Connections

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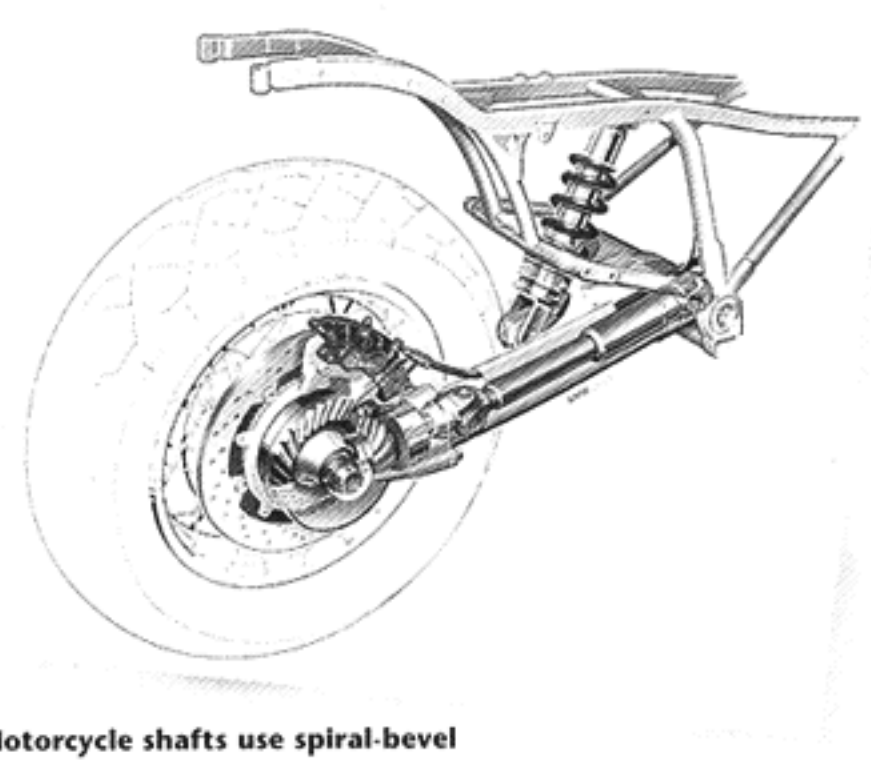

Motorcycle shafts use spiral-bevel gears, not your crummy automotive hypoid bevels....

My first "motorcycle," if I may call it that, was a bicycle I fitted with an old two-stroke Maytag washing machine engine. It had no brakes, no clutch and no throttle. In the very few rides it provided before its connecting rod broke, I stopped it by crashing. My motorized bicycle lacked controls because I had exhausted myself creating the crankshaft-to-rear-wheel connection, a complex matter about which I was then a simpleton.

Motorcycling's pioneers faced the same power connection problem. Most, like Harley-Davidson, initially used the flat leather belts then-universally employed to drive machinery in factories. H-D has recently returned to belt drive, but with a toothed, no-slip high tensile strength synthetic belt instead of leather.

Flat belt drive had significant advantages 90 years ago: With the addition of a moveable idler pulley the belt doubled as a clutch, and belt slippage when the engine fired acted as a drive shock absorber. We still have to feed power from crankshaft to rear wheel, and we still need clutches and drive cushions after giving up belt drive.

Single- and twin-cylinder engines deliver power in big bangs, with peak loads on the order of three times that of the average for a single power stroke. Gears, chains and shafts can be made strong enough to survive the pounding, but it's better to shave the peaks and use lighter drive components.

Chains are wonderfully efficient at the job of transmitting power.

The most common drive cushion on singles and twins has been spring-loaded face cams. In this design the crank's output mainshaft is splined to the drive cam, free to move axially but pressed into mesh with the driven cam by a strong coil spring. Torque pulses force the drive and driven cams apart, compressing the spring. As the power stroke's torque peak fades, the spring shoves the drive cam back into the driven cam, returning energy stored in the spring to the primary drive.

As the number of cylinders increase and flywheels are downsized, drive-shock direction reverses; the flywheel mass of single- and twin-cylinder engines keeps them from gaining speed when a bump lofts the motorcycle's rear wheel. A modern four's modest flywheels cause it to instantly pick up revs when traction is lost. So there's a big drivetrain shock every time the rear tire loses and then recovers traction. For that reason the drive cushion typically gets moved to the clutch hub or the rear wheel.

Large back-to-front drive shocks are created by the rear-wheel hop you get from some bikes when you downshift and apply the rear brake. Honda encountered this in extreme form in its problem-plagued oval-piston GP bike, and corrected it in typically clever fashion. They stopped the four-stroke NR500's wheel hop with a clutch that limited reverse torque.

