Cylinder tuning – Part 4

PART 1 Introduction to tuning a Lambretta Engine
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PART 4 Explaining advanced port timings

PORT TIMINGS

Any port timings I have quoted in the rest of the article are based on many years experience and what I have found by measuring nearly every cylinder and engine tuned over a 30+ year period. I've used the same port timing jigs for small and large block engines for 27 years, so all timings quoted are standardised over that period of time, I've even used a standard base gasket for every set up, removing a 0.5mm base gasket will effect port timings. For one off engines and top end rebuilds I use a 18" timing disc which is accurate to 0.25 degrees.

Port timings vary from crankshaft stroke and con rod lengths whether it's a standard 58mm stroke or after market 60, 61, 62, 63 or 64mm stroke using 107, 110, 115, 116 or 120mm con rod lengths. This is why I always measure every engine rebuild and log the dimensions and timings.

My port timing jigs are assembled using Innocenti engine casings and 58 x 107mm cranks. These jigs have also set cylinder heights for top and tailed cylinders and to set correct squish clearances. The bottom half of the casing is cut off and everything is tightened from day one with a large degree disc fitted.

Every thing set up on my tuning jigs and customers engines are written down in my tuning books and are double checked on every rebuilt engine.

Every cylinder is personally marked and to date I have folders of every tuned cylinder from day one until the present day with more than 1750 cylinders logged, this does not include casings matched, Vespa cylinder kits matched or any MB Factory kits.

Timings quoted may vary from what you think you have tested yourself…… this will come down to how you read the timing disc, it will depend on chamfering of ports and shadows. But the main thing is……. the machining of the crankcase mouth varies from casing to casing! Mainly Indian and Spanish casings vary in height from up to 2mm + or – from a Genuine Innocenti version, which have over the years have proved to be very stable. Just 1mm can put at least 5 degrees onto transfer timings, making one cylinder look within range and another totally over the top!

I've always been the practical type preferring what the timing disc says and how I read port timings. There is a long winded formula which will work out port timings without a degree disc, today with computers there are plenty of programs you can add your dimensions into and these are worked out quickly

for you……. the problem here is you need to be very accurate measuring port heights to 0.25mm which is impossible to measure by eye with a vernier looking down a cylinders bore. So figures can tend to be out by at least a degree or two! At the end of the day it all comes down to individual eye sights and methods used. So don't argue over a couple of degrees either way from my degrees to other peoples degrees.

INLET PORT TIMINGS

What works? A good low down bog standard Lambretta may run 120 – 130 degrees inlet timing, we all know, let the clutch out from low revs and they are off, they ride great around a town, city and back streets but run out of steam easily on an open road and takes some winding up on acceleration to get a good top speed of 60mph.

Take the Mugello/Rapido with 160 degrees and they need loads of revs to get them moving, hit a hill or wind and they slow down and they spit fuel back and are harder to jet in! DJ wrote he used 160 – 180 degrees on his race engines, high revs and slipping clutches are needed to get moving and its hard to keep them in the power band and larger inlet ports make starting harder!

Graham Bells book quotes inlet port timing in degrees to suit rev ranges that the engine is required to work in.

- 7'000rpm, 150-155 degrees
- 8'000rpm, 155-160 degrees
- 9'500rpm, 165-170 degrees
- 11'000rpm, 185-190 degrees

These quoted are where the cylinder is designed to work! Not really from zero revs to the limit, it's where the cylinder needs to buzz along at, cruising to top end speeds! Looking at the above a Mugello/Rapido really needs to be set up in it's element between 8 – 9'500rpm! Thats 80 – 95mph using a Sx200 gear box! Yeah right! Either Graham Bell is wrong or someone else is wrong! Now look at the 7000rpm range 150 – 155 degrees, this does work, I've always used these timings and yes they work well below and above 7'000rpm and a decent Stage 4 – 5 that I would do will certainly pull one to one gearing which is the magic Sx200 gear box. So I know in this instance Mr Bell is correct to suit a low/mid/high revving Lambretta cylinder. Look further and the big timings quoted by Dave Webster are too big if you follow the set standards from Bell. Look at a Lambretta standard inlet timing of 130 degrees, work it out on the above list and a standard Lambretta shouldn't rev right until say around 4'500. Which it does, it's in it's peak at that rev range and we know a standard Lambretta runs to at least 6'000+rpm showing that the above is a good working guide. A over tuned inlet of 160 would rev to 9'500rm which it would with the right exhaust, I have done this many times.

What it doesn't say is these big inlet timings will have poor low down running out of it's peak/nice running range where the fuel is sucked into the engine and because its not sucking fast enough the air fuel mixture reverses

and spits back out of the carb! Something everyone complains about and something which isn't nice sat in a pub with your passengers foot stinking! It's saying 160 degrees needs to work between 6'500 – 9'500rpm…… 65 – 95mph! If it got there how long can you keep it there, it's head down arse up revs? I'm not saying big timings do not give power it does, but it has it's down side.

