On The Tools

TECH SERIES... In coming issues:

ISSUE 1 SUSPENSION MODS

How to get the most from your suspension budget.

ISSUE 2 GEARING

Understanding sprocket combos and optimising gear ratios.

ISSUE 3 CARBS & EFI

Clever tuning tips to get your air/fuel ratio right.

ISSUE 4 NUTS & BOLTS

How to remove broken bolts & get the right torque settings.

Transmoto Expert

WHO DA DOLE?

Nick Dole owns and operates Sydney-based suspension business, Teknik Motorsport. In the past decade, the man has tuned suspension for the Ballard's Offroad team, performed engine and suspension work on Australian Safari-winning GHR Honda XR650s, run a Kawasaki Pro Lites team in the Aussie MX Nats, worked as an independent technical consultant for magazine test programs, and dealt with just about every punter and butchered dirt bike to ever roll into a workshop. We reckon that qualifies him to offer up credible advice about how to get the most out of your spend at the local workshop.

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GEARING

...and how to make it work for you

The right gearing can transform the way your bike drives and handles. We take the mystique out of the sprocket math to help you tailor your ride.

NICK DOLE iKAPTURE

A dirt bike's chain and sprockets operate in a nasty, open-to-the-elements environment, and yet we'd be lost without them. Over the years, we've tried shaft-drives, hydraulics and belt-drives, but we keep coming back to the humble roller drive-chain invented by a Greek around 300BC. Why? Because they suit dirt bikes perfectly. They're tough, simple, light, create minimal power loss and they're cheap.

Sure, shaft-drives are quieter and require far less maintenance, but they're heavy in an unsprung mass kind of way, plus they make gearing changes difficult. And while belt-drives are quieter and more efficient than shafts, sand, rocks and mud make very short work of their lifespan.

So what makes this world of chains and sprockets tick? How can you alter you bike's power and handling characteristics with different gearing combinations? And how can gearing changes make life in the saddle more enjoyable? You're a few toothy pages away from enlightenment. ↘

GEARING GLOSSARY

Countershaft sprocket – the countershaft delivers the power out of the gearbox, and the front/drive/countershaft sprocket is attached to it.

Cush-drive (hub) – a rear hub designed to have a carrier mounted to it so the engine's drive or torque pulsations are dampened by large rubber blocks. This saves the gearbox from shock-loading. There are also aftermarket cush sprockets available.

Low-noise sprocket – has a ring of rubber bonded to it so the chain runs on it. They're common on trailbikes, and can be replaced with a non-rubber type with accompanying noise.

Gear up/taller/higher gearing – the drive ratio is numerically decreased by fitting a smaller rear sprocket and/or a larger front sprocket.

Gear down/shorter/lower gearing – the drive ratio is numerically increased by fitting a larger rear sprocket and/or a smaller front sprocket.

Loctite – proprietary name (eponym) for an anaerobic thread-locking agent. That is, it hardens in the absence of air.

Final drive – chain and sprockets in combination as a gearing set.

GEARING
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WHY GEARING IS IMPORTANT...

Why do we have a gearbox at all? Why not just run in a single gear? After all, gear changes cost you time on the track, right? Well, if we were punting a go-kart running around a flat course, not changing gears is a practical way to go faster. Unlike go-karts, dirt bikes need to start from a standstill, climb hills and have a broad speed range. This is why many enduro bikes have six-speed gearboxes, why most motocross bikes have five-speed boxes, and why big-bore machines with oodles of torque can get away with four-speed transmissions.

So, for a given gearbox, how do we tailor the final drive to suit us? That all depends on where you use the bike and how you like to ride it. Do you ride to work and rev the engine hard at 110km/h? Gearing can solve that. Do you struggle to get up big hills? Gearing can help there, too.

MX/SX

How many times do you change gears around the average motocross or supercross lap? Twenty, thirty times? When you shift, you're not accelerating; you're revving the engine near peak horsepower and shifting back into an RPM band with peak torque to start the acceleration curve again. What happens if you miss a shift or hit a false neutral? Do you let a rider by as you lose forward drive or case a jump and crash? By thinking about your shift points and whether you're in the right portion of the power curve through the fastest corner on the track – the corner we traditionally gear for – substantial improvements in lap times can be made.

