BY LENNARD ZINN | BANGKOK, THAILAND

KEEPING IT ROLLING

Ancient and modern meet in Vittoria's tire factory

ONE AT A TIME Surprisingly most tires are painstakingly laid-up by hand.

There is nothing more integral to the performance of a bicycle than its tires. We depend on tires for everything from traction over slippery roots on a mountain bike, to holding us on the road when speeding down mountain switchbacks.

Behind those performance nuances are countless people working to make better tires. They are the engineers who cook up the rubber compounds, tread patterns and casing designs of modern tires, as well as the technicians who study durability, strength, grip and rolling resistance. All are key factors in high-performance racing tires, which use sticky rubber blends, advanced casing designs and precise assembly techniques to deliver the death-defying grip we trust our lives to.

Despite the progress in technology, however, the basic steps for producing a tire have changed little since the days of Charles Goodyear and John Boyd Dunlop. Goodyear discovered sulfur vulcanization in 1839, a process that hardens rubber and gives it durability and strength. Dunlop, meanwhile, invented the air-filled, or pneumatic, tire in 1888 after he watched his son bump along on the solid rubber tires of his tricycle and realized that a cushion of air would improve the ride significantly. Goodyear's vulcanized rubber made possible Dunlop's pneumatic tire construction, where a light fabric casing made of numerous threads is coated in rubber and capped by a rubber tread strip to provide traction and durability.

But while these basic elements have not changed in a century, the details of how they are produced and assembled is subject to constant development. One company paying close attention to these details is Vittoria, a maker of bicycle tires which, though founded in Italy 50 years ago, has transformed its business with a recent change of venue.

VITTORIA'S LION TYRES FACTORY

Seventeen years ago, Vittoria was one of the world's premier manufacturers of tubular racing tires. The company had come to the conclusion, however, that rising labor costs in Italy would soon prevent its tubulars from being competitive in the world market. Furthermore, if Vittoria wanted to produce clincher tires — a much larger segment of the tire market — it could not do that economically in Italy, either. Vittoria decided to go where labor was cheaper and rubber more abundant — Asia. In December 1987, it opened the Lion Tyres factory, just outside Bangkok, Thailand. Tubular production began immediately, with clincher production following six years later. Today, the factory produces 4.5 million clincher tires, 1.5 million inner tubes, and 700,000 tubular tires per year and has capacity for considerably more.

As one of the world's major bicycle tire producers, Vittoria is the only company to recently transition from being a high-end producer of tubular tires to a producer of clincher tires at ever-decreasing price levels. Lion Tyres only makes bicycle tires, a rarity in the industry; most bike tire companies such as Michelin and Continental have car and motorcycle tire businesses that dwarf their bike production.

This singular focus could account for the attention to detail Lion Tyres incorporates into even its inexpensive tires. Can you imagine shaving off all of the little rubber nubs left over from the mold with a hand razor? How about straightening any wobbly edges between the tread and the casing by hand-painting them straight with a fine brush? Or hand-washing each and every high-end tire? Lion Tyres not only performs these steps on tires carrying the Vittoria brand, but also on the tires it makes for other European and American brands. It is hard to imagine paying German, Italian or Dutch (or American) workers to do these steps on a tire that sells for as little as $10.

TESTING AND DEVELOPMENT

Lion Tyres has an extensive testing lab that checks the quality of incoming and outgoing products as well as the development of new products. The lab tests mechanical properties such as tensile strength, elongation, and modulus of elasticity of treads, casings and inner tubes. It charts resistance of tires and tubes to ozone, heat, UV rays, abrasion, puncture and fatigue as well as viscosity, curing characteristics and vulcanization parameters of the rubber and the latex it uses.

A standard hardness test of the tread rubber, called "Shore A," reveals grip information, since, in general, softer rubber grips better. However, grip is also affected by rubber additives, as Specialized so brutally found out when it sent soft gray Umma Gumma road tires to pros in Europe for the spring classics and got them back with the explanation that they were too slippery on wet roads. Rolling resistance is examined by studying the energy absorption (hysteresis) of the rubber.

The testing of the tread compounds is particularly important, since the possible combinations of ingredients are almost infinite. Alberto De Gioannini, product manager and design engineer for Vittoria and its mountain-bike tire brand, Geax, says, "The compound is the most critical secret of a tire manufacturer, since it is so hard to come up with it."

Outside the confines of the quiet lab, Lion Tyres tests 2500 tires per month to destruction. Computers track every revolution of 55 large spinning drums, constantly running against tires inflated on wheels. Random tires are burst-tested by injecting high-pressure water into them while underwater — to prevent a giant explosion as air would cause when they blow off the rim — with some tires exceeding 520psi before

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BANGIN' THE DRUM Tires are constantly being tested to destruction to check production quality.

blowing off. Additionally, every Geax UST tubeless mountain-bike tire is leak-tested by inflating it on a rim and submerging it. If a single bubble is seen, the tire is rejected. This is a far tighter standard than required by the UST license, which only asks that the tire lose less than 7psi in 24 hours.

