Bear in mind, that this is an "informal study" and the facts within, though compelling and accurate for the most part, are not exacting. By "not exacting", we mean that none of the photos were squared up except by eyeballing, none of the actual angles were measured and there was no allowance given for the artifacts produced by backgrounds, lighting angles and camera lenses. In short, this is not a very "scientific" essay thus you will find missing the usual (and usually suspect) plethora of confusing statistics & numbers that often appear in articles of this type. There's not much math here for one very simple reason -- there is no need for it. As we assembled the photographic evidence to support these theories regarding motorcycle tire wear patterns, the evidence **so obviously supported** the theories and so **strongly disproved other theories** we felt no need to provide minutia. True, that lack here may leave some unsatisfied. So be it. We invite those obsessed with such detail to supply same and we will be happy to add those facts to these since we have no doubt that the conclusions drawn by them will be the same as those drawn here by us.

The first question to be addressed is "What is tire wear?" Tire wear is the actual ***removal*** of rubber from your tire. ***Scuffing*** is what wears out your tires. Just like when you were a kid and skidded your rear bicycle tire to make marks on the driveway, the abrasion of scuffing is the **only** contributor to tire wear. If you never scrubbed anything off your tires, they would never wear out. It takes some pretty good stiff forces to come into play for pavement to scuff stuff off of your tires. This scrubbing of material off your tires becomes evident in what is called cupping, flat band upright tire wear which presents itself most evident on the rear tire and side flat band tire wear which presents itself most evident on the front tire. All of these wear patterns will be discussed and all are present to some degree on both the front and rear tire. But in the following discussion, it is important to remember that it takes a goodly amount of force where your tire meets the road to grind material off of your tires to produce tire wear. Too, we assume that you will run with properly inflated tires. Improperly inflated tires will cause all of these wear patterns to be greatly exaggerated and will cause you to lose many many serviceable miles. Check pressure often. Empirical evidence for Valkyrie and VTX tires shows that running 38/40, 40/40 or 40/42 (or slightly above/below) will greatly extend tire life. The Honda spec of 33psi for these bikes is way too low and is designed for maximum comfort and grip but minimum tire life. Increasing the pressures to some combination of the above will provide increased longevity and improved handling for these tires.

So, with that in mind, let us begin with probably the biggest bugaboo tire wear pattern in the motorcycle arena.

FRONT LEFT SIDE TIRE WEAR:

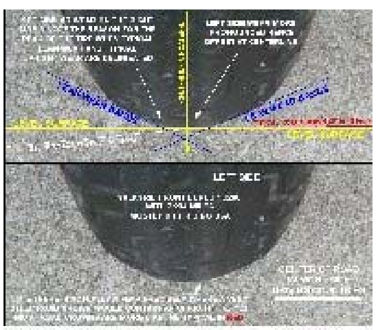
NOTE: "LEFT"& "RIGHT" are herein referred as one is sitting on the bike.

Thanks to Ron Fentress who provided me with a '98 Valkyrie which exhibited excellent wear patterns after some 7,000 miles of mostly city driving on the OEM Dunlops D206's. Many thanks go out to Marty Rood who first imparted to me the theory of "left side wear" the explanation of which and the details of cupping are my own.

There has probably been more misinformation and speculation concerning this common wear pattern on motorcycle tires than just about anything else. Why do the front tires show wear on the left side early? (Of course, that is a USA question as you will come to see.)

One needs really first to understand what causes "side" tire wear to begin with, as this "side" wear is evident on ***both*** sides of a front tire and also to a lesser degree on both sides of the rear tire. *Side wear is a band of wear evident on the sides of the tires at the most common lean angle for that motorcycle.* It is caused by the interaction of the pavement and the tires in a turn. When you turn, your bike really wants to go straight (Newton's First Law of Motion). You apply a force to make it turn in your wise desire to stay on the curving road. The bike's desire to keep going straight is the natural and inertial *centrifugal force* in this interaction and the force resisting the inertia making the bike turn to follow the road is the *centripetal force*.

As one can imagine, there is quite a bit of force coming into play when your bike makes a turn. You are probably not a light weight (how about a generous 200lbs with gear?). Your bike likely weighs in at several hundred itself (A loaded Valkyrie goes near 800 or more). Add to that half ton, the actual acceleration of your vehicle (about 45mph in a typical casual turn). So you are running fine up the road until the road presents you with a curve. You pitch your bike into a typical lean, that half ton at 45 wants to go straight and you need it to go around the bend. The only thing preventing a crash is about a 2 inch contact patch between your tires and the pavement where the forces involved in a simple casual turn exceed 1 G in space age parlance. The scuffing where your tire meets the pavement is what causes the "side wear" bands to appear sooner or later and this scuffing is the only "*force*" that is capable of producing the wear that eventually becomes evident. If one looks at the pictures of the worn front tire and the worn rear tire, the *squared off side band wear is evident at the typical lean angle for casual riding on typical roads.* In comparison with the tread pattern of a new Avon tire, one will see a much deeper tread precisely at the point where the squared off side band wear will eventually appear (might the Avon designers know something about this wear?).