When you drive out of a corner, are you usually in second gear and struggling to grab third on the exit? Is third too tall for the engine to pull through several corners and you find you're using a lot of clutch to keep it in the meat of the power? Could you gear up and use second until the bike is straight and not bouncing off the limiter, or gear down so you can comfortably grab third earlier for a smoother drive? Is there a long straight that you are grabbing a gear on towards the end and wasting time? Are you forced to upshift dangerously close to the upramp of a big jump? These are the key questions to think about to ensure your gearing is not unnecessarily costing you precious seconds around each lap. With many different corners on any given track, there will ultimately be some sort of compromise. But changing one or two teeth on the rear sprocket will usually be enough to sort most issues.

When changing sprockets and making corresponding changes to the rear axle position, also consider the implications of the effective change in swingarm length. Generally speaking, a longer swingarm (or wheelbase) creates a more stable chassis that is less inclined to wheelstand. A shorter swingarm allows the bike to turn quicker, but it also creates a firmer feel from the rear suspension because of the decreased leverage.

ENDURO

Not many off-road riders count gears; we're usually too busy with fistfuls of throttle, dodging trees and bashing away at the gear lever to notice. So next time you ride, take some time to think about it. How often do you use first gear? Is the gap from first to second too big? Can you make a gearing change to effectively create a gear between first and second, or to never use first at all?

New-model four-stroke enduro bikes generally have a broad spread of useable power and wide-ratio gearboxes, which makes final gearing less critical. But that doesn't mean gearing changes can't reap benefits. If you're having trouble taming a two-stroke for the bush, for instance, taller gearing can help smooth the power delivery. And finding the right gear for tight singletrack can be the difference between flowing through the trees and kissing one on a missed shift.

Bear in mind what you do at the bottom-end will affect the top. If you shorten the gearing for more snap at slow speeds, you will lose some top-speed. Carefully consider the terrain type, and aim for a final gearing combination that offers you the most versatility.

TRAIL/DESERT

Desert is easy – run the tallest gearing your engine can pull. Machine the rear hub down if required! Then, let natural fear regulate your decision and put a few teeth back on the rear. The Honda CR500s that dominated the Finke Desert Race in the 1990s ran a 15/36 final drive, while the new-gen CRF450s run a 15/44 or 14/42 gearing combo at Finke – much taller than the bike's standard 13/48 motocross gearing.

Trailriders can use the easy-to-swap nature of the countershaft sprocket to have ride-to-work road gearing and off-road gearing. One tooth will usually do it with no chain length changes needed. For example, you could use a 13-tooth in the bush and 14- or 15-tooth for the road, with that one tooth transforming the bike for each application.

Gearing changes can make the one bike versatile in a variety of situations.

WHY CHANGE GEARING?

Below is a simple chart for gearing. The ratio is simply the rear sprocket divided by the countershaft. For example, if your bike is running a fairly common 14/48 combination, that will give you 3.43. Notice that 13/45 or 15/52 will give a similar result at 3.46 and 3.47, respectively, just slightly shorter.

Numerically higher numbers will make the engine turn faster for a given speed, giving faster take-off and a lower top-speed. Higher numbers will give a slower take-off and a higher top-speed. Note that shortening the gearing will effectively close the gearbox ratios up, giving a closer-ratio feel.

COUNTERSHAFT SPROCKET

REAR SPROCKET

TEETH	12	13	14	15	16	17
39	3.25	3.00	2.79	2.60	2.44	2.29
40	3.33	3.08	2.86	2.67	2.50	2.35
41	3.42	3.15	2.93	2.73	2.56	2.41
42	3.50	3.23	3.00	2.80	2.63	2.47
43	3.58	3.31	3.07	2.87	2.69	2.53
44	3.67	3.38	3.14	2.93	2.75	2.59
45	3.75	3.46	3.21	3.00	2.81	2.65
46	3.83	3.54	3.29	3.07	2.88	2.71
47	3.92	3.62	3.36	3.13	2.94	2.76
48	4.00	3.69	3.43	3.20	3.00	2.82
49	4.08	3.77	3.50	3.27	3.06	2.88
50	4.17	3.85	3.57	3.33	3.13	2.94
51	4.25	3.92	3.64	3.40	3.19	3.00
52	4.33	4.00	3.71	3.47	3.25	3.06

GEARING
...and how to make it work for you

HOW GEARING AFFECTS...

