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BICYCLE TYRE TYPES AND SYSTEMS

STRUCTURE AND BENEFITS OF TUBULAR, CLINCHER, AND TUBELESS CLINCHER CONSTRUCTION

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SINCE THE INCEPTION OF THE BICYCLE, IT HAS BEEN REFERRED TO AS THE PERFECT MACHINE, DUE TO ITS INHERENT SIMPLICITY AND EFFICIENCY. TYRES HAVE PLAYED A CRITICAL ROLE IN THIS, FORMING THE CONNECTION TO THE GROUND, PROVIDING BOTH CONTROL AND COMFORT.

THE BICYCLE HAS EVOLVED, AND EMERGING CYCLING DISCIPLINES HAVE NECESSITATED NEW AND DIFFERENT TYRE TYPES AND SYSTEMS TO CATER TO THE GROWING DEMANDS OF CYCLISTS GLOBALLY.

IN THE PROCEEDING WHITE PAPER, WE WILL REVIEW THE FORMS THAT PNEUMATIC BICYCLE TYRES HAVE TAKEN, AS WELL AS THE DIFFERENCES AND BENEFITS OF EACH. LASTLY, WE WILL GLIMPSE INTO THE FUTURE OF EACH TECHNOLOGY, AND HOW EACH IS LIKELY TO FURTHER INTEGRATE IN USE.

INTRODUCTION

→ When determining the type of tyre system that is needed for a given application, it is critical to first understand the intended use, including the types of surfaces that the tyre will be used on. For example, will this be a road or off-road application? What type of wheel will be used? Will the performance KPIs (Key Performance Indicators) be based on rolling resistance, handling, durability, protection, or some combination of these factors?

Next, the individual components of system will need to be reviewed, to recognize how the materials and processes work with each other. Depending on the intended use, specific materials are chosen, and construction methods are employed to produce the desired outcome. Finally, comparing the benefits of each system will serve to set performance goals, from which the system can be built around. Simply put, tyre systems have evolved to overcome challenges that cyclist have found themselves in need of conquering. In each example, individual systems will have benefits that define the whole, and combine both the consideration of the intended use as well as production methods to serve a purpose that is unique to the system.

In the course of this white paper we will cover these topics and equip the reader with detailed descriptions and key characteristics to quickly differentiate between tyre types and systems commonly found in the marketplace, as well as the benefits of each. In all examples, we will be using pneumatic (air-filled) tyre types, as these are most common, and have historically given the highest level of performance.

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TYRE CONSTRUCTION TYPES

SECTION 1. PART 1.
COMPONENTS OF A TYRE

In essence, a tyre is made up of three main components: tread pattern, tread compound, and casing. The tyre then relies on either an innertube to hold air, or in some cases may use a tubeless style casing, once mounted on the wheel. Each part plays a key role in how the tyre system is assembled, as well as how they perform within their intended use.

When a tyre model is produced, the name typically refers to the tread pattern. This is a bit unfair to the compound and casing, which do much of the work, but as the tread is the most obvious visual feature, it has become the standard in identifying the model.

In simple terms, the tread pattern of a tyre is designed for the terrain of the intended use, and developed to reach specific goals in this setting. Whatever the goal, we must first define what makes the tyre perform well in the conditions it will be used in.

FIGURE 1.
Tyre components: tread, compound, casing, inner tube and bead.

The term "fast" is not universal. For example, a tread that will be used in a time trial on pavement will be designed for low rolling resistance as the top key performance indicator (KPI). In contrast, a tread designed for downhill mountain bike racing in muddy conditions will have a completely different set of performance criteria. In both examples, the key performance indicators reduce time between the start and finish lines, so they are both equally "fast" in their intended use environments.

Speed is just one example of a KPI that is considered during the tread design phase. Others may include abrasion resistance, ultimate mileage, maximum load, etc. Whichever KPIs happen to be on the list during tread design, the system (as a whole) must be considered, and perhaps nothing effects a tread design quite like the compound itself.

The compound is the very substance the tread design is composed of, and is typically made from either natural rubber, synthetic rubber, or a blend of the two. Occasionally other substances are added to the formula, to enhance specific characteristics of the compound itself. One example is Graphene, which has been proven by Vittoria to reduce rolling resistance, decrease abrasion, and increase wet weather grip. Silica is also a popular additive, which can be used to decrease rolling resistance. Other brands, like Continental, refer to their secret formula as BlackChili, without disclosing the ingredients.

Regardless of the formulation, the compound must work in concert with the tread and casing to achieve the desired outcome. The composition of the compound can change the way a tread design works in practical applications, as the elastomeric properties of the rubber will have a large effect on the flex and wear of the tread.

In road racing applications, Vittoria has found that the properties of the compound, combined with the thickness of the tread can have as much an effect on the rolling resistance as the casing itself. This is notable, as the road surface is quite uniform, which helps to isolate the effect of outside influences on data, clarifying the performance traits.

