Harley-Davidson Staging

Staging
Stages 1, 2, 3 & 4

Aerocharged
Paul White's FLHT

Boz's 107bhp
Twin Cam 95

Efficiency
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Staging Your Harley

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Pics: Harley-Davidson Archive

This was originally going to be a "How do you define a Stage 1 / Stage 2 / Stage 3 / Stage 4 upgrade" question asked of anyone and everyone who might have an opinion, but the more you look into the subject you realise that in Harley terms, staging follows fairly set patterns and there isn't much room for interpretation at this level. It's not a general thing: you can stage any motor, and the numbers they go up to can get silly, but we're not here to talk about that.

We are still going to be inviting specialists to add their comments on another question – subject to my having the presence of mind to ask them as soon as I've finished writing this, so they've got chance to reply before we need their words for the next issue. That question will revolve around the recommendations they would make for a rider with a budget of "x" and a requirement of "y". But, back to the plot.

The fundamental issue with all new Harleys out of the box is that they cannot breathe efficiently, and there is a good reason for this: they have to meet all current legislation for emissions, and for noise. The expression "Harley Tax" creates the impression that it is Harley's way of squeezing another few bucks from your recently unburdened wallet, but that is very definitely not the case. It's long since been the case that UK-spec bikes are more tightly regulated than UK law demands, but that is because there is no such thing as a UK-spec Harley. As we get closer to Europe, it looks likely that we'll inherit their Euro 1 and Euro 2 standards which could put a different complexion on the whole thing, but that's another story. Either way, it is more cost-effective for Harley to make as small a range of alternative specifications as possible, which means that the Americans get one model, unless they're in California, and everyone else but the Swiss get the International models. Californians and the Swiss get an even more restricted model, with catalytic converters, to meet those market's demands.

That stockers can't breathe efficiently doesn't mean they can't breathe and increasing numbers of new Harleys stay in their stock form for longer because the available power is actually enough for a lot of people, but the rewards are tantalisingly close for those who are prepared to dig their hand in their pocket for the most basic of tweaks: the Stage One.

Before we start, this isn't meant as an absolute "thou shalt fit a …" because we don't work that way, and because experts will disagree with each other, and with us. There is no such thing as a definitive guide to staging, and there is no absolute right way to go, but this will hopefully put you on the right path.

There are a few myths concerning "Stage 1/4" and "Stage 1/2" but forget them because they are a poor substitute for the real thing, and while certainly cheaper than the real thing they do not provide anything like the performance increases that you're looking for. If you've not come across these cheap alternatives, they revolve around getting more air into the motor by drilling holes in the plastic air-filter backplate, and seem to work on the assumption that the restriction is getting air to the air filter, rather than getting air through the air filter into the engine.

Stage One

You can spot a Stage One bike very easily indeed: the air filter isn't sunk into the plastic moulding that fills the gap between the air filter cover and the motor. It's the tip of the iceberg, but it is the most visible part.
Stage One engines generally require no internal mechanical modifications: all you are initially doing is changing the means of getting the fuel in and the exhaust gases out, but they can include ignition mods if you're feeling flush. You can go as far as you want, but the most common basis for a Stage One is a Screamin' Eagle High Flow Air Cleaner kit and a pair of slip-on mufflers.

Couldn't be much simpler, fitting an air filter, until you realise that one of the bits of emission control is that the mounting studs that hold the air filter backplate on are actually engine breathers from the cylinder head, but this explains why it is called a kit, rather than an air filter. Part of the kit is the means to change their route and then it's a matter of fitting the supplied filter onto the revised cast mounting plate, allowing more air to pass, and refitting the stock cover or supplied alternative. This is possibly the first time you will have seen the crossed chequered flags in the Parts and Accessories catalogue, and the legend "For Race Applications Only". Get used to it. As soon as you remove the original backing plate, you're beyond Harley's corporate responsibility and the onus on meeting regulations is on you. No matter that you purchased the parts from an approved outlet, and that they were made by the original manufacturer of your motorcycle, you are flouting current regs and the responsibility is yours: reasonably cool at the moment, but pray that anti-tamper doesn't become law.

