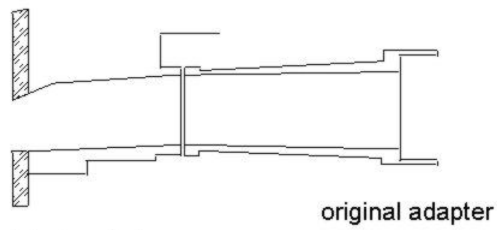




Reed block adapter



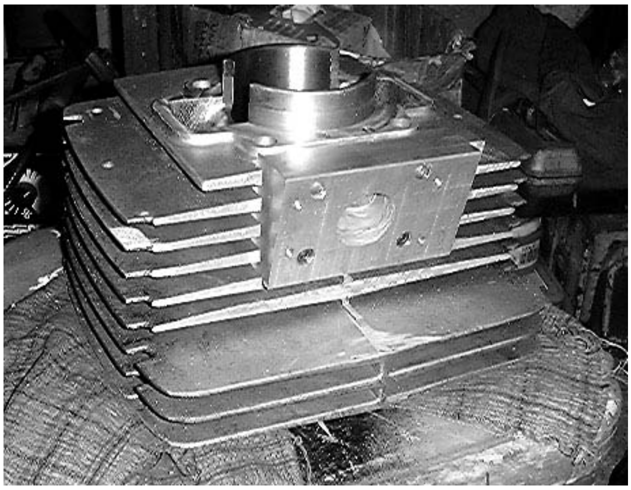
alternative adapter



original port shape

original adapter

The face of the barrel will need to be 'flattened' at the port opening to take your flange or reed block (unless you are using the original connector). You can either get this milled out in one hit (I have done this and it is pricey but neat – see earlier photo), or cut off the fins at the back of the barrel across the opening to give an open space to work in (pictured right). This can be done by carefully hacksawing down from the base of the barrel parallel to the port flange, but it takes a bit of time and effort. Worthwhile in that it gives a lot of room to work the port. An angle grinder fitted with a stone-cutting disc is useful for roughing out. My reed block is bolted to the barrel using M4 socket cap bolts (allen type) threaded into the cut faces of the fins – they are conveniently wider towards the centre and can be tapped into.



Head

Compression needs to be raised to about 7:1 from exhaust closing (12.5:1 or so from BDC) with the currently allowed fuel at max 97 octane. This raises the heat of combustion considerably and the exact value is a matter for some experiment - be warned it changes (i) jetting (ii) exhaust pipe tuned length and (iii) required spark plug heat range. NGK number 9 plug is normal with these values but could be in range 8 to 10 (see later).

The head can be skimmed to shape on a lathe or a vertical mill: the squish band should be retained and a recess made to match a spigot turned into the top of the barrel. This spigot and its recess form the compression seal - don't bother with a gasket but make sure the match is good i.e. lap them together with grinding paste. Squish clearance needs to be set either in the head, or by leaving a 'deck clearance' at the top of the cylinder liner when the barrel is machined (see previous diagram). Minimum squish 0.8mm (too small and the piston will clout the head – the conrod stretches at high speed) and a useful setting is 1.0 mm. Leaving it in the barrel can make machining the head a simpler job but I find it easier to change if it is in the head - and the variation between pistons means you might need to reset it after a new piston. It can be increased slightly using different thickness paper base gaskets but don't be tempted to use more than one to make up a size – it won't be a reliable seal and an air leak at the base is a disaster.