One way of manipulating how the compound and casing work together is by layering multiple compounds on the casing. Maxxis is famous for using three compounds in their 3C formulation, while Vittoria pioneered the use of 4 separate compounds on a single casing. In both cases, the base of the tread can be made more robust, stable, and firm, while the surface of the tread can be made softer to increase grip.

This is especially useful in off-road applications, where a "knobby" style tread is more common, where each tread block stands alone, devoid of surrounding support. Layered compounds help the tread block resist tearing at the base while under load, despite the use of a soft surface compound. Also worth considering is the random nature of the intended use (off-road) surface, where roots, rocks, and multiple dirt types are evident.

In this case, the compound must allow the tread block to deform enough to produce grip but simultaneously balance durability, while returning the least amount of rolling resistance possible. A tall order indeed, and a prime example of how compound and tread work in unison.

FIGURE 2.
Tyre structure: an example with four different components.

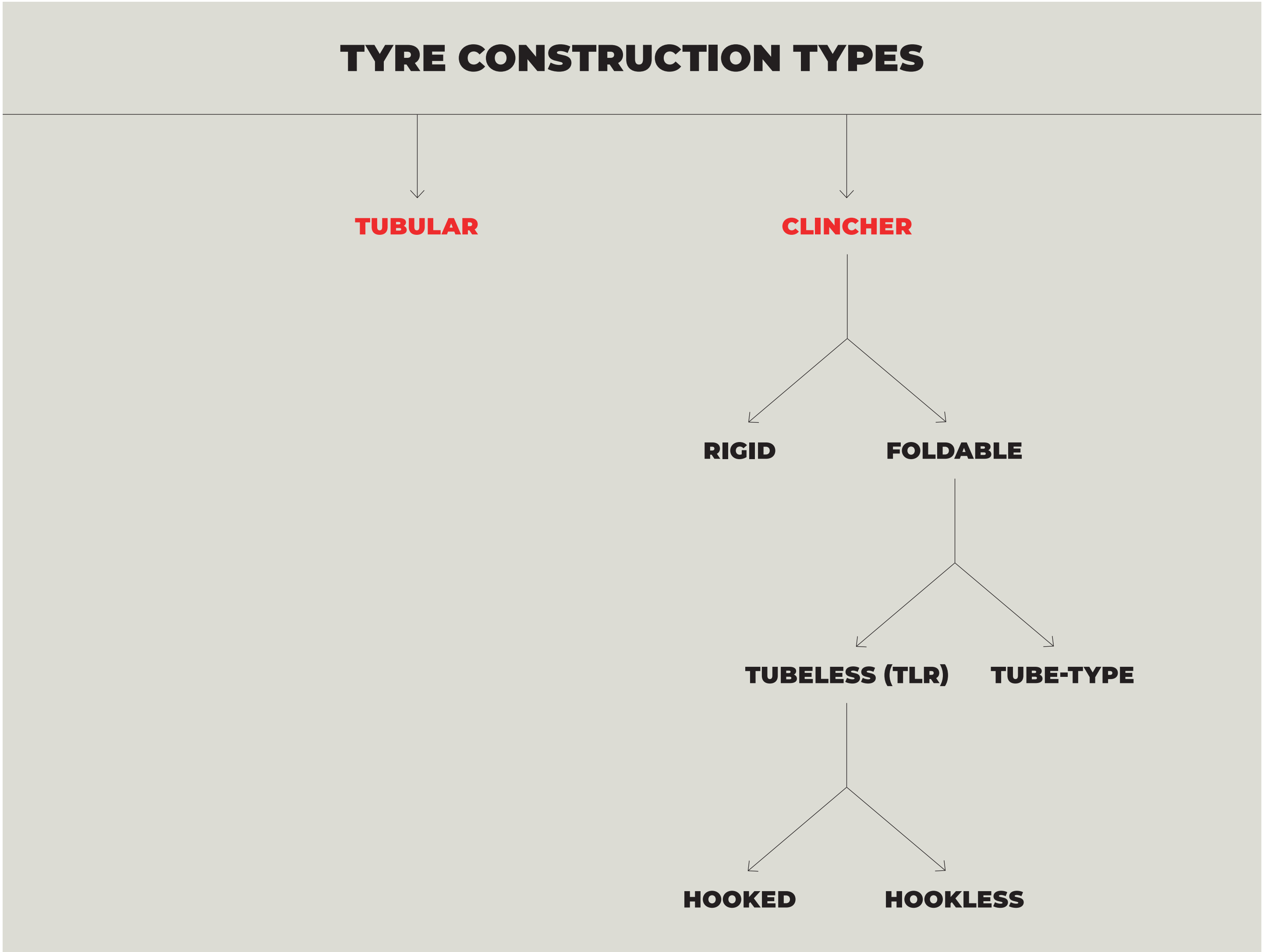

FIGURE 3. Casing systems based on casing construction.