Having let the air flow more freely, it's essential to consider the impact on the calibration of your EFI or the jetting of your carburettor. More air means proportionally less fuel, and that means a lean mixture: sort it before you run it in anger, or it could overheat and potentially seize.

Slip-on mufflers are easy enough on a new motor, while the mounting bolts are still in good nick. Slip-on mufflers do two things ... well, actually they do one, and the second is a by-product. They provide less restriction for the exhaust gases and are louder as a consequence, but a lot of people buy them just to make the bike louder.

And that could be it. For some it is enough, but it doesn't need to stop there – arguably it shouldn't.
Having got the air into the carb more quickly, and eased the path of the exhaust gases, it makes sense to make sure the fuel metering system is working as efficiently as possible so you want to have a look at that – and there's more to fuel systems than jetting and the recalibration of stock EFI modules.

All of a sudden it gets contentious. There are many ways in which you can sort out the original CV carb from a Dyno Jet kit to throwing it away and replacing it with a slide carb, and you will find a lot of variation in the advice you're given, but your path will typically come down to how much experience you have of tweaking carburettors, who you trust and how much money you've got. As regards to EFI, the stock unit can be recalibrated to account for the changes, on a dealer's rig, but Harley themselves don't offer alternative units beyond that calibration, and your warranty will

suffer if you play away.

Another useless piece of information – it's amazing what you pick up as you go through life, although I'm struggling to find supporting evidence of it – the CV, or Constant Vacuum carb was developed in the second world war for fighter aircraft. When descending rapidly, aircraft cheat gravity and this plays havoc with slide carbs as it can starve the engine of fuel. Not a problem with the fuel-injected Messerschmidts but a pain for the early Spitfires who couldn't dive as steeply without the engine cutting out or worse, the mixture getting lean for long enough for the engine to seize. The CV carb was devised to solve the problem … or so the story goes.

But anyway, Harley supply different jets for their Keihin carb and, if you know what you're doing and have access to a Dyno to speed things along, it's as good a starting point as anything. The factory-supported DynoJet recalibration kit is a common alternative to take a lot of the guesswork out, and can be backed up by their Thunderslide, which is a redesigned lightweight replacement slide, emulsion tube and slide needle for the CV and offers improved throttle response. Another alternative, but by no means the last one, is the Yost Power Tube: a selection of jets and the Power Tube itself, it's designed to eliminate flat spots and otherwise sort out your carburation.

Or you can put it to one side – or flog it on ebay – and get yourself a Mikuni HSR-42, or a Screamin' Eagle 44mm CV. And yes, Screamin' Eagle do sell a 42mm slide carb: it's made for them by Mikuni. Both carbs are for … ahem, competition use, but it's worth knowing that if you're going to stick the big bore CV on, you're going to need to think about a 44mm manifold to bolt it to. A street-legal 44mm CV is also available for 2001-on Twin Cams and possibly points the way to future legislation.

Injection-wise, you're stuck with the factory recalibrating modules unless you're feeling brave and want to go aftermarket. Not brave in terms of functionality, but in fighting your corner if your non-approved fuel map is deemed to be responsbile for a warranty failure, and there are a number of mechanical things that the fuel mix can affect.

Exhausts are no less involved. Slip-on mufflers are by far the easiest, but a full system will deliver more and that is a subject by itself. One thing is for certain and that is that the balance pipes will remain in place if you just fit mufflers, while aftermarket systems will often lose them. Balance pipes break up the lines of the V-twin on Sportsters and FXRs, but are generally there to reduce noise, reducing the speed of the exhaust gas by allowing it to dissipate before it exits the muffler, but there are many people who blame them for poor performance. The "hidden" low-level balance pipes on Dynas and the new Sportster mean they will stay in place for longer, as they don't detract from the appearance, but there are increasing numbers of people who are leaning towards 2-into-1 systems like Vance and Hines, Supertrapps or Thunderheaders, and they don't come much more balanced than both pots exiting the same silencer.

