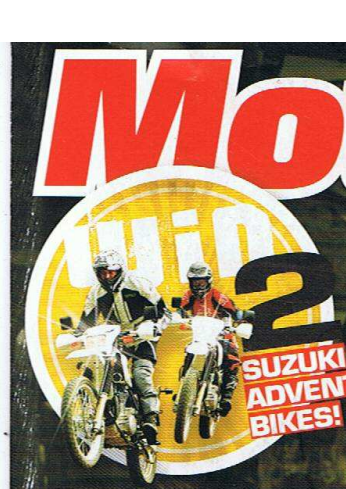
Motorcycle TRADER

Issue 283 $6.95 inc GST
On sale June 12, 2014



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TECH SESSION

PROVING THE XS650

ROB BLACKBOURN

CRANK & FILE

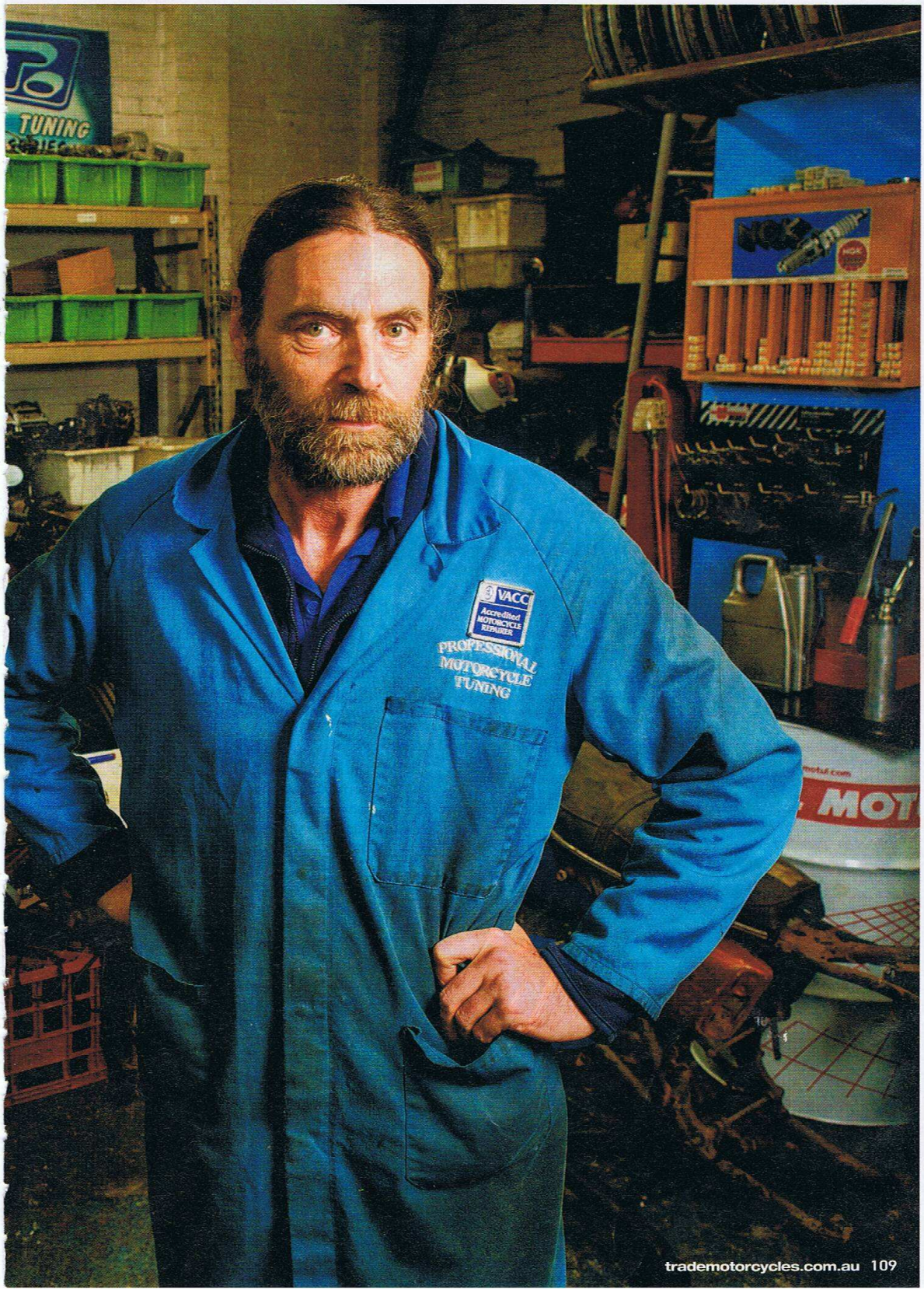
It seems that **showing some love** to your old XS650 requires more than just new rings and a pair of plugs...