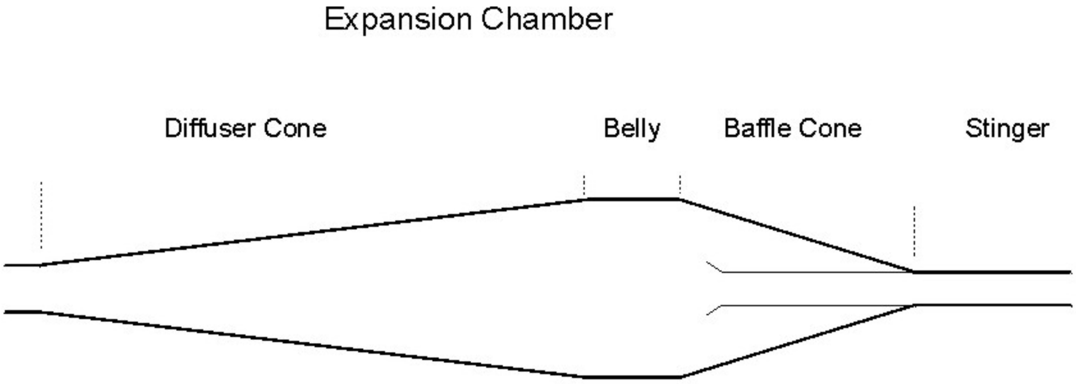
Exhaust

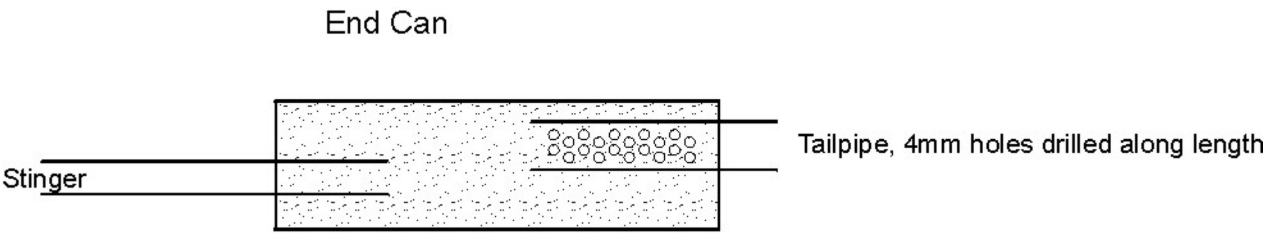
Exhaust header and diffuser cone have to be standard. To complete the expansion chamber, forget the calculations. It is near impossible to correct for the small header diameter, which coupled with the small chamber diameter (fixed by regulations), variations in ignition timing and compression ratio all affect the exhaust gas temperature and bugger up the calculations without an accurate measurement. Most of the simple models use engine speed and port duration as a basis and some even have BMEP correction, but these all make assumptions about the speed of sound in the gas which is heavily temperature dependent, and the degree of taper in the header section is critical (where the MZ pipe has zero).

Best to make up a few pipes (or borrow some) and dyno it - for a starting point roughly you need about 2 to 4 inches of belly between the diffuser and baffle cone, with a 12 degree cone. There are as many variations in this as there are bikes - steeper cones, shallower cones, shorter and much longer bellies ... you are heading for about 30 BHP at 8000 rpm with these class rules, but don't aim for an absolute figure, find a pipe that appears to give a good peak then dial in the jetting and timing to match it.

There is some good information in how to form cones in sheet steel in the A. Graham Bell book (see refs) if you are any good at tin-bashing and welding. I have even tried hydroforming using a Karcher garden pressure washer – good for fancy shapes but not much point with the restrictions we have in this class. The picture below shows my up-swept pipe made in this manner.

Set the stinger (bleed tube from the expansion chamber) to start inside the chamber – up to but no further than the start of the rear cone. This both improves the strength of the return pulse and reduces the emitted sound level, by preserving pressure energy in the chamber (courtesy 'Batwings' Hoyt McKagen). Flare the internal end of the stinger, and you can drill a few 4mm holes down the side too, just to help the flow out of the chamber. Then an end can is put on the outside end of the stinger to bring the noise level within regulation. This can be home made or there are several off-the-shelf cans available.





Ignition

Ignition is best with a PVL Kart magneto - these are supplied anticlockwise for Kart fitment so they need to be mounted with the stator pole and coil assembly reversed on the stator plate in this case, but check when you buy it. The timing mark needs to be transferred to the reverse side if so. The kit comprises a rotor and stator forming the generator, and a coil containing some electronics – it produces a short, high energy spark. It needs a mounting plate for the stator on the crankcase and the coil bolting somewhere on the frame (the leads are not very long mind you) with an earth connection to the engine.