And that's the main stuff, but not everything because there's a few other things you can do without taking a spanner to the cases, and they are the bits that light the fuel – and a good thing to do if you've gone to the trouble of fixing the carb.

As you'd expect, Screamin' Eagle offer a range of ignition systems, both street legal and "competition" which better match the spark to the less restricted motor, while Crane's Hi-4 and Dyna's Dyna2000 remain popular choices for those less concerned by their warranties, and have an element of tunability built in so you can experiment. And if

you're going to play with ignition modules, why not coils? And why not plug leads? All of which falls within the remit of a Stage One.

There's nothing in there that a reasonably competent home mechanic can't tackle, but if your bike is still within its warranty period, you'd be best advised to talk to your dealer and make sure they're not going to suck hard through their teeth when you bring it back, having made a mess.

What sort of mess can you make?

Too weak a fuel mix if you're playing with the carb, injection module or air filter, so keep an eye on your spark plugs afterwards and make sure they're the right colour. Getting an air-leak in the system if you mess about with the carb or manifold, which will make it pop under load and on the overrun, and ultimately could blow the rear pot. Getting the ignition timing wrong if you've got a fully adjustable unit that will let you play beyond your expertise, in which case it will run badly. Shearing or stripping something by overtightening it, so get a torque wrench, or be cautious ... no, get a torque wrench: it's potentially more dangerous for something that hasn't been tightened up enough to fall off, than it is to shear it. Rounding off a perfectly good nut or bolt by using the metric spanners from a previous bike, or your dad's old imperial spanners, so get decent tools before you start.

Simple stuff really, but be aware that your dealer would rather do the job for you and charge you for the privilege – but also that you've got some comeback if they mess up. Also be aware that the fitting of anything non-Harley to your warrantied bike might cause a raised eyebrow, and that even Screamin' Eagle kit is no guarantee of your warranty surviving intact.

While mentioning that Stage Ones don't need to have a spanner laid on the engine, it doesn't actually mean that a Stage One can't have a spanner laid on its engine, and a Stage One 1550 is actually quite possible. Rebore the original barrels, and drop a pair of the 1550 pistons in under the stock heads and hey-presto! You've got a Stage One 1550cc. You can leave the cams alone, although you wouldn't get the full benefit until you did look at the cams and that would be …

Stage Two

Now you're motoring, but now you're more likely to need the assistance of a professional.

First thing to do is to carry out all the "Stage One" stuff that you want to do before you start, because they are the basis for the next round of modifications: there's no point sticking hot cams in a strangled motor. By the same token, there's no point getting carried away with the need for a Stage Two if you've not taken your bike to Stage One yet – you might be quite happy at first base.

Stage Two is largely about cams. You've got the means to draw fuel into the motor already, and to get the gases out. This is about how long you open the door to let the fuel through, and how wide you open it, and that is determined by what sort of work you want your bike to do.

There is probably more written on Harley Cams that anything else, and there is no shortage of people far better qualified than I to go through the absolute specifics so I'm just going through the general stuff … that way I can't be blamed for your sticking a wholly unsuitable cam into your motor. What's unsuitable?

Something that makes your bike worse for the way you want to use it.

It is almost at odds with the perception of tuning that you can have a Stage Two motor that is actually detuned compared to the original but then tuning isn't only about power, it's about suitability for the purpose. You could make a touring Buell, a hot rod Electra or a lazy T-Sport by judicious use of cam profiles, matched to an efficient induction/exhaust system.

There is nothing especially clever about the principle of a camshaft, and all it does is transfer a rotary motion, which the crank delivers into a pushing action, that you need to open the valves.