In these examples, the definition of performance is directly tied to the scenario in which the Tyre is used, and cannot be defined universally across categories. Speed is just one measure, and is always relative. Often, depending on use, durability will be the key defining factor of the tread, especially when increased mileage is paramount. For example, this is common in Tyres that are intended for more utilitarian purposes, such as in the city/commuter category, or in high load scenarios in e-bike applications.

Regardless of the intended use, or measures of performance, one thing is constant – the tread and compound rely heavily on the casing to achieve the goals of the system.

In comparing various tyre system types, the casing is perhaps the most defining feature. The reason is, the casing type will define how the tyre is affixed to the wheel, as well as how it holds air. Virtually any tread pattern or compound can be applied to the casing types we define below, making the casing the foundation of tyre construction. For this reason, we will focus on casing as the key differentiator when comparing types of tyre systems.

The casing will dictate the type of rim the tyre can be mounted on, and whether the tyre will require an inner tube for use. This not only provides the structure of the system, but is also tasked with balancing durability and rolling resistance simultaneously, which is no easy task.

In a broad categorization, casings typically fall under one of two classifications: clincher style or tubular constructions.

In both style casings, pressurized air serves as a spring to allow for a certain amount of deformation, which provides the ability to fine tune the performance of the system. Both style casings feature some common elements, such as casing materials, and hardware such as valves. Both are available in sizes that share an outer circumference that is consistent per size, which allows users compatibility as well as the freedom to choose between systems on a given bicycle.

From a material perspective, bicycle tyre casings are most commonly made from nylon cloth, but in higher end applications, cotton cloth is also quite popular. Regardless of material, casings are assembled using a system of layered cloth, which are fused together, most often in a bias-ply layout.

Bias-ply is when the threads of the first layer of material run perpendicular (90-degrees) to the next layer of cloth. These layers together form one complete layer (or "ply") of material in the Tyre. This bias-ply pattern is then cut, so the direction of threads within both layers sits at a 45-degree angle to the direction of rotation. Doing so produces a long lasting and predictable performing tyre.

Bias-ply differs from "radial" construction, which is typically found in automotive use. Radial construction uses a much different bias angle, which approaches 90-degrees to the direction of rotation. This type of construction has benefits in terms of straight-line impacts, and potentially lower rolling resistance. While rare, radial-ply bicycle tyres have been produced, but typically are not as well suited for the lightweight system and dynamic demands of bicycle applications, as advantages in rolling resistance are often negated by diminished handling and wear patterns.

With both clincher and tubular casing styles, the two most common valves are Schrader style (as used in most automotive applications), and Presta valves, which are also known colloquially as "French" style valves. When used on an innertube (within a clincher application), either style valve will be molded into the tube structure, and the valve will exit the rim via a valve hole. The Schrader valve has an advantage in familiarity, as well as an internal spring which closes the valve. The Presta valve offers simplicity, as well as security with a threaded valve closure. Also, the Presta uses a smaller valve hole, which is beneficial on narrow rims.

When used in a tubeless configuration, the valve will resemble a Presta valve shape, but will employ a conically shaped seat which is placed into the valve hole in the rim, and tightened down via an external valve nut. During inflation, air will be sent directly into the tubeless tyre casing, as there is no innertube in this system. Tubeless valves are designed to prevent air loss through the valve hole, while allowing a familiar method of inflation for the user.

As we've seen, tubular and clincher construction share many of the same traits, despite being quite different in construction. Now that we have the common attributes out of the way, let's dive deeper into what makes each system unique.

FIGURE 4. Presta (left side) and Schrader (right side) valves.

SECTION 1. PART 2.
CLINCHER CONSTRUCTION

→ Clincher casings are the most common, and loosely resemble automotive tyre casings in form and function, where the lip of the tyre (also known as the bead) is pushed against the internal surface of the rim wall, as internal air-pressure is increased. This pressure forces the clincher bead to lock into the rim wall and form a firm and stable interface. These beads are typically made by wrapping the casing material around a steel wire hoop (one hoop for each bead), which is then molded inside the rubber bead lip. This provides a firm edge to the bead, which locks into the rim interface. Clincher tyres which use a steel wire cannot not be folded, as the internal wire is quite rigid, and will remain in the position if bent, potentially causing a mounting issue. For these reasons, wire bead tyres are also known as "rigid bead" tyres.

In higher-end bead construction, steel wire is often substituted with aramid fiber, which offers the added advantages of reduced weight, as well as the ability to fold the finished tyre. Therefore, casings that use aramid bead material are often known as "folding" casings.

In a commercial sense, folding bead tyres allow for reduced shipping costs as well as less storage room, which are of great benefit within sales and distribution channels. However, the true advantages of a folding bead tyre come in terms of performance.