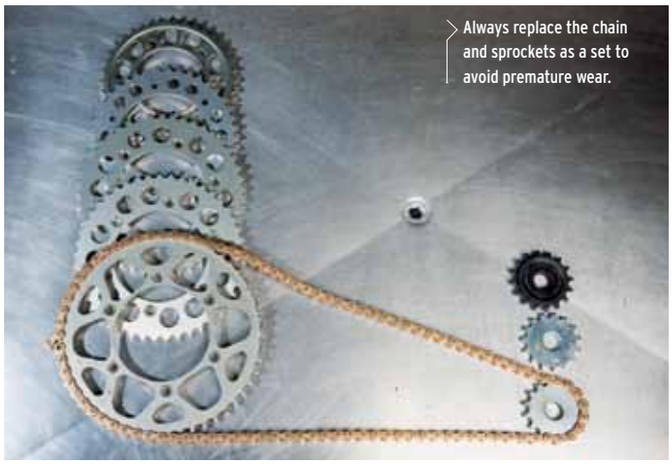
MOTOR

Back in the pre power-valve days, where 125s produced 30hp between 10,400 rpm and 10,500rpm and 15hp either side of it, gearing was critical for keeping an engine 'on the pipe'. These days, user-friendly two-strokes and new-generation four-strokes have made life easier with their flatter and more forgiving torque curves. But we still have the same objective: to utilise the engine's torque to pull us around. Under-revving (labouring) and over-revving an engine have never been ways to extract its best. So whether you want some more snap off the bottom, less gear changes per lap, or a higher top-speed, gearing changes can achieve this for you.

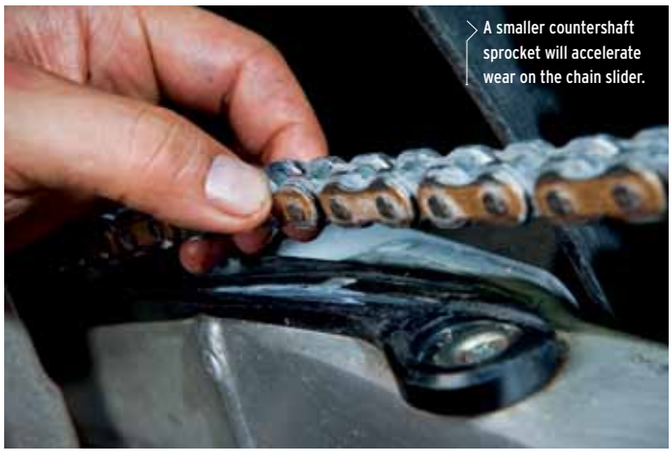
SUSPENSION

The most obvious change gearing makes to suspension is swingarm length. With the rear axle back as far as it'll go, the swingarm is at its longest and has the most leverage over the shock. This effectively makes the shock softer. Moving the wheel forward reduces the swingarm's leverage, and the shock becomes stiffer.

Chain torque is another matter and could easily fill up a book with formulas and algebra. Put simply, chain torque occurs because the countershaft sprocket is in front of the swingam pivot on the majority of motorcycles. Chain torque opposes the downward force the rider puts on the rear suspension. Don't believe it? Put your front wheel against a tree and let the clutch out. The rear of the bike rises. This lift helps you to clear obstacles in the same way pre-jumping does.



Always replace the chain and sprockets as a set to avoid premature wear.



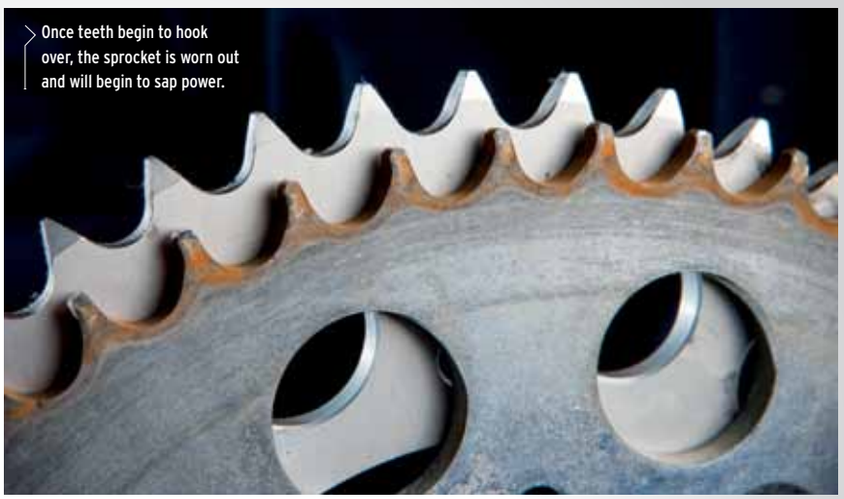
A smaller countershaft sprocket will accelerate wear on the chain slider.