I am working on an electronic timing variator for these, as they are fixed as standard, normally set about 17 or 18 degrees BTDC (1.8 to 2.0 mm). Burwins and Holmshaw sell a mounting plate for these to fit them to the cases, or one can be turned from a piece of ally bar, or fabricated from plate cut to shape (tricky this way to get it to sit square and central!) but there is a very small clearance rotor-to-stator and no margin for error.

Carburettor

Carb gets bored out to max (normally 33mm without weakening the carb body). Some of the older castings can be bored to 35mm, some of these show better power on the dyno but not always as usable on the track. You need to drift out the brass spray baffle in the carb throat in order to do the boring - remove the main jet and unscrew the needle jet tube a couple of turns, tap it to start it moving, then unscrew the needle tube a bit more and carry on gently tapping until you run out of thread on the needle tube. Then you need a square ended drift to go in its place, that can be cocked slightly to one side against the bottom of the baffle so you don't damage the thread, and drift it the rest of the way out.

Shape the baffle shoulder to give a smooth air path where it meets the floor of the throat, because now you have machined into it and the shoulder will stick up. Put the baffle stub back carefully, locating it pointing the right way in the splines (line them up!) and drift it back down using a small tube that fits over and pushes on the shoulder.

The fuel passages to the float valve are a bit roughly made and fuel flow can be a problem. The pipe connection needs opening up a little and the cross-drilling inside might need aligning – you have to drill through the end of this passage and then plug it up afterwards, but have a good close look and see if it needs it. The valve orifice itself benefits from enlarging but be careful as the edge of the drilling forms the seat of the valve and the seal needs to be checked afterwards.

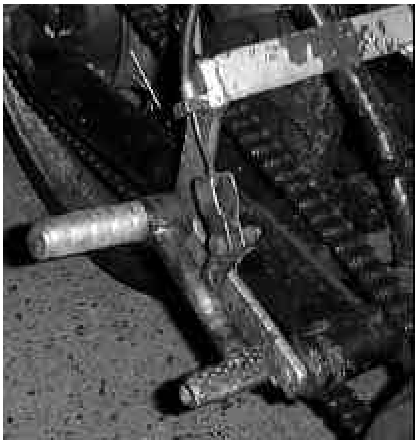
I think there is work to be done on the fuel delivery/airflow curves on these carbs. There is no air-bleed adjustment as they are 'primary choke' type carbs, and this means adjustments have to be made to the height of the spray baffle and the root diameter of the needle jet (top of the jet tube) which is complicated by the lack of different sizes available, so the whole area of adjustment gets overlooked. Some good texts on this are John Robinson, and A Graham Bell (see refs). If you need to use big jets (over 220) you will need to enlarge the jet tube from the bottom where the main-jet screws in up to the cross-drilling to prevent it restricting flow – drill it out to 3.2mm (1/8").

Dialling in the jetting ... no two ways about it, this takes time – read the books! The carburation circuits are not ideal in the BVF and are even less suited to Reed Valve modifications. There is no magic formula to determine the engine's metering demads so start with a big jet and work downwards for safety: if you run too lean ie with too small a jet you may not even complete one lap! The only guide I can safely give is that 300 is very big and 100 is very small. These sizes are the metering orifice diameter in hundredths of a mm so 220 is 2.20mm, 195 is 1.95mm etc.

Frame

General aims: chop off anything that doesn't make it go faster or stop quicker - the stand and footrest lugs (saw through the main downtube section about 2 inches below the swingarm pivot – see photo), the battery tray, the pump mounts etc. Chuck out the airbox, sidepanels, oil tank, and mudguards (the front might be useful if you keep the 18 inch wheels, and the little plastic section of the rear is a useful splash guard). Obviously the lights aren't allowed, and the horn is not much use so the entire wiring loom and all the bits & bobs can go. Renew head race bearings (fit the sealed type) and swingarm bushes. Attend to engine mounts (see below).

Footrests



Rearsets need making up or buying - Burwins and LeMoto make a set which can be bought as individual parts, or a complete kit with brackets and cable. Connecting the rear brake appears to be the biggest problem but the TS rear hub has an internal cable attachment which is very tidy. I cheated and bought the Burwins footpegs and made my own mounting bracket (photo, right) the advantage being the cable is available as a spare part from them. Then all I had to do was weld a threaded cable stop on to the torque arm (photo below). The bracket can be made from one-inch square tubing, or something similar, just three pieces welded to form a sort of 'C' section to mount across the rear frame stays. This can be attached with jubilee clips - remember that no welding is allowed to the frame in current regulations (2002). There is a 6mm stud in the main downtube that can be used, where the airbox used to go.