What MB say works

- Standard to mild tunes Stage 1, 2, 3 or 4, 120 – 140 degrees, works well up to 5'500 – 7'500rpm
- Touring tunes Stage 4 – 5, 140 – 150 degrees, works well up to 6'500 – 8'000rpm
- Race timings 155 + degrees, works well up to well say 10'000+

All the above works in relation to a 200 – 250 cylinder, these cylinders have a larger inlet port and shape compared to a 125, 150 or 175. In the 80's I did loads of Small and Large block cylinders at 160 degrees inlet timing. These tunes were aimed at a fast 70mph cruising rally going bike. Sat in it's peak power sucking in the fuel and it suited the needs of customers. But these were times before the TS1, like I've said elsewhere……trends! Small Block tunes suffered at 160 degrees, the Small Block cylinders had narrower ports and wasn't as high. But also the piston, transfer feeds and port timings were also smaller which does effect how that engine runs. But a good 175 bored to 200 with 160 degrees matched to an inlet manifold with a raised and widened port worked really well but the limitations were transfer timings which were lower than a 200 by 5 degrees! You could do a full stage 6 tune to the transfers, but what a job that was, people just went out and got a 200 casing. To get around this lack of low down power I lowered the inlet timings which helped setting off and pulling away when the throttle was wound back and eventually did the same with 200 and didn't loose power! Some Mugello's run the same timings as a Small Block but the transfers are wider in the cylinder with small transfer feeds, which lets down the basic 200 tune. If a Mugello's transfer port was decreased in width from 35 – 36mm to standard 31mm then you would expect the Mugello to pump fuel better even with a large inlet timing. Whatever inlet timing is used it will work, it's nearly impossible to take inlet ports beyond 180 degrees without been silly and grinding into fresh air or cutting half the piston shirt down.

One way to tune an inlet port is to remove metal from the lower part of the inlet port to get porting timings something like. But this is not the only way, you can cut the pistons skirt. AF uses this method and produced Asso and Vertex pistons with 3mm removed from the inlet side, GPM also offered shorter 225 pistons or in some cases tuners cut the shirts to suit. Shorter pistons meant less work, AF just matched an inlet port to a manifold and raised a bit of the inlet port and with a shorter piston it made the inlet port something like. But the inlet port is much smaller which should have helped suck through the fuel mixture, when riding with these engines to my engines with lowered ports I just left them standing and have re tuned many and improved many cylinders my way.

Take 140 – 150 degrees inlet timings which MB prefers and motors are

transformed with good setting off, mid range and top end revs with little spit back! I've tuned full race spec 200's with 160+ degrees which spit back as much down the panels as goes into the engine so expect road motors to have less fuel economy. One Group 4 205 race engine won races but only had 25bhp at the time, this engine was 300 meters ahead of MSC, Taffspeed and other tuners bikes who were only hitting 20 – 23bhp! I had tuned road bikes 10 years earlier with 155 inlet timings and had the same bhp! Stuart Owens 100.com engine had 160 – 165 degree inlet timings, on the dyno as we wound it on, it spit back a jet of fuel 3 foot from the carb and soaked us until it got near it's power band, as it got near the power band you could see this jet get smaller and smaller until it disappeared and was in peak power kicking out 32bhp. This is why I'm not a big fan of over sized inlet timings, preferring milder timings and better running motors! It's as much about inlet size and shape and port time area that works with correct length piston shirt lengths. This is not all true you can and I have tuned a Stage 6 225 engine with 170 degrees inlet timing which revved to 10'000 rpm in top and had hardly any spit back! This was an engine I developed in the early 90's using a 34mm Amal and MB pipe, everything worked perfect as a fast Road/Race bike, it could have easily gone on the track. Phil Slacker who works for me ended up having it and could hit the ton as a road bike and even setting up the idle jet there was no spit back!

On piston ported cylinders whatever manifold is fitted I always like to match the manifold to the inlet port and inlet port to the manifold. Easier said than done in some cases. The smaller inlet manifolds like a standard or 25mm are small and hard to get into once fitted to a cylinder and marking out is not easy. You can use an inlet gasket as a pattern but this is just a guide you can still miss match them. I prefer to drop the inlet manifold down the inlet studs with no gasket and scribe from either down the manifold or from inside the port from the bore side. Once you have good scribe marks I grind either manifold or port or both to make a nice smooth flow. Then I refit the manifold and finger around the best you can to tweak them better. I then satin polish the ports to 80 – 120 grit which is smooth enough to work. And I flow the length of the manifold to suit the carb used. There are theories that all the ports from the carb to the transfers should be rough to atomise the air fuel mixture. I look at it like this; by the time air fuel has come out of the atomiser/spray tube, gone down an inlet manifold with a bend into an inlet port smashed against a piston, crank, con rod and rammed through the transfer ports it's well mixed up! Mirror polishing the inlet system and crankcase areas is really a long waste of time, but it does look nice over the counter and you should pay for what you get. I could spend another 3 hours on finishing a tune, but would you want to pay for it when it makes no difference to performance? You can if you want use a gasket when fitting the inlet manifold, but it will need trimming to fit, use silicone sealer both sides when fitting and smear it around the joints. Don't match a manifold perfect and then introduce a gasket it will be wrong! On the larger 28/30/34/35mm and reed inlet manifolds I mark out the same, once roughed out I bolt the manifold to the barrel and flow through into the port, this gives an excellent flowed inlet manifold into the cylinders inlet port, of course this takes time, but is better, I don't use gaskets just silicone on a rebuild.

On reed manifolds like a TS1, Monza, Imola, RB or GT all that usually needs doing is a slight match and a flow.

I offer these inlet manifold services

- Match and flow
- Bolted and flowed
- Reed manifolds
- Imola special
- Mugello match
- Retro reed flow

Really what we need is a varying inlet port, this is where Rotary and Reed Valve designs came in to cure the problem of spit back, power spread and clean running.

ROTARY

Lambrettas have never used a Rotary Valve inlet timing design, it has been done by others as a Special and usually raced. Later type Vespas all used the Rotary method! There are two types of Rotary Valve.