SPROCKETS

Steel or alloy? A steel/alloy combo? Self cleaning? What's best? In general terms, if you are all about saving weight, buy alloy. Note that there are many varieties of alloy, and a quality English-brand sprocket will outlast a cheap no-name brand many times over. There are a few self-cleaning types around and everyone has their own miraculous cure. Personally, I'm more interested in the quality of the aluminium. However, even a cheap steel sprocket will outlast an alloy unit, so trailriders are best to go with steel. Enduro guys will have to decide where they sit on the weight versus wear trade-off, and perhaps go for one of the steel-toothed alloy sprockets or a lightweight steel unit.

Quality sprockets can cost more than $100 each, so building a collection for gearing choices can start to blow the parts budget out. Be sure what you want gearing-wise before splashing out. The best thing about a collection is that all major manufacturers have not changed their sprocket bolt-patterns in years.

So how do you know when your sprocket has had the sword? You'll see most of the wear on the drive-side. The teeth will start to hook over, before the hooks themselves begin to break clean off. The stumpy little teeth that remain will soon let the chain spin and ruin your day. As a rule, replace chain and sprockets as a set, as a worn chain will quickly ruin new sprockets and vice-versa. Once you see hooking, it's game over for the sprocket. Although not immediately obvious, sprocket wear costs power. Nothing absorbs less power than a brand new sprocket, and once your sprocket teeth begin to hook, it takes more energy to drive them.



Once teeth begin to hook over, the sprocket is worn out and will begin to sap power.

It's possible to bend rear sprockets, so always check them for any damage.

Keep in mind that the fewer teeth on the countershaft sprocket will accelerate wear on both the sprocket and the chain buffer on top of the swingarm, as it will have more sliding friction on it. So with your gearing choices, try to keep the countershaft size up to 13 or above as a 12-tooth wears too fast to keep in check. Note also that some engine cases or case savers don't allow the fitment of a 15-tooth sprocket unless modified.

The chain guide often limits rear sprocket size. A 52-tooth unit is normally about as big as you can go without mods to the guide. Always inspect sprockets for damage as it is possible to bend the rears, most likely when the chain guide is bent with a rock.

DRIVE CHAINS

Thirty years ago, drive chains were a curse. They stretched faster than you could adjust them, and broke so often that you were wise to carry a few spare links, spare section of chain, a chain breaker and a countershaft sprocket just in case. The advent of the O-ring chain in the '80s changed all that. The O-rings fit into the gap between the rollers and the links and help trap the lubricant in the pins. Mind you, the chains still need lubricating on the rollers. The early O-ring chains were bulky affairs that sapped power, but the reliability was worth it. As we got into the '90s, the O-rings were replaced by X-rings. The X refers to the cross-sectional shape of the ring, much like an O is the cross-section. The advantage of the X is not being crushed between the rollers, as the X has two contact points per face. It also meant the sealing lasted longer as the O-rings did wear out.

An unexpected benefit was that O- and X-ring chains ran cooler due to reduced friction. On high-powered machines, this meant the X-ring chains absorbed less power than a conventional chain. We now have a few manufacturers making sealed chains for low power applications, like 250Fs, in the form of U-rings and T-rings, all with seals that bear some resemblance to the letter that defines them. Only in high-level competition is a non-sealed chain still worth some power advantage. But as the non-sealed chain wears, it absorbs more power as heat loss, and the advantage disappears.

Joining links can still cause headaches. Unless you have a good reason to remove the chain frequently for cleaning, I'd suggest a rivet link is the best insurance. They take a little extra effort to put on, but there's little need to break modern chains again until they're worn and ready to be replaced.

As for chain quality, let price be your guide. The O-ring chain you buy for $89 is a nasty piece of power-robbing, sprocket-wearing work compared to the lightweight long-lasting joy of a $180 X-ring. Given the choice, always buy a gold chain. They are usually only 10 to 15 bucks more, but the plating prevents rust and makes cleaning easier as a result.