Engine Mounts

Replace rear engine mount inserts and check mount plates for cracks. These are a little bit flimsy and tend to crack, so can be reinforced in a number of ways or stiffened ones can be bought to fit.

Upper (cylinder head) mount needs modification to fit the shortened cylinder arrangement: the original one works fine if one side is attached by a stout strap, and the studs in the head are replaced by solid stand-offs. The position of the engine in the frame (up or down) determined by this mount affects the drivetrain angle so pay attention to it!

Alternative arrangements for the upper mount include using a solid bar attached to the frame stud, and rubber mounts in place of the cylinder head studs. Mine are Peugeot 505 exhaust mounts, which are cheap, quite hard and durable lasting most of a season.

Fork yokes and headstock, Forks, Rear shocks

Summary: shorten rear shocks by unscrewing the top eye and threading down the damper rod, then shorten the spring by the same amount by cutting with an angle grinder or collapsing them by heating (make sure both springs are identical); fit a bottom yoke in place of the top yoke so the forks can be adjusted up and down as per photo (fit it upside down or it will foul on the top bearing housing – or you can modify the old ally top yoke); rework the fork damper valves as described (resize rebound hole, clean up compression valve housing).

Regarding steering geometry, you have to think carefully about what is going on here. The MZ road settings are a bit spongy and unresponsive but can be sorted out with a little work. Dropping the forks down the yokes (i) reduces rake angle and (ii) reduces trail, both of which increase sensitivity to differing extents but the reduction in trail happens much faster than the rake change which reduces stability a lot. You need to find a setting that suits your riding style, body position, weight etc by experiment, adjusting the position in the yokes by 5mm steps or so. A good reference is John Bradley's 'The Racing Motorcycle' which looks in detail about chassis tuning and other aspects of setting up a racing bike, whereas a more thorough technical treatment can be found in Tony Foale's excellent 'Motorcycle Handling and Chassis design'.

You will observe many different fork positions relative to yoke on other people's bikes, but this is affected by (i) fork stanchion length if it has been modified and (ii) preload spacers that some people use. Best measurement for comparison is the height to the bottom of the headstock on a bike with exactly the same wheels and rear shocks as yours, but if you measure their rears you can correct the front measurement for differences in this.

Adjusting the rear shock length shifts the ride height, hence centre of gravity but also alters rake & trail, so the front height has to be adjusted by a similar amount to give the same geometry. It also affects the angle of the swingarm, and thus the angle in the drive train between the front and rear sprockets which affects the 'anti-squat' action (reduces propensity to wheelie) but it is not hugely sensitive to this because the power delivered is not exactly massive. This is a big issue on Motocross bikes. When I shortened my MZ rears by 25mm I noticed the difference at the start line (easier to keep the front down), and some might argue the traction at the front is improved accelerating out of corners but I don't think anyone would admit to noticing a reduction in rear traction, both of which are theoretically happening when you change this drive angle.

Bear in mind that use of preload *only* shifts the ride height, it *does not* stiffen the spring. You need to change the spring itself to change the spring rate. Preload spacers can be used at the front to make small adjustments to the ride height of the shock without having to move the forks in the yoke every time – twopence pieces fit well and are commonly used for this. Different oil levels in the front changes the spring rate slightly due to the pneumatic action of the air pocket in the fork - a higher oil level will give a stronger spring action (pressure builds up quicker with compression).

I use 250ml per leg with standard length stanchions, no preload spacers, sidecar springs. Works for my body weight. At the rear I have shortened the standard MZ shocks by 25mm and dropped the front from the standard position an additional 15mm to increase sensitivity.