Reduced weight is of great value to cyclist, as it has a noticeable impact on acceleration, braking, and handling. Weight affects cyclists as they push their limits to climb hills at a greater pace, as well as when descending and cornering. In off-road applications where suspension systems are used, the weight of a tyre is un-suspended, meaning that it is not insulated by the suspension system, so added weight can make suspension systems less responsive.

In addition to its low weight, Aramid is chosen for its high tensile strength, which is critical in maintaining a secure and consistent fitment on the wheel, especially at high pressure and in tubeless applications. This makes it a suitable high performance alternative to the proven steel wire material.

Whether the clincher system uses a rigid or folding bead, the casing will hold the air pressure one of two ways; with an innertube or with a tubeless bead and casing.

An inner-tube system is nothing more than an expandable bladder, which sits inside the tyre and employs an external valve to adjust internal pressure. These innertubes are commonly made from butyl rubber, but in higher end applications can be made from latex or Thermoplastic polyurethane (TPU), which can offer additional performance benefits. As the innertube prevents the air from escaping, the tyre beads are simply designed to provide the mounting interface and structure of the system, and are not designed to retain air.

FIGURE 5. An example of clincher construction.

SECTION 1. PART 3.
TUBELESS CLINCHER CONSTRUCTION:

→ Tubeless compatible clinchers are also quite common and have grown to be popular in recent years. A clincher tyre which has the ability to be used in a tubeless configuration will commonly be referred to as "TLR", which is short for "tubeless-ready". This means the tyre is capable of being used both ways, either with or without an inner-tube. These TLR casings feature a very defined bead shape compared to non-TLR tyres, which is molded during the vulcanization process. This shape is designed to perfectly key into the rim wall to create an air-tight seal. If the TLR tyre is being used in a tubeless configuration, the rim on which the tyre is being mounted to must also be tubeless-ready, and feature an air-tight design. However, if used with an innertube, the TLR tyre will simply be mounted and inflated in an identical manner to a non-TLR tyre.

As tubeless tyre technology has evolved, so too has tubeless rim technology. Where traditional rim walls feature a hook at the lip of the rim which is designed to hold the tire bead in place, many modern TLR rims have done away with the hook to gain advantages in tire profile and contact patch. This more modern rim design is known as a "hookless" style rim. While all TLR tyres are compatible with traditional hooked rims, only certain TLR tires are compatible with hookless rims, so it is imperative to always check the sidewall inscription on the tyre to ensure compatibility, before mounting on a hookless rim.

FIGURE 6. An example of tubeless construction.

SECTION 1. PART 4.
TUBULAR CONSTRUCTION

FIGURE 7. An example of tubular construction.

→ In contrast to clincher and tubeless clincher construction, tubular construction is also an effective method of building a casing, and is quite popular in high level road racing applications. In tubular construction, the casing material is wrapped around an innertube, and sewn closed along the bottom of the casing, opposite the tread.

There are no tyre casing beads in tubular construction, and therefore tubulars require tubular style rims, which have no rim walls. Tubular style rims are not cross compatible with clincher style tyres, so consumers who demand the specific performance criteria that a tubular construction offers, will need to purchase a dedicated wheelset for this purpose. For this reason, many athletes will train on clinchers, and race on tubulars.

In the mounting process, the tubular tyre is glued to the tubular rim, using a special form of rubber cement known commercially as tubular cement (or Mastic). While it may seem inconvenient to glue a tyre to a rim, it is a well proven and secure technique of construction, popular in high end road, and various other sub-categories such as track and cyclocross.

While there are seemingly endless styles and applications for bicycle tyres, the three systems of clincher, tubeless clincher and tubular construction provide the foundation of virtually all systems. All three of these systems provide many benefits, as well as challenges, which we will review in the next section.

SECTION 2.

BENEFITS OF CLINCHER, TUBELESS CLINCHER AND TUBULAR CONSTRUCTION

WHILE IT'S EASY TO SIMPLY VIEW BENEFITS OF BICYCLE TYRES IN TERMS OF SPEED, GRIP, AND DURABILITY, THESE COMMON METRICS DON'T TELL THE COMPLETE STORY WHEN CONSIDERED ON THEIR OWN. OTHERWISE, THE VARIETY OF TYPES, STYLES, SIZES, AND CONSTRUCTIONS WOULD BE FAR NARROWER THAN IT IS IN ACTUALITY.

RATHER, BY DEFINITION, THE BENEFIT OF THE PRODUCT MUST PROVIDE THE BEST AND HIGHEST ADVANTAGE FOR THE SPECIFIC SET OF CIRCUMSTANCES THE USER IS APPLYING THE PRODUCT TO.

