

# SIX OF THE BEST

by Alan Cathcart

The capacity for original thought is a mark of genius, often accompanied by an innate determination to prove the worth of those ideas in practical form. In the engineering arena such a combination has delivered us countless technical advances in the past century (the diesel engine, pneumatic tyres, windscreen wipers and four-wheel-drive, just to throw out a few examples at random), whose practical application has benefited mankind beyond measure. Often though, such advances have been achieved against the odds, in the face of reactions ranging from disinterest to derision: almost every engineer from Leonardo da Vinci onwards has had to deal with this. Fortunately, most of them have persevered, or else we would still be riding side-valve singles, with girder forks and drum brakes. Daring to be different is an essential adjunct of original thought.

Malcolm Beare may be no da Vinci, but the 47 year old Australian wheat farmer is indeed an original thinker, in spite of a day job apparently so far removed from the world of mechanics. For the past 17 years, while working his 1300 hectare spread in the sun-drenched outback of South Australia, Malcolm has had plenty of time to reflect on various aspects of his alternative profession: bush engineering. Like so many others at the sharp end of engineering - men who actually use the machines that others design - Malcolm Beare has had ample opportunity for original thought. "City engineers usually spend their time trying to get performance out of existing designs", says fellow Aussie Ian Drysdale, creator of the [750-V8](#) hyperbike and a vocal supporter of Malcolm Beare's idea. "Whereas you'll often find that engineers in the bush will sit back and ponder as to why something was designed like that in the first place, then figure out a way of doing it better. Because they spend much of their time repairing badly designed farm machinery - quite often redesigning it as they go - this creates a reluctance to take anything for granted, which leads in turn to original ideas".

[Drysdale V8](#)

## A BETTER WAY.

Finding a better way for the motorcycle has been Malcolm Beare's mission in life since 1981, when he built the first of five prototypes which have formed the development path of his so called six-stroke engine design. Well not strictly a six-stroke, perhaps - except in so far as four plus two equals six, because what Beare has done is to create an innovative hybrid engine, combining a two-stroke top end with a four-stroke - well, not bottom end, really more a middle section.

Various two-wheeled applications of this avant-garde bush technology have resulted in the latest proof that Malcolm is smarter than your average Beare: a V-twin Ducati-based BEARS/Sound of Thunder racer fitted with a 90-degree V-twin version of the Beare six-stroke, and I had the chance to ride it at Melbourne's Calder race track as an interlude to testing the Drysdale V8 and [Hunwick Hallam X1R](#) Superbike.

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OK - what's it all about, Daddy Beare? "I began working 17 years ago on a stratified charge opposed-piston two-stroke design," recalls Malcolm, "but after building a couple of prototypes I realised flow control was a problem, with too many ports going everywhere. So I simplified (!) it into a six-stroke with the objective of improving efficiency and increasing performance compared to a conventional engine by overcoming the drawbacks of poppet valves, by means of a rotary valve application to four-stroke engine technology. I do have some engineering background, so I'd read widely about the various rotary valve designs aimed at overcoming the problems of poppet valves - inertia, inhibiting flow and especially the exhaust valve hot-spot in the combustion chamber. But while the Cross, Aspin and various other rotary valves were advantageous because they didn't restrict flow or absorb as much energy as poppet valves, they still had significant overheating problems of their own, with associated drawbacks in lubrication, oil and especially



sealing. Of course, a two-stroke doesn't suffer such problems because it has no poppet valves - so I decided to try to resolve these drawbacks by taking the basic components of a rotary disc induction two-stroke engine, and grafting them on to a four-stroke to produce the best of both worlds. After a deal of work and experimenting since building my first six-stroke in 1990, I truly believe we've refined the concept, proved it's reliability and established it's worth, so now we have it fully patented - even in the USA - and ready for commercial use in the variety of applications it obviously lends itself to, including motorcycles, stationary engines and, because of the exceptional torque at low rpm, propeller aircraft engines."

## HOW IT WORKS.

Gosh, could this bush-engineered Better Way perhaps be the mechanical equivalent of a Bimota Tesi or a Saxon Saxtrack/BMW alternative chassis concept for volume production? Well, let's see what it consists of.

Below the cylinder head gasket, everything is conventional, so one advantage is that the Beare concept can be transplanted on to existing engines without any need for redesigning or retooling the bottom end. But the cylinder head and its poppet valves gets thrown away. To replace the camshaft and valves, Beare has retained the cam drivebelt and fitted an ultra short-stroke upper crankshaft complete with piston, which the belt drives at half engine speed just as it previously drove the cam. This piston drives up and down in a sleeve, past inlet exhaust ports set into the cylinder wall, very much like on a two-stroke: these are all exposed during both inlet and exhaust strokes.