The fork damper design is a bit agricultural, to be polite. It works reasonably well with SAE30 engine oil or EP80 gear oil (both of which are about the same viscosity) but it tends to froth up. It can be improved if the 3mm upper bleed hole in the damper rod is welded up and redrilled at 2mm – this stiffens the rebound damping to a level that works with 20 to 30 weight fork oil, preferable for its anti-froth properties. If the hole is much smaller, I have found other problems with cavitation and poor oil flow. The lower hole in the rod should also be resized, to 3mm.

The lower valve can stay standard with the above modification – again I have found problems when the throttle plate holes are reduced. But the recess in the fork leg that the valve lives in can be very roughly machined which makes the valve washer stick, so take it apart and smooth out the ridges carefully with emery paper or a die-grinder. A lathe would be the best way, but it only needs tidying, be careful not to make the throttle plate a slack fit in the leg and make sure the circlip holds the valve assembly snugly against the stop as backlash will aggrovate fork patter coming out of long corners.

Wheels and tyres, Brakes

Summary: Braided steel brake hose, racing pads, high spec fluid, racing tyres, new wheel bearings. Optional 17 inch wheels, giving greater tyre choice inc. slicks & wets, lighter handling & more responsive.

Fitting front wheels: alignment of the forks and headstock must be carried out before the yoke and wheel spindle pinch-bolts are tightened, or mudguard and forkbrace where fitted. It is simple enough, but important to do otherwise the fork action may be slightly stiff: with the bottom yoke pinch bolts tightened, and the top yoke, headstock centre nut, wheel spindle nut and spindle pinch-bolt a little more than finger-tight, bounce the forks up and down a few times to align the sliding parts. Tighten the top yoke pinch-bolts, headstock nut and spindle nut in that order, and bounce it again. Then tighten the wheel spindle pinch bolt. Check that all is sliding freely before tightening the mudguard or forkbrace. If not loosen the spindle and yoke pinchbolts, bounce it a few more times and try again.

Rear sprocket carrier can be modified for interchangeable sprockets, which is useful for fine-tuning the gearing when you are in close competition. The standard 48 tooth rear is useable with 3 different fronts (say 17, 18 and 19 teeth with 18 inch wheels) but the condition needs to be checked carefully, the original ones don't tend to be very round which makes the chain tension a bit of a lottery. One of the best 100-quids I spent was on the split sprocket kit from Tony Holmshaw – see photo, right – so you don't need to remove the rear wheel and carrier to dial-in the gearing. Anything that contributes to a hassle-free race meeting is good in my book.

The recommended 17 inch rim sizes are 2.15 (WM3) or 2.50 front and 3.50 rear. These give the greatest range of tyre fitments, including the '50' profile slicks and wets. Alternately 1.85 front (WM2) and 3.00 rear work with the Dunlop intermediates (KR364) but it is wise to check tyre availability and suitability with a specialist. These low profile types are very sensitive to the rim width.

General preparation

Scrutineering is a bit like an MoT, the bike is checked for compliance with the regulations and for race-worthiness – ie that the bike has been carefully prepared for the meeting. It helps alot if the machine is clean as this is a good sign that attention has been paid to it since the last meeting and will not raise doubt over your commitment to the safety of yourself and others.

Ensure after you have worked on the bike all nuts and bolts etc are secure. Do not over-tighten things as you will strip the threads easily on the engine and wear them quickly elsewhere as on a race bike they are undone and done up so often. Make sure NOTHING is touching the wheels that shouldn't be - ie the exhaust, caliper bolts etc. Especially in a "loaded position".

Chain tension should be checked with weight on the suspension also. ACU regulation for 2002 requires a chainguard at the entry points to sprockets to prevent clothing etc becoming entangled so a rear guard must be fabricated and fitted to the swingarm covering the lower segment of the sprocket.

ACU regulations also require any oil-retaining plugs to be fixed with lockwire to prevent spillage if they work loose. For the MZ this is the two plugs in the gearbox underside and the filler bung (see photo). Breathers have to be routed to a catch-tank of a specified size – technically this includes the hole in the gearbox oil filler bung and carburettor float bowl breather on the MZ.

The throttle control must return to the closed position when released, and an on/off switch must be fitted to the handlebars (not a 'kill' button with momentary action – photo shows my left clipon, which has both!).