TAKING THIS INTO CONSIDERATION, WE WILL BEGIN BY DISCUSSING THE BENEFITS OF TUBULAR CONSTRUCTION.

FIGURE 8. Tubular tyres in action during a hill climbing stage.

SECTION 2. PART 1.
BENEFITS AND CHALLENGES OF TUBULAR CONSTRUCTION

→ Rim widths in almost every category have grown in recent years, which can pose fitment challenges for consumers of tyres. However, a great benefit to tubular construction is the consistency in tyre width, despite rim width. Unlike a clincher, a tubular will measure the same width no matter the width of the rim, as a tubular is a self-contained unit.

Another top benefit is the tubular profile. Due to innertube being sewn within the casing, and given that the innertube radius expands equally when inflated, the cross section of a tubular bicycle tyre is almost perfectly round. While this may seem obvious, it is worth noting, that by comparison, clinchers have a cross section that more closely resembles the outline of a lightbulb, and therefore can deform quite differently under load.

This round tubular cross section provides an even and dependable contact patch area where the tread meets the ground, as the tread remains perfectly tangent to the ground throughout the full spectrum of lean angles. This effect communicates predictable grip and control for the rider, as the feel through the corner is often more consistent compared to a clincher construction.

This profile also allows for more usable sidewall, as the complete area between the tread and rim is utilized to improve performance. As there is no vulcanized clincher bead within the tubular sidewall (which typically entails a tapering of sidewall material thickness), the casing can be made in a uniform thickness between the tread and rim, and thus can flex uniformly. This factor has been proven to not only enhance comfort, but also significantly reduce rolling resistance through vertical compliance, and the reduction of tyre deflection over bumps in the road.

Being that the tubular tyre is glued to the rim, performance at the lower range of acceptable pressures can be greatly advantageous. For example, in cyclo-cross applications, riders can use lower pressures than a clincher system would allow, without the risk of pinch flatting, or burping air from the TUBELESS system in hard cornering. This provides unmatched comfort, as well as traction.

If desired, using a tubular construction at higher pressures, can also be advantageous. Since the construction allows for a more supple deformation of the casing, tubulars can be used at a slightly higher pressure than they might on a clincher system, without completely sacrificing the lively feel and bump absorption described earlier. This advantage allows the rider to set the pressure of the tyre to have less drop (the vertical distance a tire deforms at a given pressure when loaded with the weight of the bike and rider), but still retain bump compliance and grip, producing a very fast and efficient system. If a user were to apply this same pressure to a traditional clincher with innertube, the feel would be more harsh. It's also worth noting that the max pressure of a tubular is often much higher than a clincher, in situations where ultimate pressure is advantageous, such as in track cycling.

Safety is also an advantage of tubulars. As the tubular is glued to the rim, a catastrophic blow-off at the highest end of the pressure range is greatly reduced. In the event of a flat, there is greatly reduced risk that the tyre may unseat and tangle in the bike, as a clincher might.

Last, and certainly not least where performance is concerned, a tubular system can be made quite lightweight when total system weight is considered. The tubular rims do not need reinforced walls, and the tubular tyres have no beads, so there is potential to drop weight when compared to a clincher system. As a cyclist's budget can at times be measured in "grams saved per dollar spent", the lightweight, supple, fast rolling nature of tubular construction can appear quite attractive.

FIGURE 9. Tubular tyre rolling.

However, despite all these positive tubular attributes, there are some potential challenges that tubular tyre construction can't escape.

The first, and likely largest hurdle of mainstream acceptance, is the mounting method. It is simply more complicated to glue tyres onto a special rim, compared to the convenience of a clincher system. This factor arises not only at time of replacement, but also in the event of a puncture, which can necessitate a somewhat more complicated removal of the tubular tyre for servicing. Especially so, as most tubular glue takes up to 24-hours to fully cure, so the process is anything but quick.

Add the fact that many bicycle shops do not carry tubular wheels and glue as standard items, as these parts tend to be slightly more specialized in nature. Tubulars are not common in the OEM (original equipment manufacturer) market, so shops are less likely to see tubulars on new bikes that are being built for general use.

In terms of puncture repair, tubulars pose a challenge, as the innertube is completely enclosed in the casing. Causally, tubulars are known as "sew-ups" in the cycling industry, as to patch the tubular innertube, a person would literally have to cut the casing open to gain access for repair, and then sew the casing closed once the patch is cured. Nevertheless, still requires more effort than changing a flat on a clincher style tyre. This is also the main factor why tubular construction is less common in off-road categories, where thorn and pinch related punctures are a constant risk.

As we've seen with tubular tyre system construction, there are many benefits, as well as challenges that may impact their effectiveness for certain applications. Now we will take a similar look at clincher tyre systems, both with and without the use of an innertube.

SECTION 2. PART 2.
BENEFITS AND CHALLENGES OF CLINCHER CONSTRUCTION

The inherent simplicity of a clincher system is quite attractive and suits the “simple machine” philosophy of bicycle design, as mentioned previously.