A gold-plated chain is less likely to rust and is well worth the extra coin.


Regular application of chain lube will extend the life of the rollers and hence your chain.

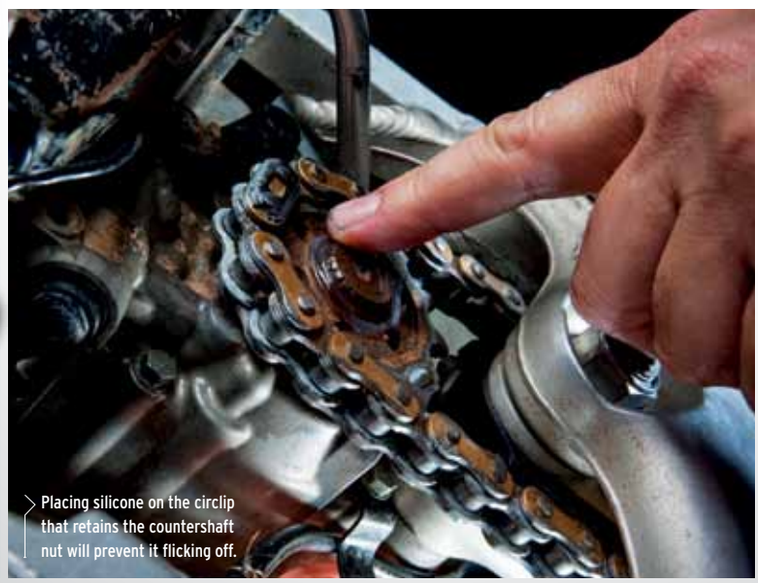
GO ON, CHANGE IT!

Swapping sprockets is a simple enough job with few basic tools. The most difficult part is removing the countershaft sprocket nut, and avoiding losing skin on the rear sprocket.

There are two common ways to remove the countershaft nut. The old method was to have an assistant stand on the rear brake while you used a long bar and socket. The folding tab needs to be knocked back with a cold chisel and if there is Loctite, some heating will help to make the nut shift. You need to stand on the rear brake quite hard to make this work. The advent of cheap air compressors and impact (rattle) guns from hardware stores means there is now an easier method. Leave the chain on and have an assistant stand on the top of the chain to keep it tight while you loosen the nut. It's only the shock of the hammering action that loosens the nut. So by keeping the chain taught, all of the impact is acting on the nut. Don't be tempted to put the machine in gear as the rotating hammering action will be lost on the gearbox gears, not on the nut. And using a section of chain curled up and jammed into the cases is also a good way to break a case.

While the rear wheel is out, remove the chain adjusters that run into the swingarm and apply some anti-seize. There's no telling when they will be out again.


Use Loctite on the sprocket bolts, as loose bolts can destroy a rear hub.


Placing silicone on the circlip that retains the countershaft nut will prevent it flicking off.

TOOLS

If you have an Allen key set, ring spanner, Loctite and a 24, 27 or 30mm socket to suit your rear axle nut and countershaft nut, then there's no excuse for you not to experiment with different gearing combos.

DIY TIPS...

- ✓ Sprocket bolts don't take kindly to being over tightened, even a small amount. Put a set of high-quality replacements on your shopping list when you buy a sprocket.
- ✓ Loose sprocket bolts will destroy a rear hub faster than you know how to spend $400-$800 on a replacement. It doesn't take long to check the bolts before each ride, so get into the habit of it.
- ✓ Some type of mechanical self-locking nut is a must for rear sprockets. Be aware that self-locking nuts do wear out after two or three tightenings.
- ✓ For the few bikes that still use a circlip to retain the countershaft sprocket, a bead of silicone will provide cheap insurance against the clip being flicked off.
- ✓ Replace the folding tab that mechanically locks the countershaft nut rather than relying solely on Loctite. It's such a critical fastener, overkill does not exist here.
- ✓ Use a long ring-spanner to loosen the sprocket bolts' nuts before you start turning the Allen-head. The Allen-head is only for holding and loosening, not tightening.
- ✓ Look for blackening around the bolt heads during your post-ride wash. If you can see it, chances are the bolts are loose and fretting.
- ✓ The sidewall height of a tyre will affect gearing. A 110/80-19 will have a smaller rolling diameter than a 110/90-19, thus shortening the gearing. Conversely, the 90-profile is taller and will require you to gear up to counteract its affect.