- Disc method as used mainly by Kart engines
- Crank web timing

Vespas used the crank method where the inlet port is sat on the casing directly above one of the crank webs, the crank web was cut so it had a certain opening period above and below Top Dead Center. You can tune the inlet port to be bigger either way letting fuel in, either before or after and you can cut the crank web to do the same. If you look at a PX/PE/T5/Cosa/SF you would see a larger inlet timing than suggested in Lambretta engines. Timings of 160 – 170 – 180 degrees are quite normal, I've tuned Vespas to 230 degrees. As with piston port timings the larger you go the higher up in the rev range power wants to come in, over tuning a Rotary will also have reduced power low down and will spit back fuel. The beauty of the Rotary system is air/fuel is sucked in and once the crank and inlet port shuts it can not go anywhere other than into the crankcase and through the transfer ports. This system uses much smaller transfer timings over the piston port method. A standard Lambretta 150 – 200 would use 118 – 125 degrees, a Rotary would use smaller timings around 110 – 118 degrees as the Rotary system is more efficient and can push the mixture into the cylinder in a better controlled way. Obviously you can tune transfers larger, rightly or wrongly to produce higher power where it's needed. Performance Rotary timing engines are rare these days, we are talking Lambrettas so will move on.

REED

The Reed inlet valve fills in the problems of the Piston Port and Rotary Valve by controlling Air Fuel flow through a Reed cage, this cage holds thin flaps that open and shut based on the up and down movement of the piston and crank. This pumping effect tells these thin flaps to open and shut allowing the correct amount of air fuel that the engine needs. It's not perfect as the

reed cage is a restrictor, but it’s proved to be good enough that all the major 2-stroke manufacturers have employed for many years. There are hundreds of different Reed Blocks with different shapes and sizes, some are very basic and others are designed to flow better. Reed petals vary in materials and thickness and do effect power output, as does the reed cage to carb sizes and internal shape designs. In theory a Reed Inlet shouldn’t spit back fuel but it can, especially if set up and over jetted wrong, but it does improve the piston port problem with spit back and usually gets a better power output.

I first came by a Reed Valve Lambretta in 84/85 when Beedspeed were doing one off Reed inlet manifolds made from bits of Alloy welded to CDC inlet manifolds. When I worked there I also made these very time consuming Reed Valve Manifolds, I became very interested in Reed Valves and tuning the Reed way MSC, Mikeck, Taffspeed and myself produced bolt on Reed Valve Manifolds in the 1980’s to work with standard cast iron cylinders. These Reed Manifolds went out of fashion in the 1990’s as the TS1 was so good, until recently where more remade over ported piston ported cylinder kits became popular and by fitting these retro after market Reed Manifolds fuel consumption and power out puts were improved.

So why is the Reed Inlet port better over a Piston port Lambretta? With a Reed you don’t have to think ‘oh what inlet timing is going to suit my style of engine’. The main advantage of the basic Reed Valve design is you can add a boost port or number of boost ports into the cylinder porting design above the inlet port to aid fuel flow which usually produces more power.

The first real Reed Lambretta produced cylinder was the TS1, followed by the Monza, the Small Block Imola and later the GT cylinder, RB and Super Monza cylinders. The TS1, Monza, Imola and RB cylinders used multi port transfers in the cylinder, by this I mean a standard piston ported cast iron cylinder used a traditional inlet, 2 transfer and a single exhaust port design. The newer generation Reed cylinders used an inlet port with a port cut above it called the boost or rear port, the transfers are bridged making 4 transfer ports which wrap wider around the cylinder bore and has a single exhaust port. It’s thought the basis of making these cylinders faster, are these extra ports! Yes its true, add more ports, use a reed and raise the exhaust port increases power. Now we’re getting complicated by adding a Reed Valve it gives you more scope to tune the other ports. But is it the be all and end all for tuning or giving a customer what he wants?

One main advantage of using a Reed Valve is you can fit a boost port above the inlet port, you can fit 2, 3 or 4 depending on where the ring pegs run and how wide the ports are and how big the bore is. This boost port or multi boost ports can be cut and aimed in different directions. Get them right and you can either produce more or loose power!

More tuning theories should come into designing a multi port cylinder. Look at a modern engine, there are usually 4 transfer ports like a TS1 style but because of our restrictive Lambretta design we can not wrap these ports further around like a modern engine. Usually modern cylinders only use 1 or 2 boost ports. By wrapping the ports all the way around the bore means there is more port area which will give more air fuel which can be rammed into the

bore, by doing this you need to reduce transfer port timings.

MB offer many inlet manifolds, Reed Blocks and Reeds to suit various Reed Cylinders, there are theories to inlet port widths and sizes, this is mainly based on keeping the piston safe and reliable rather than increasing power. But in an attempt to gain power some, like myself have cut ports from the inlet port into the casing through welded casings, or use the Boyesen port method where ports are cut from the inlet port into the transfer ports. Are these power ports? Not always, these take a lot of work to do but don't necessarily increase power output, it's a way to get more air/fuel into the crankcase, after that it's a case of are the transfers and exhaust port set correctly to produce the best power required. Today the higher powered cylinder kits are mainly the Large Block Reed style cylinders of the TS1 and Monzas (at the time of writting the Super Monza is not commercially available). The Small Block Imola and GT are ok and give more of a good Stage 4 200 type of ride, But these are open for more tuning where 20+bhp is reached.

Today there are bolt on retro Reed Manifolds available to help with normal piston ported cylinders. There are lots of over tuned cast iron and alloy cylinders with an inlet or exhaust timing too big. A way around these over tuned kits is to rework the inlet port, open, match and flow and reshape a retro Reed Manifold to suit and add a boost port. This reduces the inlet spit back and usually increases power, even if the exhaust port is left standard. But it can be an advantage depending on timing to increase the exhaust as the Reed Valve makes for a much more flexible engine lower down in the rev range and the big advantage is a massive gain in fuel economy even compared to a TS1 as these older style two transfer ported cylinders work more efficiently and don't loose fuel out of the exhaust port. By retro Reed Tuning Genuine, SIL, Rapido, Mugello, SR and Race-Tour piston port cylinders you can lift power, spread power and increase the fuel economy and we have seen 80mpg! Compare that to the purpose made Reed Cylinders where it's not uncommon to see 18 – 50mpg from a TS1 or RB type of cylinder. The retro Reed Blocks are an advantage to convert 12 – 18bhp Piston port cylinders to 20 – 25bhp cylinders but with more TORQUE because we don't need to raise exhaust ports as high as a TS1 or RB. These modified Piston ported cylinders may not get the max power but gain on low down and mid range, pulling high gearing and gaining that all important fuel economy making for a better engine in the end.