A perfectly round shaft spins at half the speed of the crankshaft, driven by gears in the case of Sportsters and pre Twin Cam big twins, and a chain on the stock Twin Cam. On that shaft is one "lobe" per valve and as the shaft spins, anything that follows the track round the shaft and up over the lobe will rise and fall with it. That 'anything' is a cam follower, and it faithfully follows the track of the cam's lobe, climbing the opening ramp, and pushing a pushrod up to a rocker shaft. The rocker shaft rocks when it's pushed, pushing down onto the top of a valve, which is held in the closed position by heavy-duty springs. Springs move on demand, whereas the lobe on the cam is immutable, so the valve opens and stay open for as long as the lobe on the cam is holding it there, but as soon as it rotates beyond that point the spring pushes the valve closed again, rocks the rocker arm, which pushes the pushrod down quicker than gravity would force it to drop and the cam follower rolls down the closing ramp for another circuit before the opening ramp comes round again.

A couple of quick things. The cam spins at half the speed of the crank because it only needs to do something every fourth cycle in a four stroke engine. A classic 2-stroke doesn't have a camshaft spinning at the same speed as the crank because it doesn't have a camshaft at all. And cam followers are the quaint old English term for what we now refer to as lifters: almost the same logic in the naming department as lifters lift, but then they also drop. They are also sometimes called tappets, probably because badly adjusted ones make a tapping sound, I guess.

Cams are specified by lift, duration and angle … and quantity: Sportsters and Buells have four with a lobe apiece, one for each valve, big twins up to and including the Evo had one with four lobes that run all four valves, and Twin Cams have two with a pair of lobes each, one per cylinder.

There is actually a fourth quotient, and that is the ramp. A steep ramp will take the pushrod to the maximum lift very quickly, and return it to rest as quickly as the spring can force it – as opposed to a gentle ramp which the cam follower will … well, follow.

A high lift cam will let more fuel through but they are generally used on fast spinning motors – the high lift allowing a good lungful of fuel and air compensating for the need for a short duration to give the valve chance to close again and be seated correctly before the next cycle starts. You don't want to compress the fuel while the inlet port is open, because it'll spit it back out again. If you're playing with high lift cams, you're more likely to use stronger valve springs to get the valve shut quickly, but there is a trade-off in that the harder the spring is pushing against the valve-train, the greater the potential for wear of the cam, follower and any bearings.

A long duration cam will give the maximum amount of opportunity for the fuel/exhaust to get in or out, but shutting the valve late increases the chance of the valve being open on the compression cycle. Better suited to slower-spinning motors in conjunction with a lower lift.

The angle will determine when the valve starts to open, and there can be an overlap built in according to what the engine is to do. It is possible to open the inlet port a little before the piston has reached TDC to make sure that it has opened sufficiently when it starts to descend, drawing fuel through; it gets away with it because the exhaust port is wide open and provides the easier route through. Similarly the exhaust valve won't quite have had time to shut before the piston descends, but by then the inlet valve will be wide open and it will draw it through there rather than the exhaust valve that is slamming closed.

You will be delighted to know that you haven't got to make your own decision on any of those elements, as every combination will have been tried repeatedly by very bright engineers. The resulting profiles represent everything from radical to realistic, wild to mild, and are well known for their characteristics. Hopefully you'll have a better appreciation of why the engineer who knows about these things is asking you lots of questions – and if they're not, be concerned: they may be good, but they're not psychic and they need to know what you want.

If you want to play a greater part, you might want to consider the technology of the follower/lifter/tappet. Back in the old days of British pushrod twins, the cam followers were little more than hardened steel metal blocks that slid on the hardened camshaft lobes on a thin film of clean oil; they had a means at the top to locate a pushrod, and a means of adjustment. Meanwhile, Harley have used roller bearings to track the lobes for generations, and housed them at the bottom of their lifters. Not just ordinary lifters either, they've used hydraulic lifters since the end of the Knuckleheads: high technology at the heart of the big twin, but the fashion for decades was to replace them with solids. But times have changed.