Numbers must be displayed in the designated colours, currently white numbers on green backgrounds. One at the front, one either side at the back. Burwins do a nice matching set of clipons and front number bracket, shown in these photos.

Information

Book References

A Graham Bell 'Performance Tuning: Two Stroke'
John Robinson 'Motorcycle Engine Tuning: Two Stroke'
Gordon Jennings: 'Two Stroke Tuners Handbook'
G P Blair: 'The Basic Design of Two Stroke Engines'
John Bradley: 'The Racing Motorcycle'
Tony Foale: 'Motorcycle Handling and Chassis Design – the Art and Science'

Suppliers

Dartford Karting - PVL Kart magneto, it is the 'Small Bore' model.

Tony Holmshaw motorcycles - full tuning range including pipes, reboring, crankshaft rebuilds, port work, new and secondhand MZ parts, advice etc; specialities include modified rear sprocket carrier and split sprockets

Burwins motorcycles - full range of tuning parts and services as above, new and secondhand MZ parts, specialities inc clip-ons, rearsets, engine mounts

LeMoto - special chassis parts inc modified shocks, fork yokes, rearsets, seat units etc

Talon Engineering (Southampton) – alloy wheel rims, fancy stuff
Central Wheels (Birmingham) – all manner of wheel related services
Hagon (E London) – wheels, shock treatment.
Maxton – shock experts

Tony Hartlen: vintage and racing motorcycle engine machinist. 01483 202540 near Guildford, Surrey

Alec Jay: wheel builder, vintage restoration. 01403 752774 near Horsham, W. Sussex

Table: Piston displacement

Crank degrees against mm ATDC

Angle	Disp.
0	0.00
1	0.01
2	0.02
3	0.06
4	0.10
5	0.15
6	0.22
7	0.30
8	0.40
9	0.50
10	0.62
11	0.75
12	0.89
13	1.04
14	1.21
15	1.38
16	1.57
17	1.77
18	1.98
19	2.21
20	2.44
21	2.69
22	2.94
23	3.21
24	3.49
25	3.78
26	4.08
27	4.39
28	4.71
29	5.04
30	5.38
31	5.74
32	6.10
33	6.47
34	6.85
35	7.23
36	7.63
37	8.04
38	8.45
39	8.88
40	9.31
41	9.75
42	10.20
43	10.65
44	11.12
45	11.59
46	12.06
47	12.55
48	13.04
49	13.54
50	14.04
51	14.55
52	15.06
53	15.59
54	16.11
55	16.64
56	17.18
57	17.72
58	18.26
59	18.81
60	19.37
61	19.92
62	20.48
63	21.05
64	21.61
65	22.18
66	22.75
67	23.33
68	23.90
69	24.48
70	25.06
71	25.64
72	26.22
73	26.81
74	27.39
75	27.98
76	28.56
77	29.15
78	29.73
79	30.32
80	30.90
81	31.48
82	32.07
83	32.65
84	33.23
85	33.81
86	34.38
87	34.96
88	35.53
89	36.10
90	36.67
91	37.24
92	37.80
93	38.36
94	38.92
95	39.47
96	40.02
97	40.57
98	41.11
99	41.65
100	42.19
101	42.72
102	43.25
103	43.77
104	44.29
105	44.80
106	45.31
107	45.81
108	46.31
109	46.80
110	47.29
111	47.77
112	48.25
113	48.72
114	49.19
115	49.65
116	50.11
117	50.55
118	51.00
119	51.43
120	51.87
121	52.29
122	52.71
123	53.12
124	53.53
125	53.92
126	54.32
127	54.70
128	55.08
129	55.46
130	55.82
131	56.18
132	56.53
133	56.88
134	57.22
135	57.55
136	57.87
137	58.19
138	58.50
139	58.81
140	59.10
141	59.39
142	59.68
143	59.95
144	60.22
145	60.48
146	60.73
147	60.98
148	61.22
149	61.45
150	61.68
151	61.89
152	62.10
153	62.31
154	62.50
155	62.69
156	62.87
157	63.04
158	63.21
159	63.37
160	63.52
161	63.67
162	63.80
163	63.93
164	64.05
165	64.17
166	64.27
167	64.37
168	64.47
169	64.55
170	64.63
171	64.70
172	64.76
173	64.82
174	64.87
175	64.91
176	64.94
177	64.97
178	64.99
179	65.00
180	65.00

An interesting discussion on tyres and handling

A mailing-list posting (one of Michael Moore's – see above):

Subject: MC-Chassis Re: Black rings

Dave w asked:

<<
a comparison to other cruisers whose equal front & rear sizes
made them "theoretically" unable to steer "on lean angle alone."