WORDS: **ROB BLACKBOURN** PHOTOS: **NATHAN JACOBS**

Daryl Hutcheon has been running Professional Motorcycle Tuning in Melbourne's Airport West for about 13 years. He went out on his own after many years as a dealership mechanic across the Japanese brands, a brief stint with Suzuki race bike guru Phil Tainton and service manager duties at a Suzuki dealership. I got to know Daryl after hearing that, as well as servicing modern bikes, he knows a thing or two about classic Yamahas – I'm in the early stages of bringing my long-neglected XS650 back to life and was looking to get a few tips from him.

One of the first things that catches your eye in his workshop is sets of brand-new looking, freshly vapour-blasted, XS650 crankcase castings.

A few questions about his engine-building work reveal that he specialises in re-phasing the crankshafts of these old parallel twins from the original 360-degree set-up to 270 degrees to meet the continuing demand from XS650 enthusiasts around the world.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1. Those XS650 cases don't look over 30 years old.
2. Here's the full kit to build a 270-deg crank. Note the specially machined splined pin in the centre.
3. The splined pin on its way into one crank web.
4. With the pin in, the camchain sprocket's in position.
5. The second web goes on, with its crank-pin opening now 90 degrees ahead of the other one.

THE YAMAHA XS650 STORY

During the 1960s the major Japanese factories got serious about developing larger-capacity bikes to appeal to mainstream western motorcyclists. The dominant bikes were the British 650-750cc, parallel-twin, four-stroke brigade – think Triumph Bonnevilles, Norton Atlases and Commandos, and BSA Spitfires.

The variation in the approaches the Japanese factories devised to take the fight up to the Brits was breathtaking. Suzuki and Kawasaki threw their exciting, but ultimately short-lived, two-stroke creations into the fray, while Honda's inspired choice of the CB750 Four proved to be a pointer to the future.

Yamaha, however, decided to produce a modern version of the British twins (whose design was rooted in the 1930s). Interestingly, this would be Yamaha's first four stroke. The resulting XS650, 360-degree, parallel-twin engine featured an overhead camshaft instead of the dated pushrods of the Brit twins and eliminated their chronic oil-leaks by having a horizontally split crankcase.

The combustion chamber design was light years ahead of the British, being based on a design Yamaha had produced for a high-performance Toyota four wheeler, the GT2000.

Launched in 1968, the XS650 became Yamaha's top seller by 1972. Total production over its 15-odd year run was more than 500,000.

Kenny Roberts rode an XS650-based, 750cc flat-tracker to two championship wins in AMA dirt-track competition between 1973 and 1976.

These days original XS650s are prized collectables and also provide a popular starting point for builders of retro café racers, bobbers and, naturally, flat trackers.

Curiosity aroused, I wanted to see how Daryl does the re-phasing job and I also wanted to look into the technicalities behind 270-degree parallel twins to get a sense of what's driving the demand for them.

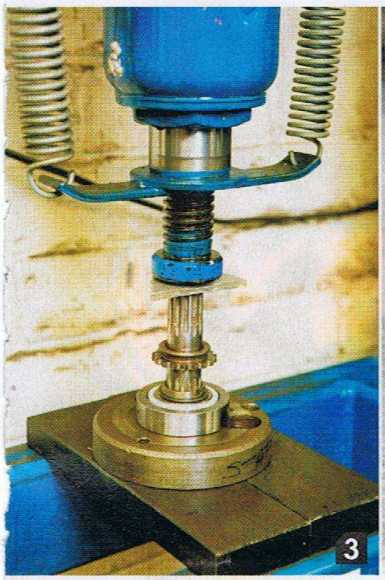
THE STARTING POINT

The standard built-up XS650 crankshaft carries its two conrods on separate crankpins between pairs of circular flywheels (or webs) – a pair for the right-hand (RH) conrod and another pair for the left-hand (LH) conrod. The two pairs of flywheels are linked by a splined nose on the RH inner flywheel that's a press fit in the female splined bore of the LH inner flywheel. This splined linking shaft also carries a pair of main bearings with the cam-drive sprocket between them. By definition when the two halves of this 360-degree crankshaft were pressed together in the factory, the splines were engaged with the two crankpins in line.

DOING THE MATHS

To produce a so-called 270-degree crank you need to separate the two halves of the crank and rotate one half to a position where its crankpin is 90-degrees ahead of its mate in terms of one 360-degree revolution of the crankshaft (360°-90° = 270°). Then you hook the two halves together again.