In terms of benefits, a clincher system is easy to understand. Most pneumatic tyres in other industries are a form of clincher, and so there is a broad understanding of the system functionality.

The second main advantage of clinchers is that the tyre can be mounted to (or removed from) the appropriate rim in minutes. This allows for great flexibility in tyre choice for enthusiasts, as tyres now become easy to change, based on terrain.

In traditional clincher applications, the innertube is easily removed by simply dismounting a single tyre bead to gain access. Therefore, the aligned components of an already simple clincher are also simple, and allow for independent replacement since the units are separate. An added bonus is that innertubes are fairly inexpensive, and can be inflated to full pressure with a simple hand pump.

The new trend of wider rims adds further potential benefits to clincher systems, by increasing the cross section width, and reducing the classic lightbulb shape. This can improve handling as the tyre deforms, adding stability. In fact, rim width trends have made such an impact on the cycling industry, that ETRTO (the European Tyre and Rim Technical Organisation) recently amended the recommended compatibility of tyre and rim widths, as a result.

Despite all of these positive traits, clincher style bicycle tyres do have certain challenges that are worth mentioning.

As a clincher tyre relies on air pressure to seat the tyre beads against the rim walls, a puncture can increase the risk of the tyre unseating during sudden air loss. A sudden loss of air pressure may be the result of a large puncture or impact, and can even result in a catastrophic failure in certain instances.

Lastly, when used at higher pressure ranges, the risk of tyre blow-off in clinchers increases as well. This pertains most closely to the growing number of low volume high pressure tubeless road tyres, since mountain bike tyres typically use higher volume and lower pressure.

FIGURE 10. Clincher tyre in action.

SECTION 2. PART 3.
BENEFITS AND CHALLENGES OF TUBELESS CLINCHER CONSTRUCTION

FIGURE 11. Tubeless clincher construction used by a professional team in the World Tour.

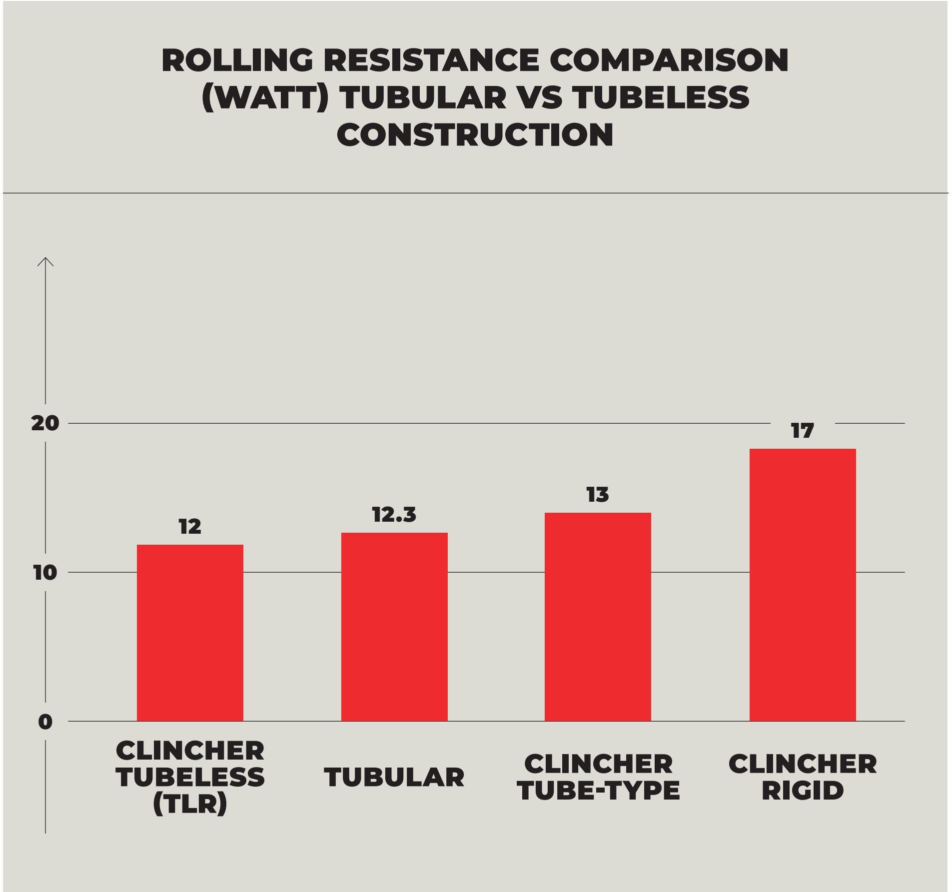

FIGURE 12. Rolling performance comparison data between Tubular and Tubeless construction. Based on internal laboratory data on same product version and size, different construction.