Just adding a Reed Manifold and Valve to a non tuned inlet port, with a unmodified piston will do noting for power. In graham Bells book he mentions power porting, I've tried it, we found it didn't work at all, it was a total flop and failure in a TS1. I've always use 360 degrees inlet timing by having holes or cut outs in the piston, this means at any part of the crankshafts revolution the crankcase is open to the reed letting air fuel do what it wants.

We've covered the inlet side of a cylinders induction but for an engine to produce power the inlet mixture needs to go into the cylinder and transfer from the crankcase hence 'transfer ports'

TRANSFER PORTS

Transfer ports are very important and miss understood and again like inlet ports are usually over tuned to suit decent Rally going touring Scooters. With most after market remade cylinders, transfer timings vary far too much and cylinders are down on power or can be improved by tweaking very small differences.

Lets go back to Graham Bells recommendations and compare them to standard Lambretta transfers timings.

- 6’000rpm, 120 – 124 degrees
- 8’000rpm, 124 – 128 degrees
- 9’000rpm, 126 – 130 degrees
- 10’000rpm, 128 – 132 degrees

Look at Standard transfer timings on a Lambretta cylinder, bare in mind these where aimed at low revving, commuter Scooters with good fuel economy

- Small block, 116 – 118 degrees
- Larger block, 120 – 124 degrees

Compare these to Dave Websters recommendations and after market performance tuned cylinders which seemed to have followed his recommendations

- DJ 200/225, 130 degrees
- TS1, Rapido, 130 – 132 degrees
- RB 135 – 138, degrees
- Monza, Imola not standardised from one to the next!
- Mugello the same as a Monza, 116 – 138 degrees

Look at Bells recommendations and compare them to a standard Lambretta cylinder. Roughly standard 118 – 124 degrees which is just below Bells 6’000rpm so say 5’000rpm which we know a Standard Lambretta works at. Look at the rev ranges that 130 – 138 degrees work in and its 9’000 – around 14’000rpm usually far too high for any road going engine. 138 degrees is far too high for a race engine unless you want to rev the engine to 12’000+ which is really out of any Lambrettas performance rev range and makes for a gutless motor with power bands razor tin and are hard to ride, were you need very light flywheels, exhausts tuned to suit and multi close ratio gears. Even our championship winning Zip only used 132 degrees and revved to 13’000rpm! So maybe less is more.

So why have after market cylinders and tuners aimed at higher figures, who is right these tuners or Bell? To me I’ve always found good power for an all round tune using standard transfer timings and still got usable high revs which are similar to Bells recommendations so Innocenti got it right. Take the TS1 with 130 – 132 degrees, Bell says it should work at 10’000+rpm, road Scooter engines never get to that even with a high revving exhaust. But we know a TS1 works, again who’s right, I guess if it works it works. The TS1 cylinder uses the 4 port transfer system plus the boost port and floods the cylinder of fuel, to get round this and increase power it raises the exhaust

way beyond any touring tune. Depending on set up, some TS1's only do 17 – 18bhp which is easy from a Stage 4 cast cylinder which is more rideable and drivable. Compare to what DJ said with his tuning and most 200 Jap converted cylinders used 130 degrees! I always found a 200/225 cylinder with 130 degrees which lots of tuners used from the 80's was gutless, an engine needed lots of revs to get in the power even with small inlet timings. I once tuned a reed cylinder with 140 degrees and it just hit a brick wall, it was gutless and didn't rev. I did the same with a Suzuki 190 using a Spanish cylinder, the Spanish cylinder has higher transfer port heights and gave 134 degrees, even with the same inlet and exhaust timings compared to an Italian cylinder it was gutless compared to mid 120 degrees! I once talked with DJ and said that I found my motors pulled much better with standard timings, the next DJ cylinder I measured was down to standard timings!

To get higher 130 degrees transfer timings the cylinder needs jacking up around 2mm and 2mm removing off the top of the cylinder, this leaves a wall from the piston at BDC to the bottom of the transfer port. Dave says grind this wall down level with the piston, if you do this without opening, tapering and flowing the full length of transfers then the transfer port size inside the cylinder will be too big and gases slow right down and kill the engine. Cylinders are better if this wall is left alone, In 1988 I tuned my own Li125 Series One upgraded to GP using a 150 cylinder bored out to 61mm using a Kawasaki piston, it was the first engine I set up with a 25mm Dellorto and was to set standards for many years. I had a great roundabout test system in Grimsby where you could trash from one to another back and forth and measure speed. This tune quickly went off the clock between each roundabout, it was great, as good as anyone could want, as an experiment went back to the workshop, I stripped it down, lowered down the transfer wall level with the piston at BDC and did the same road test within an hour……. It killed it, it would not rev and would not go off the clock! A valuable lesson!

Based on these big timings throughout the 90's both myself and Taffspeed recommended lowering the TS1's cylinder down by 0.5 – 1mm by either machining the base of the cylinder or using 110mm rods and a smaller packing plate to give mid 120 degrees. This gave the effect of more lower down pulling power yet still revved, especially if the exhaust port was raised and we both found more power over standard! This also applies to the RB with well over tuned transfer timings, I've found more power out of the milder TS1 cylinder compared to the RB using the same, carb pipe and port timings!