The complicating factor is that the two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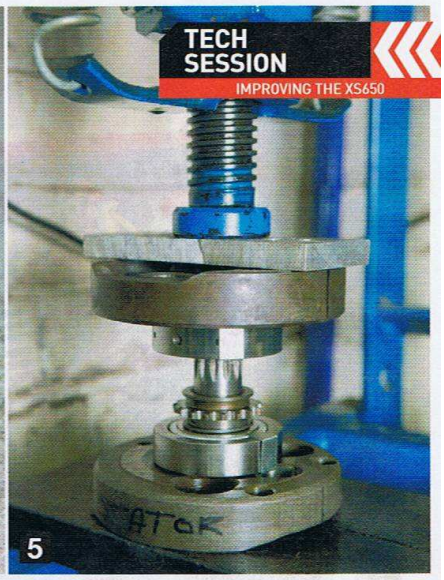
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"The 20-tonne hydraulic press gets a serious workout on these crankshaft jobs."

halves of the XS650 crank are joined by 13 splines. With, say, 12 splines you could get the 90-degree phase-shift (a quarter of a turn) by rotating the RH half ahead by three splines. But you don't get that neat option with 13 splines.

The 13-spline set-up requires the RH inner flywheel (the one with the splined nose) to be scrapped and replaced with a second LH inner flywheel (with a female spline) that's cannibalised from another crankshaft. The two internally-splined flywheels are then joined with a custom-machined central pin, splined at both ends. A 90-degree shift requires that the two sets of splines on the pin be slightly staggered as follows: With 13 splines the pitch between splines is around 27.7 degrees. So rotating the RH side of the crank three splines ahead would give a phase-shift of 83.1°, which is 6.9° short of the 90° we need. By machining the new central pin so that its RH splines are 6.9° ahead of its LH splines you achieve the 90-degree shift with a three-spline move.

WORKSHOP TIME

The 20-tonne hydraulic press at Professional Motorcycle Tuning gets a serious workout on these crankshaft jobs, making the odd loud bang when a reluctant, interference-fit pin finally lets go, releasing heaps of pent-up energy.

But the crank soon comes apart, ready for cleaning and inspection and measurement. However, regardless of the results of his inspection, Daryl routinely fits new crank pins and conrods with new needle-roller big-end bearings and thrust washers, along with all four crankshaft main bearings. It's false economy to not replace all of these items considering the labour required to get right into the guts of an engine. Generally, he's also fitting a big-bore 750cc kit so the barrels, pistons and rings are all new as well.

Interestingly he usually finds that valve


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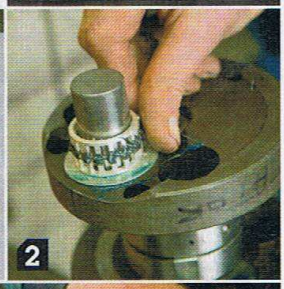
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1. Daryl always fits new crankpins, conrods, big-end bearings and thrust washers to his crankshafts.

2. Moly-disulphide grease keeps the new needle rollers in place in the carrier until the full set is installed. Note that one thrust washer was installed first.

3. With the conrod in place the the needle rollers have nowhere to go. Next, the other thrust washer is fitted and it's ready for the other web to be pressed on.

Once this outer web is pressed on, the crankshaft rebuild will be halfway there.

WHAT'S WITH 270 DEGREES?

The idea of these days re-phasing a Yamaha XS650 engine that's based on the 360-degree British parallel-twins of yesteryear has a fascinating full-circle connection with that era.

Back in the day no less a person than Phil Irving tried on and off for years to persuade Triumph that its 360-degree parallel twins needed to go to a re-phased crank to deal with its balance issues and lack of smoothness.

Unsurprisingly Triumph's Edward Turner disagreed and the Brit twins kept their 360-degree cranks until the bitter end.

Fast-forward to the late 90s when Yamaha introduced its TRX850 parallel-twin with a 270-degree crank. Was this just about its faux V-twin, Ducati-like feel and sound? Or was it about Yamaha's desire to finally build the best parallel twin possible, based on what was learned from the XS650 project?

A feature of a 90-degree V-twin like a Ducati is that it is said to have perfect primary balance – thanks to the fact that when one piston is momentarily stationary at the top or bottom of its stroke, the other is at mid-stroke moving at maximum speed. The momentary zero kinetic energy (KE) of the stationary piston is perfectly balanced by the maximum KE of its opposing number.

A 360-degree parallel twin by contrast has very imperfect primary balance because both pistons stop together and reach maximum speed together producing huge, ultra-rapid swings in KE and millisecond-long leaps and dives in torque output. Put simply: Smooth, it ain't. It's the same issue that Yamaha tackled by fitting cross-plane cranks to its R1s from 2009 to improve drive out of corners.

There has been much debate about the best phase-shift angle for parallel twins. Irving's complex calculations even involved conrod length. I've never been sure whether he went for 76 or 77 degrees, nor whether the best figure for the long-stroke Triumph would also be best for the shorter-stroke XS650.