→ In tubeless clinchers, the innertube is not a part of the system, which saves weight. However, the real gains are not just in weight, but in how a tubeless clincher deforms. By removing a layer within the system (the innertube), the tubeless tyre is able to be more supple as it rolls. This change in deformation reduces rolling resistance, as the tyre becomes less rigid, and thus deflects less off of bumps in the road.

Due to this, we have seen an increase in tubeless road tyres at the professional level of racing, where tubular construction has previously ruled for decades. In fact, commercially available tubeless road tyres have reached new levels of performance, previously thought unreachable, as a result of this technology.

The benefits of tubeless clincher systems don't stop there though. This increased suppleness also increases traction, particularly in off-road applications, since it allows the contact patch of the tyre to expand. This is highly beneficial when riding technical terrain, where uneven surfaces are common, such as trails where off-camber rocks and roots are present.

To enhance the performance of a tubeless clincher system, liquid tyre sealant is commonly used. At inflation, the sealant will be pressurized inside the casing, and will automatically find any potential leaks as it tries to escape from the system. In the event of a puncture, and the sealant is exposed to ambient air, it immediately cures to form a seal on the puncture. In fact, tyre sealant is so effective, that the majority of the time the rider will not even realize the puncture occurred.

This single innovation has dramatically changed bicycle tyres across all categories, but perhaps the largest gains have been in the off-road segments. Previously, a single thorn, or errant impact could end your ride. However, with the advent of tubeless tyres and sealant, both concerns are largely eliminated.

However, liquid tyre sealant is not a perfect solution, as it must be low in viscosity to find small punctures quickly and effectively, so it has inherent limitations in the size of puncture that may be realistically sealed.

For this reason, an entirely new category of tubeless tyre liners has emerged in recent years, which offer protection against large impacts, where a rim strike may cause a puncture. These liners sit tightly against the rim, with a profile that protrudes above the rim wall, yet do not inhibit Tyre performance or prevent the tubeless casing from deforming. Liners are intended to be used with liquid sealant, which retains the benefits for fitment and small punctures, as normal.

As these liners typically replace a portion of the air volume inside the tyre, the air-spring effect will feel slightly more progressive, and is bolstered by a progressive nature of the liner material as the tyre approaches full compression under impact. In the event of a full compression, the tyre is protected from the rim striking the underside of the tyre tread.

Aside from impact protection, liner systems offer benefits when used as a run-flat. In a run-flat scenario, the tubeless tyre beads are held in place along the rim walls by the width of the liner, which prevents the tyre from unseating. The tyre volume is filled by the liner itself, which has expanded to fill the internal volume, once the pressure of the tyre has been released. This enables a rider to travel up to 50km on a completely flat tyre.

FIGURE 10. Example of Tubeless Liner System

When it comes to inflation, this is one area where a TLR system can be a challenge, as the beads of the tire will be pushed into the rim wall by air-pressure alone. For this reason, TLR tires often have a very tight fitting bead, which can add to the effort needed to mount the tire. However, this tight fitting bead allows for minimal air-loss during inflation, which helps to build internal pressure, ultimately seating the beads in their final place.

In the end, when comparing between traditional clincher and tubeless clincher systems, it's important to note that the tubeless version shares many of the basic benefits of the traditional version. Both are quick and easy to mount and dismount, both are easy to understand from a consumer perspective, and both can be mounted on traditional style rims. Whether using a tube or not, a clincher is still a clincher, and it remains the most common form of tire system available.

SECTION 2. PART 4.
COMPARING BENEFITS AND SUGGEST APPLICATIONS

→ Now that we've covered the benefits of tubular, clincher, and tubeless clincher constructions, let's compare them directly.

The chart below serves to illustrate the key KPIs used in deciding between systems. Using the above comparison, we can now narrow down potential uses for each system. While all categories will have examples of standard tube and clincher applications, if we apply the system KPIs from the above chart across the spectrum of cycling disciplines, we find alignment for the best and highest performance uses.

For example, within track cycling, speed is the determining factor. If we move on to road racing we see a mix of casing constructions used, depending on the goal of the rider.

In time trial use, fast rolling tubeless clinchers have become quite popular, but when road racing turns to the hill climb stages, there is still deep loyalty to the tubular construction. However, not all cyclists are racers, or place their top priority on speed alone. For commuters and casual cyclists, simplicity and durability are top priorities. In off-road categories such as mountain bike and gravel, enthusiasts have a different set of demands, where tubeless clinchers are currently king.

While it may seem complex to have so many tyre systems to choose from, these examples provide a more clear picture of the practical applications of each. Despite the variations, each is intended to help the rider increase performance, and ultimately happiness with this simple machine. As product designers within the bicycle industry continue to cater to emerging trends and uses, the evolution will continue, perhaps in ways we have yet to imagine.