The Mugello, Monza and Imolas are cast so bad that timings vary from one batch to another from 116 – 140, get a cylinder between that magic figure of around 118 – 129 degrees and one of these cylinders will perform better than others. Get one with a large inlet and exhaust port and wrong transfers timings and it really won't help make a cylinder work well. With low transfer timings usually they need raising with special cutting tools or packed up which will lower inlet timings and raise exhaust timings, which can also be too large so its always a compromise. The same with over timed transfers on these cylinders, ideally the cylinder needs machining on the base to lower transfer and exhaust timings but this increases over sized inlet timings, You

can never win unless you use a retro reed Block which helps all round and is becoming more popular.

All standard cylinders from Innocenti and Spain use standardised transfer heights and timings and always worked well. SIL cylinders are not as well made and can vary in widths and heights but as long as they don't go over 130 degrees they work well. Our Race-Tour cylinders are designed to set up with small or large transfer timings for low to top end power with 0.5 – 1.00mm adjustment and still keeps inlet and exhaust port timings in a workable area. This still keeps our transfers within the magic figures and gives 122 – 128 degrees. The GT190 cylinders uses mid 120's and are fine, the SR kits vary and depending on how much tuning or cleaning up needs doing they are still usually within the magic figures.

Cylinders with 130 degrees plus are made to rev or need to rev to work, get one set up right with the right exhaust and keep it in it's power band and they can be very fast engines, indeed can you can see 28 – 30+ bhp. I find big transfer timings flood the engine low down, you can see this in a dyno graph, as the exhaust starts to work there is a dip at around 4-5'000rpm where you get splutter. The dip is exaggerated as the low down down power is too high from the big transfers and flood. Tweaking transfer to exhaust timings make for a better engine, this is called overlap and covered later.

We need to re address transfer designs in a Lambretta cylinder, at the moment we have two designs.

- Standard 2 transfer ports….. Innocenti, Spanish, SIL, Mugello, RT, SR, Casa and GT kits
- Updated 4 transfer ports….. TS1, Rapido, Super Monza, Imola, Monza and RB kits

Standard 2 port transfers have a very limited transfer feed size based on the casting thickness. A genuine iron cylinder is limited the most and is very difficult to add more meat to the cylinder, for many years the transfer feeds have been opened out to the maximum along their length to feed the transfers into the cylinders bore and have been called the Stage 6 tune. Is this needed? Well as with many tuners I have tuned this way in an effort to make cast cylinders quicker, in the end I gave up on road bikes and didn't loose any power at ALL. In a race engine it's all about ramming as much air fuel into an engine as fast as you can to make power and speed. I have tuned cast cylinders with 2 bhp higher than Webbo's Group 4 with standard transfer feeds with a smaller 30mm carb! I'm not having a go at Dave Webster tuning it's way to compare one persons tuning to my way, in a way that people can relate to, it's up to you who you believe, Me, Dave, Graham Bell or anyone who tunes Lambrettas. I looked and thought why spend an hour or two opening transfer feeds when if you used standard feeds with a good timings then they gave good power, I didn't see the point! Others would disagree because they fell into this Stage 6 130 degrees routine! Now you could look at the transfers on a 2 port they are tiny comparing to any modern cylinder, it makes you wonder how we get decent power from a tuned old style cylinder. You could look at it like these transfers need more timings to allow enough air fuel mixture in at the higher rev ranges, you could look at it like the higher the crankcase

compression the more can be pushed through smaller timings. It's a mine field and far too complicated to cover here.

As touched on, the 4 port cylinders use wider ports with a bridge to spit up the main to secondary ports, a standard 2 port transfer width on a 200 is 31mm, add the 2 ports and it will be something like 38mm and can be widened even more. The 4 port system introduced with the TS1 has to use larger feeds from the gasket face to feed this 4 port system. Tuners have for many years welded, filled and bodged these transfer feeds to become massive from the transfer fed gasket face copying the Motocross style cylinders in an attempt to raise power. Unless done correctly you can just slow down the gases and make a cylinder slower compared to a good un-welded cylinder. I've seen 37bhp on a TS1 with no welding but I've seen less than 30bhp with welded ports using the same port timings! It comes down to transfer port areas and volume from the crankcase compression. It's here that 2-strokes can get very complicated as these over sized ports rely on exhaust pulses to pull the gases through the transfer ports. If you look at it like this; the 4 port cylinders have larger areas of port feeds, with wider transfers and big transfer timings the gases slow down into the cylinders bore, to compensate, timings should be reduced not increased like a standard TS1, RB or Rapido! This is why I suggest lowering transfer timings below 130 degrees.

Take a KX 250 they are hardly ever above 122 degrees, they are more like 116 – 118 degrees yet are 40+bhp, take a KDX200 with a 66mm piston and and the same stroke of a Lambretta 58mm, these use around 124 degrees transfer timings and 184 exhaust port timings and the inlet reed is twice the size of a Yamaha block from a TS1 yet only gives 25bhp, we get that from an under fed cast or alloy cylinder quiet easily. So with some examples as shown it's a mixture of port timings, port sizes and much more to tune a fast Lambretta…….. but it's not just about making a high revving gutless engines, what I'm trying to point out is you need to add torque and pulling power into a Lambretta engines design and big is not always best as I'm pointing out.

Air fuel has to come from the carb through the inlet port and into the cylinders by the transfer and boost ports, exhaust port timings and sizes will dictate how and when the power comes in.

EXHAUST PORTS

It's without doubt power comes from the exhaust ports, size, width, shape and port timings giving either high power outputs or power of a standard. Again lets use Bells timings and compare it to standard and look at what modern Lambretta cylinders use and how we can compare them these days. Exhaust port timings and overlap over transfer port timings will dictate how an engine will work. This is why I wrote in the order of Inlet port, to transfer port, to exhaust port. It's a simple order from carb to exhaust and I hope I've shown why the transfer ports are important between the two.