As we saw earlier re-assembling an un-modified XS650 crank with a three-spline shift would give an 83.1-degree phase change – let's call that a 277-degree crank. In fact, many 277-degree XS650s have been built and owners report huge gains in smoothness.

However, the majority view (and to some extent, the science) holds that the 270-degree set-up (à la the TRX850) gives the greatest benefit.

"Daryl has built close to 50 re-phased cranks over an eight-year period."

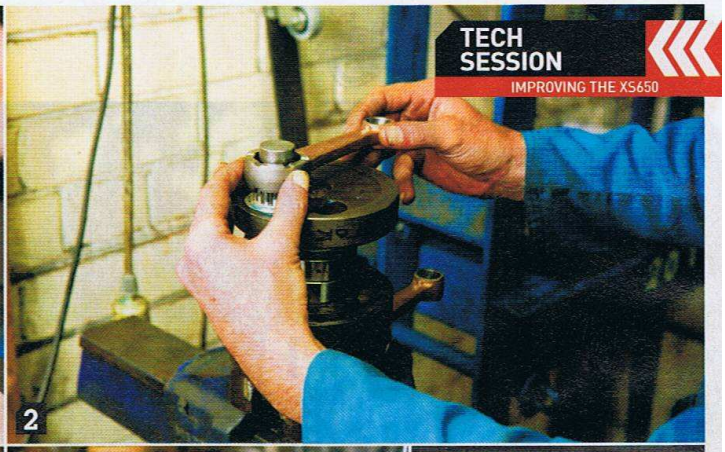
guides are within spec and that the valves themselves seldom need replacing when he's reconditioning the head. After re-facing they're good as new. He recommends new Porsche-style 'elephant's-foot' valve-adjusters, though.

The new RH inner flywheel from the donor crankshaft requires minor machining adjacent to the camshaft sprocket position as part of the preparation.

Now it's back to the press to build up the new 270-degree crankshaft.

Once a new crankpin is pressed into place in one of its pair of flywheels it's time to fit a new conrod. Daryl uses a moly disulphide assembly grease to hold each big-end needle-roller in position until, with the full set in place, the rod is slid over them. When the second flywheel is being pressed on to the pin he uses a spacer to prevent the rod's big-end being squeezed between the pair of flywheels. The spacer is designed to give the required 20-thou (0.5mm) side clearance. A quick check with a feeler gauge confirms that all is well.

The assembled crank is then supported in V-blocks on a surface plate and checked for



1. With the second web pressed on it's crucial to check that the conrod has the correct side clearance.
2. Good progress as the second conrod goes on.
3. Voila! A complete re-phased crank assembly.
4. Run-out is checked with a dial indicator.
5. A heavy copper hammer can be a precision instrument in the right hands.

run-out at each end using a dial indicator. The high point on the shaft is marked with a feltpen on the flywheel's rim. Then Daryl finesses the crank alignment in the time-honoured way by clouting the flywheel with a heavy copper hammer to rotate it on the pin by a miniscule amount. After a couple of goes he got it within his preferred one thou (0.025mm) – up to three thou (0.075mm) run-out is considered acceptable.

Daryl draws on his experience to decide whether the pins on the completed crankshaft need welding in place. It's only when a pin pushes into position too easily that he welds it. He does weld them though if the customer is planning to seriously modify the engine in a quest for big horsepower.

Regarding Daryl's experience, he has built close to 50 re-phased cranks over an eight-year period, and before that did a lot of other pressed-up crank work including fettling a hot NSR250 two-stroke race-bike that had its crank stripped and rebuilt numerous times per race season.

THE VALUE PROPOSITION

There's a range of options for Daryl's clients. He supplies the custom-machined central pin to serious DIY-types for $350. The pins are popular with his overseas customers. He has sent them off to the UK, Europe, North America and New Zealand. He was packing one for dispatch to South Africa on the day of our photo shoot.

He will convert customer crankshafts for around $1075. Bear in mind that a re-phased crankshaft also requires a re-phased camshaft and ignition.

These are available for around $475 and $350 respectively. Daryl warns against using "cut 'n' shut" cams for obvious reasons.

His are original cams that have had the lobes ground off and new lobes built up to suit the application. While he's at it, the cam grinder gives the engine a bit of a performance boost by increasing the cam's duration.

Complete re-phased engines including the 750cc big-bore kit can cost $5000-$5500 depending on the amount of extra work and optional features the client specifies.

For this the customer gets a much smoother, livelier and significantly more powerful engine – testing indicates that vibration is reduced by more than 40 per cent. And of course there's the bragging rights that come with exclusivity: "Mine's got a 270-degree crank."

At the heart of this handsome 750cc engine is a 270-degree crank.