Hydraulic lifters are self-adjusting, using clean engine oil to fill a chamber within the lifter body and a piston that provide the base for the pushrod. The size of the chamber is determined by the valve train itself, and the slack built into it. With the chamber full of oil, the lifter takes up the available slack and acts as a single unit of exactly the right size. But so does a screw thread, I hear you cry. Ah, true, but here's the rub. An engine is made of metal and gets hot, and metal expands when it gets hot. So as you run your motor the hot bits expand and the cylinder head actually moves further way from the camshaft. How far can a motor grow? Not far but enough to make a difference. Try .040" on an Evo motor, when your valve clearances should be somewhere nearer to .002. With hydraulic lifters, as the engine gets hotter, and the gaps increase, more oil fills the bigger chamber and the slack is taken up.

It's the opposite of your recollections, if your recollections are of old Brits, because the expansion of the pushrod is greater than the barrels, so Brit bikes rattle when they're cold, and Harleys rattle when they're hot – or they do if they've got solid lifters.

There is a downside, there always is. Hydraulic tappets are much more complex, and susceptible to dirty oil, and fall down as an engineering principle when the lifter becomes worn and oil can escape from the chamber because it screws up the adjustment.

For all their sophistication, mechanically adept luddites and power junkies missed the simplicity and economy of "solids" and they converted back, backed up by experience of failed units in days when engineering tolerances weren't as fine as today, but for the

majority of owners a set of hydraulic lifters were always better than a badly adjusted set of manual tappets.

Today there are a massive number of engineering companies offering a vast array of hydraulics, semi-hydraulic and solid lifters for your Twin Cam, Evo, Shovel or Panhead. It will come as no surprise either to note that you can also get high performance lifter blocks to house them, and these are not to be confused with cosmetic covers: if you're going to seek the finest engineering tolerances in your lifters, you're advised to make sure they're sliding in a block engineered to the same standards.

While you're in the motor playing with cams, it's as well to replace the stock cam bearing with a better one, but aside from that – and the original Stage One mods – you're about there. You might want to consider a different ignition module – but you should perhaps have accounted for that when you did the Stage One, giving yourself some elbow-room for further development.

You'll note from Harley's Parts and Accessories catalogue that 1550cc motors rear their heads quickly when talking about Stage Two, but that's not a pre-requisite. Yes, a 1550cc big-bore would be nice, a 1700cc stroker would be nicer but that isn't necessarily a Stage Two. It could be, but if you're going to those lengths, it's worth contemplating a little porting and checking of the rest of the lump, which takes us to …

Stage Three

There are those who would say that the first thing you should do to make a Harley work properly is to sort out the heads, but that is generally where "Stage Three" comes in.

The combustion chamber on Harley V-twins has benefited from better gas flow characteristics with every evolution, but the standard porting is not best suited to high performance. Porting is a subject in itself, and will be dealt with in the near future by someone who knows what he's talking about, but we have reached the point where you're really not going to sit in a shed with a bastard file and an heirloom toolkit. If you've got a fully equipped workshop – and we are talking fully equipped here, with lathes, milling machines and a space heater – you'll know much more than I do already, and I'm amazed you're still here.

This is where the engineers come in, and you have to put yourself in their hands. Sure, you can buy heads etc and stick them on yourself, but when you're that deep in, you're not going to put those heads in without seriously considering what you want from the bike. Well, if you've got any sense you're not.

You're in big money country now and a half-cocked Stage Three will be not much better than an amateur Stage Two – certainly not worth the additional expense of the parts. Yes, I know you can get ported heads off the shelf, but ported for what? More torque or more horsepower? Higher or lower revs? Fuel efficiency or straight line ability? Before you start you need to know where the power is needed, and what sort of power, to determine the size and shape of the valves: until then it's merely a technical exercise.