Lets look at Bells book, he doesn't list a rev range as per Inlet and transfer ports. What he does is list types of engines either single or multi cylinder and what that type of cylinder needs to work at in revs. It's funny I've not read Bells book for many years, I've only used it so anyone

interested can compare my finding with Bells and Dave Webster as these people have gone out on a limb many years ago and put facts into a book which everyone has read over these years. As I flicked though Bells book again, I realised there are pages I must have flicked through, got bored and never read and as I know a little bit more now than I did in the 1980's most his findings are very true even today.

He doesn't really list engines directly compared to a tuned Lambretta the nearest is a 175, 200 or 250 Enduro or Motocross, the road racing engines rev far beyond any Lambretta cylinder so I'm not comparing them. I'm going to look at the single cylinders which are listed which are as near as there is a comparison to a Lambretta in tuned form. A four speed heavy wide Lambretta may benefit from timings say 5 – 10 degrees lower than Bell quotes just to get enough power to pull between the gear changes. For those who don't know, an Enduro Bike resembles a Motocross, they look the same but have a different job to do. You will have seen Motocross racing on television on mud and dust tracks, flying over humps and bumbs, doing tricks and been thrashed from start to finish, these are flat out engines! An Enduro bike is a different kettle of fish which is used over rough terrain, they may need to be flat out at times or may have to fly up a big hill or through tight twisty forest tracks or pull though mud bogs, these engines need to be more tractable. Looking at the table below timings are all very similar, it maybe transfer timings or compression ratios and exhaust designs that make a Enduro more rideable over a Motocross bike! Today an Enduro or Motocross cylinder is way beyond any Lambretta cylinder with Liquid Cooling, power valves and have 6 speed gearboxes. If you compare the list below, port timings decrease duration the larger the engine gets, probably based on mean piston speeds, I've never done this calculation in over 30 years and pistons last in my engines, so I don't worry about it. I guess the nearest we have here is a TS1 which has 185 degrees timing compared to an Enduro engine.

- 175cc, Enduro 9'500rpm, 186 – 188 degrees
- 200cc, Enduro 9'000rpm, 184 – 186 degrees
- 250cc, Enduro 7,500rpm, 180 – 182 degrees
- 250cc, Motocross 8,000rpm, 182 – 184degrees

I've not even got a copy of Dave Websters book to refer to, from memory he used very similar port timings and never went above 190 degrees on any Race tune, I say race tune as he never quoted a road engine with road port timings I will come to that in a bit. Dave was more of a smaller exhaust port timing man but a big inlet and transfer timing man, which produced quite low revving engines at the time which sounded different as they pulled and suited his riding ability. It would be difficult to compare them to a Charlie Edmunds rev monster with peaky power bands, Dave's last motor was 23bhp compared to Charlies 35bhp. Dave may have used higher gearing compared to Charlies high revving gearing, these are not exact facts but it gives you an idea what has happened over time in the Lambretta racing game and how one person looks at the job compared to another.

Look at standard Oval ported Lambretta exhaust port timings, tuners (who set they're own standards) and compare to modern road cylinders

- Standard Lambretta below 160 degrees
- MB Stage 4 – 5, 170 degrees
- DJ Stage 4 – 5, 175 degrees
- Taffspeed Stage 4 – 5, 180 degrees

Of course these will vary as mentioned on engine casings, gaskets and packers and what the tuners did on the day or if they were repairing an already tuned cylinder. So what works? We all know how a standard works, quick off the mark and runs out of steam! By lifting the exhaust port to 170 degrees suddenly the power shoots up without increasing the transfer or inlet timings over standard. But full benefits occur by altering inlet and transfer timings as explained above. A 170 degree exhaust port has great pulling power, it suits a full bodywork bike and works two up without the need to thrash too much and pulls high gearing, this is what we used on our Race-Tour cylinders. Increase it to 175 especially if the transfers are increased and it needs more revs to move it and very slightly looses torque so the gearing needs to be refined. Raise it further to 180 degrees as Taffspeed did and the bike can drop out of the power band on a hill and into the wind especially if over geared. I've ridden and road raced for many miles with a Taffspeed 180 degrees engine vs my 170 degrees, on every hill or when the wind was stronger he dropped back, get him to slip stream or going down a hill and he could just slightly pull away, in the end my bike just kept pulling and he gave up. Raise the exhaust further to 185 degrees and we're into full Road Race/Race porting where ideally an exhaust is required to work with it and only wants to rev in a high power band, raise it further too 190 degrees and it's at full race spec, go further up to 200 degrees and this is where many race engines are tuned to these days. These examples are for piston ported cylinders.

Look at modern remade cylinders

- SR all over 160 – 175 degrees
- Rapido Road 170 degrees
- Mugello all over 170 – 185 degrees
- Race-Tour 170 degrees
- GT 175 degrees
- Casa 175 degrees
- Rapido Race 180 degrees
- Imola 180 – 190 degrees
- TS1 185 degrees

If you wonder how modern cylinders work then the last few paragraphs should have explained the basics of how they should work. But it goes further and there is something called 'blow down period' or 'port over lap' this is the duration in degrees between the exhaust port opening and the transfer port opening. Listed are common blow down periods for common cylinder kits, these are as important as the port opening periods for the transfer and exhaust ports and will tell you more of how the cylinder will work in the real world.