MAKING TUBULARS, OPEN TUBULARS AND CLINCHERS

For all tires, the rubber for the tread (and for pressing into the casing fabric of clinchers) is mixed in giant hoppers into which workers add components measured out to the gram; the mixture varies depending on the tire. Giant steel cylinders knead the rubber by rotating against each other, making popping noises as air bubbles in the sheet of warm rubber burst.

Multi-color treads are made by laying strips of different colors on top of each other. A tread calender applies pressure to the top of the tread strip, combining dissimilar compounds into a single tread to attain a large difference in durometer (rubber hardness) on the tread center vs. the tread edges. This approach differs from the faster extruding process, by which most striped treads are made. An extruder applies pressure from the back, pushing the rubber through slots like a pasta maker, but Vittoria claims that the extruding process does not stick the parallel strips together as well as a calender applying pressure from the top. Aesthetically, the extruder has an advantage because the strips come out very straight and allow fine lines, while a calender-made tread can have wavy lines (resulting in the hand painting to straighten the lines). The calender method, however, can yield a higher durometer difference. "We are a product-driven company," says Vittoria's export manager René Timmermans. "We prefer to have the performance of the tires and are willing to sacrifice some aesthetics for that."

STEADY STREAM Liquid latex is poured by hand over the casing to produce an airtight chamber.

CLINCHER CONSTRUCTION

The production of a clincher tire is the same the world over. First, a calender presses the rubber into nylon casing fabric between giant cylinders. Lion Tyre's three-story tall, $3 million calender is "the pride of Vittoria," says Timmermans. Made in Italy and unique in the bike tire industry, this calender can squeeze nylon casings to a thickness of only 0.2mm, which is why Vittoria claims to be the only company that can make a 220 thread-per-inch (tpi) nylon casing in a vulcanized clincher.

Workers cut the casing on the bias (at an angle), so that when a strip of it is folded lengthwise, the threads cross to resist burst pressure. The casing strip is wrapped around a drum and adjusted until the two ends meet perfectly, whereupon a machine folds it lengthwise around two beads of Kevlar or steel wire so that it overlaps across the center, making three

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WHY DO SOME TIRES ROLL FASTER THAN OTHERS?

When it comes to road tires, rolling resistance and cornering grip tell the performance story. Rolling resistance is a function of the casing, the tread, the tube and the air pressure, while cornering grip depends largely on the casing, tread and tire shape.

Higher-density (higher thread count) casings roll faster than less dense casings for two reasons. The denser casing has thinner threads, which bend more easily than thicker, stiffer ones and thus deform around small objects on the road surface more easily. Also, a casing ply made of fine threads is thinner, so it takes up less rubber and therefore absorbs less energy in the rubber as the tire deflects.

Rubber compounds affect rolling resistance because they absorb different amounts of energy. In rough terms, thick, soft rubber usually absorbs more energy than thin, hard rubber. This is why a mountain-bike tire rolls slower.

Similarly, butyl inner tubes absorb more energy than latex inner tubes; consequently, tires with latex tubes roll faster. Also, coating a tube with talc reduces rolling resistance because the movement between the tire and tube is lubricated; the two parts do not move as one thicker unit. The contribution of the tube to the rolling resistance of the tire is one argument in favor of tubeless road racing tires, now under development by Michelin and Hutchinson; a tire without a tube should absorb less energy rolling along.

As you might imagine, rolling resistance drops as inflation pressure increases and tire flex decreases. Beyond a certain point, however, rolling resistance rises again, since the tire starts to bounce over small objects rather than rolling over them. This threshold pressure varies from tire to tire. Higher thread count tires remain supple at higher pressures than stiffer ones with less dense casings. Also, a tire with a latex tube reaches a higher pressure before its rolling resistance increases again than does one with a butyl tube. As a general guideline, it is wise to abide by the maximum recommended pressure for the tire, and not to exceed it in search of greater speed.

CORNERING GRIP

Tread compound and tread pattern are critical for cornering grip. However, so are casing design and tire shape. A tire with a high thread count deforms more easily around the micro topography in the corner and holds the road better.

The cross section of an inflated tubular tire is round, whereas any clincher inflates to an oval shape. As a tubular leans into a corner, the contact patch stays the same size, whereas the contact patch shape is ever changing on a clincher as lean angle changes. Vittoria claims that its testing shows that a 21mm tubular corners better than a 23mm clincher due to the roundness of the tubular vs. the changing radius of the clincher. This is why pro teams generally race on either 21mm tubulars or 23mm clinchers (although they may sometimes use narrower clinchers so they can make fast wheel changes without opening the brakes). —**LENNARD ZINN**

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plies under the tread and two on the sidewalls.