And it's not just heads, and that is why we now start to differentiate between engineers and fitters. A Stage Three motor really should be a blueprinted engine. It's no longer enough that it is as good as an assembly line can make it, if you're going to do it properly, it's got to be as accurate as the original drawings: the blueprints. If the drawing has a dimension of 1.7701mm that's what it has got to be, not +/- .005mm.

Production lines don't do that, fitters can't do that, mechanics would love the time to learn that. The only people who can do that properly are engineers – and even then, only the better engineers. The bad news is that there aren't many left because there are few coming up through the ranks, and that's because production lines have rendered a lot of basic skills obsolete and machine minders fill their steel-toecapped boots in industry.

A blueprinted engine will be less stressed than a production line example – even a good production line example – because everything will work as it should: as it was designed to do. The sort of engineer who will be capable of matching the specification will be more than capable of sorting out your porting, cam and carb requirements to make it better than the blueprint for your specific application, and that is the ultimate state of tune for your bike. Harley-Davidson produce motorcycles for the masses, an engineer will make a motorcycle for you … assuming you know what you want, and can communicate that to your chosen professional.

Stage Four

Anything goes. Turbos, blowers, nitrous, strokers, billet motors, massive motors built for the purpose from parts that have never seen Auntie Janet's bar and shield logo.

Quite bizarrely, a Stage Three bike would be the better bike in the vast majority of cases, and when compared to some of the bikes that drop into the Stage Four category, is likely to be quicker for longer in road use because there's no guarantee that it'll be hand assembled to the same standard as a Stage Three.

That said, you could always get a Stage Four engine and get it blueprinted it to make it better still – unless you're 100% certain of the ability of the original builder and you'd be foolish not to entrust to an engineer who you did trust implicitly.

It doesn't get any more sensible when you consider that it is perfectly possible to bolt an off-the-shelf turbocharger to a stock motor, in which case it's a Stage Four instantly. Stock cams and stock carb (on at least one option) with just the turbo's plenum and convoluted plumbing to drive the compressor replacing the air-filter and exhaust. The only thing it has in common with the more serious hardware is the power output, which can be twice that of the stock motor: torque and horsepower. Oh yes, and cost. Stage Four doesn't come cheap.

A turbo can work out at £3,500, and an engine can cost twice that before you open it up and fettle it some more – and it would be a strange horsepower junkie who could leave the cylinder head in place once they'd unpacked the motor … or the barrels.

And it's worth a quick look at the crank while we're down that far.

And it'd be silly not to weigh the pistons seeing as they're out.

And is that a slight lip on the inlet tract … ? Pass me the emery …

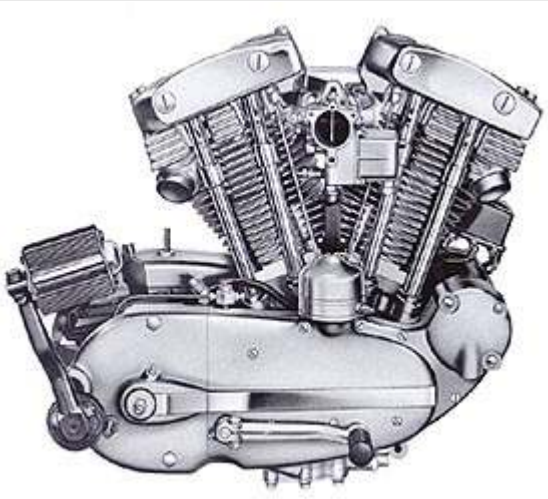
Stage Four is the domain of the serious power addicts. Doubling the stock horsepower isn't a challenge any more, trebling it would be good though. You won't see many of these bikes on the road because they'll have sacrificed a lot of their rideability along the way – in fact some will be physically unrideable – but on a quarter mile strip of tarmac, head-to-head with someone who thinks they know better, they will demonstrate just how much you can get out of an air-cooled v-twin motorcycle.

The sad truth, though, is that yesterday's Stage Four will be thrashed by tomorrow's Stage Two, and the day after's Stage One. Performance is transient, even in Harley circles.