Listed as…… Model / transfer port timing / exhaust port timing / blow down period in degrees

Piston port cylinders

- Standard 200, 122/158, blow down 18 degrees
- Rapido Std 200, 130/170, blow down 20 degrees
- Race-Tour, 126/170, blow down 22 degrees
- Mugello best 200, 126/175, blow down 24.5 degrees
- Rapido race 200, 130/180, blow down 25 degrees
- Mugello worst 200, 134/ 185, blow down 25.5 degrees
- Mugello worst 200, 116/180, blow down 32 degrees

Reed valve cylinders

- Imola worst 190, 140/175, blow down 17.5 degrees
- GT190, 125/175, blow down 25 degrees
- RB 138/188, 25 degrees
- Imola best 190, 122/175, blow down 26.5 degrees
- TS1 225, 130/185, blow down 27.5 degrees

Look at the list, the blow down period varies from 17.5 to 32 degrees with an average of around 24-25 degrees, what's best? Look at a standard this could vary depending on cylinder from say 14 to 20 degrees as I keep saying a standard has great low down power but does not rev, standards suit a large % of Lambretta riders. Compare this to an Indian SIL factory stage 4 cylinder which are known to have more power over an Italian cylinder and the blow down is increased to 21.5 degrees, showing an increase in blow down will increase power and revs.

Compare short blow down periods from standard cylinders to Stage 4 – 5 tunes and they increase from 14 – 21.5 degrees to 22 – 25 degrees where it's expected a Stage 4 – 5 will have higher bhp that would be saying if we used a common 30mm carb on a cylinder with a reasonable exhaust.

This figure of 22 – 25 degrees we know can produce some fast all round Stage 4 – 5 tunes with good pulling power which is what I've been trying to explain. So take it further and look at a Rapido Race and a Mugello worse it's 25 – 32 degrees, not only do these cylinders have large inlet port timings they have a big blow down period and I've already said these cylinders are hard to set off, they die on hills and into the wind, are hard to jet in, going two up makes them worse and gearing needs to be altered to get them something like. So is this too far in port blow down? Well yes probably in a piston ported cylinder.

Look at the Reed Valve cylinders of the TS1, RB and a good Imola which is from 25 – 27.5 degrees and higher than most piston ported cylinders, as explained the Reed helps spread power so higher durations can be used without loosing bottom end power. Look at the GT cylinder at 25 degrees as stated earlier these ride like a mild 200 which you can see by the above it's right in there.

Now remember what I said about lowering cylinders and transfer timings on a TS1 and re raising the exhaust port to 185 this gives around 30 degrees blow down, move on and raise the exhaust port and tweak the transfers to give a good low/mid/top end tune and you can push the blow down to 30 – 32 degrees. Push them even further to 34 degrees and power output goes even higher but

you are now building a very peaky motor which becomes unrideable unless flat out racing all the time.

You can use this low down to tweak a cylinder where you want, the blow down period sets how the engine wants to work and dictates the spread of the rev range. Use a standard TS1 blow down of 27.5 degrees, you can lower the cylinder to 120 transfers and 175 degrees exhaust port and then hey presto your within what I have been saying in our tuning articles for touring engines that work. By lowering the cylinder so much you will loose the big power outputs that is expected of a TS1. Go further and raise the cylinder with the same blow down to 135/190 and this will have the effect of moving the power graph higher in the rev range. Go further to 140/195 and it starts to die a death! Compare a lowered cylinder to standard to raised and you can say I want this engine which suits my style of riding and all with the same blow down period.

EXHAUST PORT SHAPES AND FLANGES

In the old days it was very easy, we had a cast cylinder, all we needed to know was it standard or tuned? This way we offered a standard exhaust gasket or a big bore exhaust gasket, then the TS1 tuned up! So then we had a ‘Cast’ or ‘TS1 cylinder’ and people knew they used two different exhaust gaskets……. then it all went to cock!

Lets start at the beginning, the standard style cylinder used an oval shaped exhaust port and bolted an exhaust on by two off set 7mm studs. All ports looked the same, heights and widths internally where different between each model but externally they were the same and used the same gasket. As we started to tune these older cast cylinders we increased the exhaust port size and various tuners introduced a newer big bore exhaust gasket which should have matched to a big bore exhaust.

Then the TS1 came along which totally altered things, it used a round shape exhaust with 2 studs but the studs where positioned in a different place and the exhaust flange was longer so you could not fit a standard style exhaust on a TS1.

So to start with we described them as CAST (cast iron cylinder) or TS1 (alloy cylinder) and this lasted for years we only had these two choices.

Then more and more cylinders started to appear, some used the same exhaust port as a standard and others used the TS1 flange, then came the RB flange which used the same round port of the TS1 but went further and sloped the flange towards the back of the bike. Why? Well I would guess the designers thought the gases would flow better, it practice it didn’t make a difference and we find more power from the TS1 flange, probably not the flange but port designs.

Initially it was easy I coined the phrase ‘Round Port’ and ‘Oval Port’ because ‘Cast’ didn’t describe an Alloy Rapido, Mugello, SR, Casa or RT kit correctly.

So it stuck;

OVAL ported cylinders include

- All Inocenti, Spanish, SIL cylinders
- Spanish Autisa
- Alloy Rapido, Mugello, Race-Tour, SR, and Casa cylinders
- Cast GT cylinders

ROUND ported cylinders include

- TS1, Monza and Imola cylinders

And then we got the the RB, all RB 200, 225 and 250 cylinders have the same flange, so we now call cylinders Oval, Round (or RB) which uses three different exhaust gaskets, standard, big bore or TS1 style gaskets. The RB uses the same exhaust gasket as the TS1.

There were some small differences, our RT cylinder went a little further as all exhaust ports can be a pain to seal and can create some problems as I feel the 2 x 7mm studs used on all Lambretta cylinders are too small and nuts can come loose or studs snap. Ideally the exhaust port needs 4 studs equally spaced to seal gaskets. We use 2 more studs on the RT to help exhausts stay tight, we very cleverly designed our RT cylinder so a standard or big bore exhaust could be used. If you used a flange that we supplied then you could improve the design to have 4 studs. Still not perfect but better than standard, I wanted to alter the idea to be perfect but the design spec of the RT cylinder was to be an easy fit using peoples existing exhausts to save money and not need a bespoke exhaust as does the RB cylinders. Some cylinders are machined incorrectly, some Mugello kits come with a longer flange, this means standard exhausts are 10mm out of line towards the floor, also the GT kit has a longer flange and both can be a pain to get an exhaust to fit. There was an exception in the Spanish Alloy kit from Autisa from the 1980’s which used a round port but no gasket and was sprung loaded, these are so rare it’s not worth worrying about.