The tread strip is placed onto the casing (on some tires, over additional puncture-resistant fabric strips); tubeless tires have additional strips of rubber laid onto the inside of the casing that melt into it and make it airtight. A worker places the soft "green" tire into a mold, a hot job, since high-pressure steam inflates a bladder inside the tire while hot steam circulates in the tread mold to melt the rubber into its contours and simultaneously vulcanize it.

Inexpensive cotton tubulars are molded the same way, except they have no bead and come out as flat strips, ready to be stitched around an inner tube.

HIGH-END AND OPEN TUBULARS

Like car and motorcycle tires, most bike tires are vulcanized clinchers as described above. However, Lion makes another class of tires: extremely high-thread-count tubulars and "open tubulars," which are clinchers sharing the same 290tpi casing. The high-end casing is made by wrapping fine "Polycotton" (polyester/cotton) strands onto a spinning cylinder. Corsa Evo models use Kevlar for every fifth thread in the outer casing layer for cut resistance, while the Pavé Evo tire for Paris-Roubaix uses 50 percent Kevlar on the inside and outside layers of the casing. A worker coats the thread-covered drum with latex to hold the threads together and then cuts it off the drum in a spiral fashion so that the resulting strip is bias-cut.

CASING THE JOINT Vittoria prides itself on having the highest TPI casings available.

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On another drum, two strips of casing are laid in opposition so that the fibers cross each other. For open tubulars, beads encircle the drum and the casing folds over them; tubular casings are simply folded over. Seamstresses stitch latex tubes (also extruded and hand-glued) into tubular carcasses with thin protective fabric between the stitches and the tube. Other workers glue on the base tape.

Open tubular casings are then inflated on clincher rims, while tubular carcasses are inflated and hand-straightened on tubular rims. A tread installer hand-glues the tread, pre-vulcanized in a heated mold, onto each carcass with a puncture-resistant strip under it. He lines it up using laser markers while rotating the rim on a drum.

Obviously, there is a lot of handwork in any tire, and many

tires can claim to be "handmade." However, the tread gluing on open tubulars and high-end tubulars takes "handmade" to another level. Vittoria sells these tires under the Vittoria name and the Clément name (which it has licensed from Pirelli), as well as to Ritchey for its tubulars and open tubulars, and to Vredestein for tubulars. The only other companies making open tubulars are Veloflex, in Italy, and Challenge, in Thailand.

THREAD COUNT AND QUALITY

High thread counts are associated with reduced rolling resistance, and Vittoria goes to 220tpi in a vulcanized clincher, while 130tpi is as high as any other bicycle tire brand offers. That said, some brands claim extremely high thread-count by adding up all of the layers under the tread. That reckoning makes no sense, because it leads to the conclusion that adding ever more casing layers would improve performance, while in fact the opposite is true. Lion makes vulcanized clinchers with thread counts of 26, 60 and 120tpi under the Vittoria name and other brands, but it will not make 220tpi vulcanized clinchers for anyone other than Vittoria.

Vittoria's sole focus on bicycle tires led to its adoption of equipment that makes casings too fine for motor vehicle tires. That may be a loss for the motorized world, but it has given cyclists tire technology that's second to none. VN

HOW A TIRE CORNERS

A bicycle in a corner constantly accelerates toward the center of an instantaneous circular arc. The radius of the arc might be constantly changing as a rider sweeps a turn, but at any given moment, both the front and rear tires are heading in their own specific arcs. It's the force generated by the front and rear tire working in unison that allows the bike to sweep around (or slide through) a turn, whether on asphalt or dirt. The force generated by the tires is called lateral force or side force — or, more commonly, "grip."

As a rider heads through a corner, a tire produces lateral force using a slip angle. Slip angle occurs when the rider turns the handlebars, at low speed, or both turns the bars and leans the bike over at higher speeds. The slip angle is the difference between where the tire is pointed and the actual direction of the bicycle. Tire designers build elasticity into tires (through the casing and tread) to allow this slip angle to be possible. The tires are able to grip the ground, but also yield somewhat, through flex, to the forces pressing them outward and downward. They oppose these forces with equal opposite forces and recover when the force has passed (when the bike straightens out).

When heading in a straight direction, the tires see only vertical loading. The transfer of vibration through the tire in addition to how it behaves in a turn is referred to as the tire's suppleness. Vertical loading is one of the most straightforward tasks a tire is expected to endure. It's in cornering where design and materials are stressed to their limits.

— ANDREW JUSKAITIS