Continuing the two-stroke analogy, two 35mm Mikuni CV carbs mounted on each cylinder feed mixture into it via a reed-valve block, thus preventing exhaust gasses from escaping through the inlet. At the other end of the upper crankshaft is a two-stroke type rotary disc-valve that regulates timing, cutting off the exhaust flow at the appropriate time to stop the gasses returning into the cylinder, thus creating sub-atmospheric pressure during the inlet cycle. This being it's only function, the rotary valve is lightly loaded, reducing lubrication and sealing problems. It does need close tolerances though, which led to warping of the stainless steel disc Malcolm used on his first six-stroke, based on a Honda XL125 farm bike. Replacing the disc with a cast-iron one (on a Mk2 XT500-based version), cured this problem at the expense of extra weight. The Ducati uses hardened anodised aluminium discs, which work well.

During the compression and expansion strokes, the upper piston seals off both ports, leaving the pressure contained between the two pistons, with the lower one a conventional flat-top three-ring design, while the conical upper one (so shaped to aid gas flow during both inlet and exhaust cycles by guiding it towards the ports) has two rings - one compression, one oil. In the combustion phase, twin spark plugs provide ignition via the stock Ducati CDI and a pair of Harley coils - one per cylinder - and not only does the engine run on pure petrol (no need to add oil, because all required surfaces are positively lubricated, in spite of the application of two-stroke technology), it's also happy on low octane unleaded fuel. Obviously there are no valve seats to suffer from lack of lead, and Malcolm says the compression ratio can be increased significantly from the Ducati motor's 10.6:1 quite safely because of the lack of hotspots, without problems with detonation.



So now the claimed advantages of all this start to come to light - allowing a higher compression while still happy with low octane unleaded makes this an efficient and cleaner engine. There are no poppet valves to float or bend (OK, OK - I know this was once a Desmo, but this is a much more cost-effective way of achieving this than expensively machining a set of closing rockers for all the valves in a cylinder head, quite apart from the unwanted inertia such a system still entails) In turn, this implies a far higher safe rev limit for the six-stroke - 28,000rpm in theory, given the half-engine speed operation of the upper crankshaft, and the fact that GP reed-valve two-strokes peak at 14,000rpm. But Malcolm Beare says the rev limit, as on such two-strokes, depends only on what the main (conventional) crankshaft is able to bear, and he's arbitrarily limited the Ducati-based 6S-V2 to 9,000rpm for that reason, at which point he says (according to computer predictions) 86bhp is delivered at the rear wheel - there aren't too many dynojet rigs out in the Australian outback! Comparisons are hard to make, because of the difficulty of determining the exact cubic capacity of the 6S-V2's six-stroke engine: what began as an elderly Pantah V-twin now has a total 744cc's of compression/expansion volume, and 602cc of inlet/exhaust volume, and instead of absorbing about 10% of engine power in driving the camshafts, the cambelts now deliver about 9% net power to the main crankshaft after combustion via the upper, conical porting piston (see, desmo power!). But if you figure that a '97 model Ducati 900SS delivers 73bhp at the rear wheel in stock form, that's quite an impressive claimed power increase.

But there are other, much more significant apparent spin-off benefits from the Beare design. First of these is fuel economy: Malcolm Beare claims his engine is 35% more economical at low revs/throttle openings than an equivalent conventional engine and 13% less thirsty at high rpm/full throttle, in spite of the doubled-up carbs. That should mean fewer hydrocarbon and CO2 emissions, because you're using less fuel to achieve the same performance. Next there's improved torque at lower revs - on both his Yamaha and Ducati-based prototypes Beare discovered the six-stroke version produced the same torque as a four-stroke 1,000rpm lower down the scale, as well as producing exponentially more torque as revs rose. But in a commercial application, perhaps the most attractive benefit is the reduced number of moving parts, compared to a four-stroke design, so the six should be cheaper to make. Not as few as a two-stroke, but what you appear to be getting here is improved performance and torque, coupled with the inherent advantages of a four-stroke, on the cheap. Finally, as the upper two-stroke piston is driven at half engine speed, it should have twice the life of the lower four-stroke one. Sounds promising...

## **RIDING**

Time to find out for myself, so while I hopped off the V8 to let the Drysdale equipe carry out some R&D adjustments, Malcolm Beare fired up the 6S-V2 to give me a hands-on impression of bush engineering at its best. OK, while the Beare V-twin may appear a little rough at the edges, remember it's obviously been built to a budget as well as being a rolling testbed for continuous modification, so let's ignore the looks and worry about the sizzle. To start with, it has an absolutely unique sound, like nothing else I've heard in my life, even a Norton rotary racer. You can clearly hear the ring-ding two-stroke signature tune above the trademark four-stroke V-twin boom from the twin megaphone exhausts. Two engines in one - uncanny. In fact, the engine seems very loud, but that's apparently only because the megaphones of this BEARS racer are unsilenced. In fact says Malcolm, mechanical noise is less than a four-stroke, because of the fewer moving parts. " We silenced the exhaust on the XT500 considerably," he says, "and the result was you could hardly hear the engine running. Without any tappet noise it's remarkably silent - and that's in spite of being air-cooled, as all my prototypes have been. Heat dissipation is not a problem, so while it'd be easy to water-cool the engine by drowning the combustion chamber, there's honestly no need for the extra complication on grounds of noise or thermal efficiency. But one area I haven't done any work on is exhaust development - the six-stroke format would certainly lend itself to expansion chamber exhaust technology borrowed from performance two-strokes." How so? "We could overfill the combustion chamber during the intake stroke, trap a small portion of the mixture in the first two or three inches of the exhaust pipe, then use back pressure to force it back in just before the upper piston closes off all the ports. This could add significant performance, but it's an area I haven't experimented in yet."