EXHAUST SHAPE FOR TUNING

We have 3 ports as discussed in terms of gasket shape

- Oval shaped Cast Iron, Autisa, Casa, SR, RT, Mugello
- Round shaped TS1, Imola
- Round shaped slopped RB

We have 3 internal port shapes

- Oval, Cast Iron, Autisa, Casa, SR, RT, Mugello
- Square/Rectangle, TS1, Monza, Imola
- Square/Rectangle, with sub exhaust ports, RB

What makes a good exhaust port shape? We need to look at two areas ‘power’ and ‘reliability’. Exhaust port shapes can produce power but at the cost of ring and piston wear so it’s a compromise power vs reliability. The Oval

shape works really well, the ports are shallow giving good low down power from a flat top shape and small exhaust durations. The big nice round edges help rings pass over the ports. Extend this style of port and lift it to the TS1 port timings of 185 and the shape becomes a square/rectangle shape with large rounded corners, this is very good for higher power but looses bottom end power but still has good piston and ring life, (providing you don't go too far).

The wider you go the more power is gained, but we have limits in widths, modern motors aim to go as wide as you can to gain power but to do this the piston and ring needs supporting. This is done in two ways; Bridge the exhaust in the middle and have two exhaust ports the only cylinder like this is the Avanti kit. Or add two smaller sub ports either side of the exhaust port above the transfer ports the same as the RB 225, 250 and super Monza cylinders.

I have been doing bridged exhaust port conversions on cast iron cylinders right back to my early Liquid Cooled cylinders from 1983, I have also done them to TS1 style cylinders and raced one at Brno in the Czech republic in 97. Bridge exhaust ports do gain power as you can really widen the total exhaust port right out to the transfer ports, but they come with problems! The bridge is difficult to get wide enough to be strong and can crack and in running the bridge flexes into the bore and can wear pistons and rings so the bridge needs grinding to relieve it. I have done the sub exhausts ports conversion on my 40 bhp Sprinter from the 90's so these are nothing new and was convinced it was this conversion that got us to hit 40bhp before anyone. Both of these exhaust ports creates their own problem, as we still have the bad Lambretta design where the two lower main cylinder studs are the limit and they get in the way to do a real bridge port or a real sub exhaust design so both designs have their limits, then you could look and ask does a exhaust port flow as well with a bridge in the way of flow!

So how wide can you go? This is a question often asked, it depends on ring type, cast iron rings are the worst and have no strength, go too far and the rings will catch the port edges and snap called a ring dropper, these are rare these days as most people with any sense don't use cast rings other than in standard cylinders. My first 200 tune used cast rings and was a ring dropper cylinder and needed a new piston and rings every 1000 miles and often snapped when trying to start the bike, never when running. I got around this problem by machining pistons and fitting Jap rings!

There is a formula you can use to see how far you can go using a standard style port without bridges, this is based on % of piston diameter, Bell talks of 0.65 for brittle cast iron rings and between 0.71 – 0.75 for modern rings. Take a 66mm piston x it by 0.65 and it equals 43mm exhaust port width which is around a standard Innocenti width, tune it too far to 48mm and the rings will drop/break. But use a modern piston with wire rings which don't break then you can go to 49/50mm wide no problem (if the bore/plating is hard, soft iron cylinders will wear). Taffspeed and others have gone to 55mm wide, but I find this is too far, rings, piston and bores do wear, as does the upper exhaust port and these widths knock the ring pegs loose. Ok for full race porting but not for road motors. How do you measure this width? People

wrongly state it is measured in a straight line from one side of the port to another, it should be measured around the circumference of the bore. Do it in a straight line and it would really measure 60mm wide!

Traditional Lambretta exhaust ports can be tweaked to gain power, widening the top edge wider will gain power, opening the RB sub exhausts should gain power but is limited by the strength of the walls holding them together, these break from the factory and when run wears the plating away and you have the cylinder stud problem. In Bells book there is a drawing of a Honda MT125 race bike with eyebrows exhaust port, I've tuned one of these cylinders, he says it has nothing going for it, the design does for power but not for reliability, today I know of one tuner doing this style of tuning with massive power outputs but at what expense for high mileage? Race tuners on the track are now doing something similar where they combine the eyebrows port and half a bridge where they grind the port to leave a finger like the uvula at the back of your throat. Done right this works well but I've not seen a good one yet and only seen mass cylinder and piston wear. Lowering an exhaust port like the SIL, Rapido or AF tune does nothing but make the port area larger, lowering ports below 2mm of the pistons crown and BDC will heat up the piston.

Is there any need to make the outside of the port bigger? Well it depends, one way to look at it big is best or you can now say small is best. Older Motocross cylinders have massive diameters, modern ones have small diameters, an RB is smaller than a TS1. Personally I match a port to an exhaust flange and give it some flow, but you do see some really badly sized exhaust flanges, this size is limited by exhaust studs diameters so it's hard to go too big. With a Oval port it's difficult to go too big as there is not enough meat to play with and personally I would rather have a good seal to a seal say 1mm thick.

So there you have it, it's not the be all and end all of 2-stroke tuning, there's enough information to shut up the knowitalls on forums and there's enough information for you to attempt a tune yourself. I've not said everything, some things need to be a secret especially when there are tuners all fighting for a bit of business in these hard times. What this article should have done is shown that I have probably more experience than any one else at tuning road going Scooters. As I've explained earlier, to do this job needs thousands of pounds worth of engineering equipment to do it right, not every dealer has all the equipment.

If you have any questions please email mark@scooters.co.uk