Is there anything to this, or is this a case of a motojournalist
knowing what he likes in a bike's handling but not why it handles
like that...
>>

The actual statement is far too general. There are all sorts of parameters
that determine both steering and tyre size effects on handling.

Cornering force on an upright tyre (as one tries for in a car) comes from
slip angle, i.e. we have to steer a little more than the path of a curve to
generate a force that pushes the vehicle towards the turn centre. So the
cornering force can be directly controlled by the driver, depending soley on
his steering input.

Bike steering is somewhat more complex. A tyre that is cambered in relation
to the road surface creates a cornering force due to what's known as
"camber-thrust" the mechanism for this is akin to a rolling cone which
tends to steer about it's apex. The cambered tyre is just like a slice of
a cone.
Now, obviously the cornering force so generated depends on lean angle and
tyre characteristics / sizes etc. At any given road speed this camber
thrust may be either
too little, too much or just right to provide the cornering force that the
rider wants. If it's just right then the rider need apply no steering angle
to the handlebars in order to corner as he wishes. However, if the camber
thrust is not exactly correct then he must apply either some negative or
positive steering angle to detract from or add to the cornering force. This
corrective steering angle generates this corrective force by slip angle as
with a car.
It is because much of the cornering force comes from camber thrust that
actual steering angles on a bike are much less than with a car.
Some bikes need little effort to go where we wish yet others seem to need
"holding down" to stay on line whereas some need "lifting up", this "feel"
is a direct result of how much and in which direction we need to apply
corrective slip angles to adjust for the difference between the camber
thrust generated and the cornering force required.

Just as with a car, we do not steer by the front wheels alone. Conventional
(non-RWS) cars must generate cornering force from the rear tyres also, thus
the rear must also have a slip angle, this is achieved by the car body
adopting a yaw attitude inward of the desired cornering path.
Likewise on a bike, if the camber thrust from the rear tyre doesn't balance
the required cornering force at the rear then the bike must adopt a yaw
attitude to correct the imbalance by adding or subtracting cornering force
by means of slip angle.

So to claim that equal size tyres are incapable of "steering by lean angle
alone" is quite obviously a gross over-simplification at best. There are
so many factors involved and NO BIKE steers by lean angle alone under ALL
cornering conditions. A wet road will affect camber thrust around the same

corner at a given speed, and so any corrective steering torque will also depend on road conditions. This is just one reason, amongst others, that gives a different "feel" to the bike when it's raining.

Tony Foale.

Acknowledgements

Tony Holmshaw for his endless patience and sponsorship for the Renta Racer scheme for which he deserves a plug: 'What a nice man – and so reasonably priced. Go and buy his stuff'

Martin Baldwin & Mike Wright (Burwin Motorcycles) and of course Anne Baldwin. You should buy their stuff too.

Richard Lee for the details of the secret gearbox modification .. and the cups of tea from the camper van. Everyone else in the MZ racing club just for having a good time – particularly Paul Emanuel for holding the club together for so many years.

John Wood for the loan of pictures from his book 'Villiers Singles Improvements Handbook', also some bright ideas in the making of my bikes and this booklet and an interesting website http://www.lortim.demon.co.uk

Michael Moore (Eurospares, San Francisco) fantastically interesting archive and contacts website http://www.eurospares.com

Some other interesting sites from interesting people:
http://www.22000rpm.com
http://home.mira.net/~iwd
http://www.freeyellow.com/members/batwings/best.html
http://www.ctv.es/USERS/softtech/motos/

Someone in Spain on rec.motorcycles.racing once helpfully pointed out that the MZ250 is locally known as 'La Maceta' which means Flower Pot. That makes us the Flower Pot Men?