There's something you need to know: no matter what you've got it'll never be enough.

There is some irony in that a lot of people are discovering Harleys today after years of buying faster and faster sportsbikes in search of the thrill they remember when they first started riding … only to discover that riding was more about freedom than speed, which maybe explains the sheer number of stock bikes out there today.

Sportsters



The vast majority the rest of this feature is applicable to Sportsters, but not all, and there are a few things that are specific to Sportsters that are worthy of inclusion.

A Sportster comes in two sizes based around very many common components: common cases, cranks, running gear and just about everything up to the crankcase mouth. Only then does the 883 get a narrower bore, which extends to its cylinder head, compared to the 1200. The common trick is to convert your 883 to a 1200 but this has absolutely nothing to do with staging. You can stage an 883 and stage a 1200 and the results will be very different. And there is another factor for Sportsters, and that is the development being done by a smaller Harley subsidiary in East Troy: Buell.

Finances might govern a lot of what you do, but there is good news in that there are many ways to do what you want to do. And a lot of the stuff you do is applicable to either capacity, so you're not spending money that you'll not get the long-term benefit from.

Take Stage One for example. The free breathing air filter fits both bikes, as do the mufflers. Plug leads work with anything at all, as do the vast majority of coils. You've got to be a little more cautious on ignition modules, but there are some that work with both – and at least one that works with an Evo.

Want to go to Stage Two? Cams are much the same.

It's only when you go to Stage Three and beyond that you really need to commit to the size, or throw money away if you decide to increase capacity later, and that's because 883 heads and 1200 heads aren't the same.

But staging is only part of the story. Sportsters have always been capable of being tweaked but no-one has really done a lot of it. They are too often seen as cheap Harleys and get dressed up as big twins rather than playing to their strengths.

Ignoring staging for now, where do you start?

Cheapest route? You can rebore your 883 barrels and fit a pair of 1200 pistons specially designed to sit within the 883's smaller combustion chamber in the stock heads.

Next up, you can stick 1200 barrels and pistons onto it, and have a proper engineer re-profile the head's combustion chamber, or do the same and stick a pair of 1200 heads on – a recommended route if you don't have access to a proper engineer – or even the twin-plug XL1200S heads, but being aware of the knock-on costs of coils and ignition

systems.

Or you can stick Buell barrels, pistons and Thunderstorm heads on.

One thing that always counted against the Sportster was its vibration at high revs, but if the bottom end is blueprinted, and the top end balanced, those vibrations are no longer an issue – and will go a long way to make a happier, longer lasting motor to boot. Which squares the circle nicely and brings us back to staging, for that would be knocking on the door of being a Stage Three but for a reporting of the heads, and even Buell heads can stand a bit of looking at depending on what you want to do with them.

And then there are the 2004 XLs, which haven't got the vibration issues anyway and which use Buell XB technology. The XB12S knocks out more than 100bhp, and there's no major reason why the same components – except the downdraught manifold – can't be used on a Sportster. And no good reason why you couldn't build an 883 into a 985 XB9-derived, high-revving twin. The Sportster has every chance of undergoing a rebirth, providing people are aware of its potential … and always assuming the new heavier frame hasn't compromised its lithe road manners.

Overhead Cams

Not so much a dirty word as a dirty sentence for generations, and something that still gets a mixed reaction through the V-Rod. I don't suppose anyone doesn't know the difference – and certainly no-one that'll put their hands up – so I'll keep it brief.

Overhead cams are not to be confused with overhead valves. Both are referred to in shorthand: OHC and OHV respectively, although OHV has largely fallen into disuse because there isn't much else anymore, as it only really served to distinguish the new engine type from side valves, snd OHC is often referred to as SOHC, for Single Over Head Cam.