Riding the Beare six-stroke at Calder for a dozen laps showed up three significant assets for the six-stroke engine and one, maybe two, negatives (one of those being the unreasonably loud exhaust noise, which I'll reserve judgement on but appears not to be an issue). The other question mark was over the power curve; while the 6S-V2 revs reasonably high by four-stroke standards, there seemed to be no direct benefit in doing so - there was no more power up at, say, 8000rpm than there seemed to be 2000rpm lower. Malcolm Beare says this is a function of cylinder porting and perhaps fuel mixture - the old two-stroke imponderables, here applied to a four-stroke based motor. After the test he discovered that the Mikunis were underjetted, and also believes the engine is over-carburetted - a theory I'd go along with, especially given the difficulty of balancing two carbs per cylinder correctly - and wants to play around with the porting.

One thing he certainly doesn't need to worry about is torque, which together with the crisp responsive throttle pick-up and the reduced vibration - even compared to a smooth-action 90 degree V-twin - are three strong points of the six-stroke motor. The Beare engine is unbelievably muscular in terms of torque, and from very low revs, too. Ironically, you especially appreciate this because Malcolm's evident talents as a bush engineer are not matched by those of a tube-bender: the square-tube nickel-steel chassis has pretty awful handling, especially with a pair of oversprung Koni shocks at the rear. The stock Ducati frame would have been a better bet, except on that you need to drop the engine out to remove the top end of the rear cylinder. But the fact that the bike jumps around over bumps and doesn't steer very well actually helps you appreciate the engine's responsiveness because you may need to back off the throttle in, say, the middle of the Calder chicane to allow the chassis to recover its poise - especially if leaning it over further to the right to get out of trouble might make you start worrying about grounding the lower carb on the front cylinder when you did so!

But when you get on the gas again, get ready for a surprise. Not only is there instant response when you twist the wrist, there's tractor-pulling torque at seemingly whatever revs the engine's turning over at - even as low as what felt like 2-3,000rpm or so (there's no rev counter fitted, but having ridden the odd Ducati V-twin down the years, I may claim to have a rev sensitive seat of the pants). There's also no transmission snatch at very low revs, indicating a responsive, torquey motor, while the way it pulls hard from way down low bears all the hallmarks of a long-stroke engine, whereas the opposite is in fact the case; the lower crankshaft assembly has 86 by 57mm dimensions, while the upper 'two-stroke' one measures 60 by 25mm. Yet the inherent nature of the Beare motor is one of a torquey slugger, belying these measurements. And allied with the so-responsive pick-up and a wide spread usable power that seems to be the same at high rpm as it is way down low, this makes the bike ridiculously easy to ride - you hardly ever need to use the gearbox at all, just park it in top gear and ride it like an automatic. Even backing off the throttle in the middle of a turn to let the chassis straighten up and fly right doesn't require you to hook down a gear - just open when you're ready, feel the front wheel start to aviate on you, and...drive.

## **VERDICT.**

My hands-on assessment of the Beare six-stroke leads to some inescapable conclusions, one of which is that in its present form, this isn't a performance concept; there doesn't seem to be the power on tap that the dyno says there should be, nor does revving the engine seem to deliver this. But while I'm sure some experimentation with porting, exhaust pipe design, air flow and carburation might rectify this, that's not been Malcolm's priority to date. Instead, what we have here is an elegant, hybrid engine with the advantages already recounted above, allied with good swish, the ability to run radical bore/stroke ratios, quiet mechanical operation, and no exotic materials such as ceramic coatings or costly alloys needed, nor complicated machining operations.

As such, the Beare design must surely be worthy of serious consideration for powering low cost transport in both developed and developing countries, where expense of manufacturing, fuel economy and torque (delivering carrying capacity for people and/or goods) are all paramount factors, yet where emissions are a major issue, too. The recent trend away from two-stroke power in favour of more costly but cleaner four-stroke engines in Europe, Japan and SE Asia makes a concept like the Beare six-stroke worthy of serious consideration by volume manufacturers, simply because it offers the best of both worlds. I'd say Malcolm would be well advised to start teaching himself Japanese or Italian during those long, hot days working the Aussie outback: it'll help in making the presentations he should be embarking on in the next couple of years, in pursuit of the licensing deals he's chasing for his six-stroke Better Way.

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