Honda put all but one of the clutch's driven plates on a hub fitted with a one-way "sprag" clutch. This provided a solid connection when the engine drove the bike's rear wheel, but turned freely on overrun, when the wheel is driving the engine. Torque going from wheel to engine passes across the single clutch plate, which slips when hit with the sharp torque pulses fed forward by a hopping rear wheel. The single plate's slipping keeps the hop from developing.

Honda's reverse-torque-limiting clutch has been used on various of its street models—those with high compression ratios and little flywheel effect. Two-stroke engines provide no closed-throttle compression braking and do not need this kind of drivetrain enhancement. They do benefit from drive-shock cushioning.

Yamaha, years ago, put a rubber drive cushion in the YDS2's clutch hub and the clutch on the crankshaft end. People who campaigned the YDS2-based TD1 production racer were not pleased with the clutch arrangement, but it made a certain kind of sense. Crank-speed clutches are less heavily torque-loaded than those mounted on the other side of the primary reduction gears, and are more likely to disengage cleanly when you pull the clutch lever.

Most manufacturers prefer to use reduction-ratio drives between engine and transmission. These drives can be chain, gears or belts, or a combination like that found in many in-line engines. Honda's original 750 four had a sprocket built into its crank, between cylinders two and three. A roller chain linked the crank with a sprocket on a jackshaft, with a gear on its outboard end to drive the clutch. It's an arrangement still seen in in-line engines, though now usually with a "silent" chain.

For eyes accustomed to roller-type chains, a silent chain looks strange and unimpressive. It's a bunch of flat links, each with two teeth, packed side-by-side in a staggered formation skewered by pins that hold it together. But the silent chain has the advantage of meshing its links into its sprockets without sliding, and does it noiselessly. The other great advantage of a silent chain is that it accommodates wear without becoming noisy or inflicting excessive wear on its sprockets.

Roller chain and its sprockets are entirely different hardware. Sprocket teeth don't look like anything special, but are carefully

shaped so they engage with a chain's rollers out at their tips. Each roller travels down the face of a tooth, meshes fully between teeth only when halfway around the sprocket and climbs up the opposite tooth to disengage. This is, at least, what happens when both sprocket and chain are in good condition.

Trouble arises when a chain becomes worn, because wear increases the effective pitch, the distance between rollers. A worn chain rides higher on the sprocket teeth, and no longer slips cleanly in and out of mesh. Rollers begin to pound the tips of the sprocket's teeth, and if allowed to continue can bend a hook into the tip of each tooth.

You get a double whammy from excessive chain wear: The worn chain damages sprockets, and a damaged sprocket's improper meshing quickly ruins a new chain. Ideally, sprockets should be replaced when a new chain is fitted. But in reality some sprockets, especially the smaller countershaft sprocket, are made of high-strength, hardened alloy steels impervious to damage by a worn chain. Rear wheel sprockets tend to be softer and are more likely to need replacement when fitting a new chain.

Roller chain is one of those products in which quality is invisible. You can't tell just by looking what kind of steel, surface hardening or general heat treatment has gone into making a chain. A junk chain looks more or less identical to one of first-rate quality, except for its lower price tag.

Chains, for all their vulnerabilities, are wonderfully efficient at the job of transmitting power—about twice as good as gears. Zundapp must have had this in mind when it built a BMW boxer look-alike with shaft drive to its rear wheel, but chains in its four-speed transmission: four double-row chains on eight sprockets, with "gear" selection by sliding dogs.

Gears' power losses could be lower if we had stronger materials. Gears' teeth can be shaped to make a rolling contact when they mesh, but usually are compromised in favor of thicker, stronger roots. The degree of compromise required falls as gear diameter and number of teeth increases, but of course a transmission's size and weight also are increased.

Perhaps the most interesting trend of the past couple of decades is the widespread use of shaft drive for nearly all touring—and most cruiser—bikes. Here, too, there is more than meets the eye: The final drive gearing looks automotive, but isn't, as front-engined, rear drive cars always have "hypoid" axle gears, which are a melding of worm and bevel gears created to lower drive shafts. The final drives of motorcycles use vastly more efficient spiral-bevel gears.

My choice for that crude motor-bicycle that gave me my earliest riding experiences, bruises and abrasions was a simple V-belt. It also gave me a lasting appreciation of drive technology that is reflected in the overview presented here. MC

I invite readers' comments, suggestions and even criticisms. My e-mail address is gj@wheelbase.com; call me at (805) 239-2192, 9:00 to 5:00 PST, or fax (805) 239-0855.