Another confusing little something is that a v-twin can be SOHC even though it has two cylinder heads and therefore must have two camshafts, because it refers to the number of cams per motor. So a SOHC V-twin has two cams, and a DOHC v-twin has four cams. If you want a real nasty one, you can tie people in knots with valves. An in-line four with 4-valves per head will have a 16-valve head, or a head with sixteen valves in it: piece of cake. But what about a v-four with 4-valves per cylinder, which has actually got two 8-valve heads but has got to be referred to as a 16-valve head for clarity, however technically inaccurate. In the grand scheme of things, the V-Rod has two 4-valve heads, so it's an eight valve, it's a DOHC so it's got 4 cams; the Victory also has eight valves, but is a SOHC so it's got two cams. At least V-twin is clear.
In an overhead cam engine, the cam lives above the cylinder rather than within the crankcases and is typically driven by a chain or belt held taut by a slipper tensioner of sorts. I'll have to mention Ducati's Desmodromic system for those people who have picked this up by mistake, which drives the cam through a rotating vertical shaft, and also physically opens and closes the valves mechanically rather than relying on springs to do the job – very clever design to get over technicalities of valves floating and springs binding at high speeds when introduced. Overhead cams can, and have been driven entirely by gears, but gears are heavy and there is an opportunity for backlash within any geared system and the more gears, the more potential for backlash – it needs to be there because gears are metal, metal gets hot and expands, and if there's not enough

space for them to do so, all hell breaks loose. We're used to them being around in our timing chests, but they don't transfer drive very far, unlike when they are asked to reach a cylinder head and the further the gears have to travel, the more gears are needed.

An overhead cam engine's cam is not dissimilar to the crankcase mounted one: a shaft with lobes on it, except in this case the pushrod is dispensed with and one end of the rocker arm runs directly on the centrally-fixed camshaft, reacting to the lobes. In the case of a DOHC, or a Double Over Head Camshaft, the lobes can act on the valve stems themselves, via shims in place of tappets to take up any slack, because each camshaft can be positioned directly above the valve(s).

Overhead cam engines have two inherent advantages over crank mounted cam motors.

One is a lighter valve train. Pushrods weigh something, and losing them is "a good thing" because at high speeds the pushrod needs to be able to change direction more quickly and completely than its weight will allow. It actually isn't really an issue at low engine speeds because it's got time to deal with the change in direction, and there is every chance for the pushrod to be in the right place at the right time. You could, and people do use lighter materials but you can only go so far before you compromise the required strength. Having lost the pushrod, the rocker arm was the next weak-link, hence the move to DOHC: all we've got to worry about now are springs.

Secondly is the greater freedom for valve angles, because you can put a valve almost anywhere in the combustion chamber, at almost any angle and have greater freedom for the shape of that combustion chamber. On a pushrod motor you are limited by the angle of the pushrod and how that relates to the rocker arm. In that context you can see the benefits of the Twin Cam motor over the Evo, with each pot having a less compromised set of angles compared to the neater, more elegant Evo / Shovel / Pan / Knuckle, but still a way off the XL's.

They don't have it all their own way though. An overhead cam motor carries more weight up top, where you don't want it, it is mechanically more complex at the top end, and is taller than a pushrod motor – check out the Victory and Harley motors side-by-side for a graphic demonstration – so is less well suited to long stroke motors … well, compact ones at any rate.

Overhead cam motors tend to come in a higher state of tune, generally because they can, and largely because they have been developed to their strengths, but you shouldn't confuse that with the basic engine format. The V-Rod and the Vegas are both OHC bikes, but the VR motor is a short stroke configuration against the more traditional long-stroke of the Freedom.

In the case of the V-Rod, the modified engine shows another 5% with its slip-ons, which compares to nearer 20% for a Twin Cam. Victory's mix of old format and new technology splits the difference, with 10-15% more. You won't find aftermarket Screamin' Eagle cams for a V-Rod, and Victory don't offer an in-house hop-up alternative, and there's no big aftermarket queue forming for either. Victory offers a Stage Two, which in this case is a big bore conversion as there are no signs of hot cams yet. We're still waiting to see what options await the V-Rods.