COMPARING TUBULAR, CLINCHER TUBE-TYPE, AND CLINCHER TUBELESS (TLR) SYSTEMS

BENEFITS	TUBULAR	CLINCHER TUBE-TYPE	CLINCHER TUBELESS (TLR)
SPEED	★★★★	★★★	★★★★★
LIGHT WEIGHT	★★★★★	★★★	★★★★
DURABILITY	★★★★	★★★	★★★★★

APPLICATIONS	TUBULAR	CLINCHER TUBE-TYPE	CLINCHER TUBELESS (TLR)
TRACK RACING	★★★★★	★★	★★★★
ROAD – TIME TRIAL RACING	★★★★	★★★	★★★★★
ROAD – HILL CLIMB RACING	★★★★★	★★★	★★★★
CITY / COMMUTER	—	★★★★★	★★★
MOUNTAIN BIKE / GRAVEL RACING	★★★	★★	★★★★★
CYCLOCROSS	★★★★★	★★	★★★★

FIGURE 11. Benefits and Applications of Tyre Systems

SECTION 3.

THE FUTURE OF TYRE SYSTEMS CHANGE IS THE ONLY CONSTANT IN LIFE - HERACLITUS

→ While change may seem constant in the bicycle industry, we always circle back to the simple machine, and how little the overall form has changed at the core. However, advancements in materials and processes have opened doors within the cycling industry that, until quite recently, were never thought possible.

We have traded wooden rims and heavy frames, for aerospace composites and smart power meters, but in reality, we are just beginning to scratch the surface of where the bicycle will take us.

In terms of clincher, tubeless clincher and tubular construction, the future has a place for all three, but in very different ways. The potentially lighter system weight of tubulars will still have a place at the highest level of road racing, especially in hill climb stages of multi-day events. The handmade bike market continues to thrive, as does the trend for classic and retro themes build, both of which pair well with the tubular construction philosophy. However, we see an easing of demand in general consumer use for tubulars, as clinchers and tubeless clinchers continue to gain performance and durability benefits.

Rims continue to get wider, and will likely find their sweet spot soon. This further optimizes the ratio between tyre and rims widths, and enhancing tubeless clincher usability. As sealant products become more dependable and longer lasting, and liner systems are more broadly adopted, we expect this trend to continue.

Cycling has expanded from a fairly narrow sport to a much broader need, as now the bicycle is viewed as a transportation tool, perhaps more so than ever before. As the population continues to grow, and natural resources continue to diminish, the need for environmentally friendly transportation will continue its current trajectory of high demand. This demand will attract fresh perspectives, and new ideas, spurring further technological advancements, increased sustainability, as well as cultural change.

In the course of tyre evolution, we can be fairly certain that the three main elements (the tread, compound, and casing) will follow a similar path. Current KPIs will continue to evolve through clever design and material technologies from aligned industries.

The classic grip, speed, durability triangle will always be a standard to compare within the arena of simple performance, but the real excitement will likely fall outside of this bubble. This excitement will be targeted at a broader use, where elements of the past are used as building blocks for the new era. With material and process advancements, measures in ultimate mileage, system dependability, and sustainability all will increase, and won't come at the expense of the classic KPIs.

Technologies that already exist in other applications will continue to adapt, and take this already efficient machine further. While the thought of a lightweight supple racing Tyre that may last 20,000 mile is alluring, connected technologies will likely find their way into bicycle tyres in the not too distant future, creating a new perspective on what is actually meant by the term "cutting edge".

Will it be regenerative energy? Airless technology? Near infinite wear life?

It's may seem an impossible question to answer, but one thing is certain:

Technology will play a key role in the ride ahead.

As we have seen in this white paper, the casing material plays a key role in tyre construction, in clincher, tubeless clincher and tubular casing systems. In our next white paper, we will dive deeper into casing materials, and examine the properties of cotton, nylon and other materials, and roles each of these have played in the evolution of tyre manufacturing, as well as performance.

ABOUT VITTORIA

→ Vittoria is an international industrial group, producing premium tyres for race as well as utilitarian use. It pioneered the famous and unique cotton casings to offer very fast, safe, and comfortable tubulars and tyres for professional bicycle racing, and after several years of intense research, launched a full range of premium tyres utilizing a revolutionary new material called graphene.

Vittoria produces yearly many millions of premium bicycle tyres annually, with an ever-increasing portion using graphene. This makes Vittoria the world largest graphene buyer in the tyre segment. Together with its famous cotton casing, the graphene enhanced tread combines to produce the fastest tyres in the world.

For more than 40 years, Vittoria tyres were used by many professional racers who earned countless victories. Vittoria grew into the largest premium bicycle tyre producer in the world working with several leading tyre companies.

FIGURE 12. Vittoria Corsa Control road race tires, featuring Graphene compounds and cotton casings.