But the question remains - Why is this wear more evident on the ***left front*** in most cases? Actually, excessive side tire wear is only evident on the ***left front*** in countries where one ***rides on the right side of the road***. Riding right means that the left side of your tire will have more (and likely faster) miles on it than the right side. Left hand turns have a larger radius than right hand turns in right side driving countries, hence you ride farther (and likely faster) turning left than turning right with subsequent increased side band wear on the tire's left side. The ***left side of your tire has more miles on it*** (in some extreme cases, **twice** as many) than the right side of your tire. And the **side** of your tire **only** gets mileage when you are leaned in a turn, otherwise, this area of your tire does not contact the pavement at all as shown in the photo. European left side drivers find that the right side of their front tires will wear out first. Quite the opposite effect for precisely the same reasons reversed. (If you're still not convinced, we will re-visit this issue later with more reasons)

REAR CENTER TIRE WEAR:

But if it's only the extra miles that cause the wear, wouldn't the center if my tire wear out first since I have more miles upright than leaned? Yes and some upright wear is evident upon inspection of a worn front tire as seen in the photo above left. Though this wear is not as excessive up front as the sidewall wear because of one factor... Upright miles on a properly inflated front tire are **rolling** miles with little scuffing taking place. If, on the other hand, you look at your rear tire, you will indeed see that the center wears out first and this wear is often exaggerated because acceleration, engine braking and real braking scuff stuff off the upright rear tire. Each time you downshift, upshift, roll on the throttle or roll off the throttle, you will scuff the rear tire at the contact patch. Along with that, the rear is your drive tire and at speed, the rear contact patch is the only thing that keeps you going (don't believe it? Just let off the throttle and see how quickly your bike slows to a stop!). Since most acceleration/deceleration and braking occurs when the bike is more or less straight up this wear is most evident in the center of the rear tire. Drive shaft bikes are the worst offenders since they are notably "herky jerky" and transfer the shock of accel/decel directly to the rear contact patch unbuffered. Belt and chain drives will "buffer" these shocks and lessen this kind of wear. This same scuffing action is minimal on the front tire because the front tire is *undriven* and merely rolls while the rear tire is doing all the inertial work. When brakes are applied, traction at the front tire improves minimizing scuffing while traction at the rear tire deteriorates maximizing scuffing.

CUPPING:

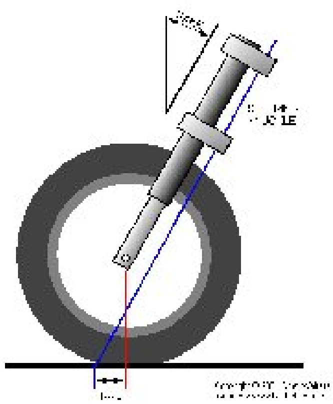
Cupping, which is more accurately described as ***scalloping*** (see pictures, but we will use the more common term "cupping" here), is a natural wear pattern on motorcycle tires and it will always follow the tread pattern. It is not a sign that you have bad suspension parts. It merely shows that your tire is indeed gripping the road when you make turns (thank you for that Mr. Tire!). This cupping develops within the side wear bands of a leaned motorcycle. The extreme forces that come in to play when the bike is leaned in a turn are what produce the effect and when the wear becomes sufficient, one will experience vibration and noise when one banks into a turn. Upon examination of the pictures at left of our sample rear Avon, our dusted front VTX Dunlop D256, and the picture of our chalked Dunlop D206 one can see how the cupping follows the tread pattern. The leading edge of the tread does not flex much as it grips the road and the rubber is scuffed off the tire in that area causing a depression. As the tire rotates, the pressure moves to the trailing edge of the tread pattern where the tread flexes more causing less scuffing so less material is ground off the tire. The more complex the tread pattern, the more complex the cupping pattern will be. The softer the compound of the tire, the sooner this cupping will develop. Radial tires are more prone to cupping than are bias ply because the compound of radials is softer. As one can see, the simple tread pattern of the Avon pictured produces a simpler scallop pattern while the more complex VTX D256 Dunlop is somewhat involved, though still easily seen in our photo. Cupping on the Valkyrie Dunlop D206 is very hard to photograph because of the complex tread pattern. Low tire pressure will exacerbate this wear pattern and you will lose many serviceable miles by running low. Improper balance has nothing to do with cupping on a motorcycle tire. Improper balance will merely cause your bike to vibrate within certain specific speed ranges.

The following textual illustration comes from Martin who contributed to this article by E-mail on June 26, 2006:

I was just reading your bit on "cupping" and thought I'd share with you how I describe what's going on. I usually tell people that what's happening is that the individual "blocks" or "islands" of tread are squirming and deforming due to the forces applied to them during cornering and braking. When this deforming takes place, the wear is naturally not evenly distributed across the surface of the tread. (I define a tread block as an area of the tire surface surrounded by a groove.) I next tell people they can demonstrate to themselves what's happening by taking a new pencil with an unused eraser on the end and while holding the pencil perfectly vertical, push down and drag the eraser on a rough surface in one direction. Then I tell them to look at the eraser and note that all the wear is on the leading edge and not evenly distributed across the end surface of the eraser. It seems to make the concept easier for many to understand. Cheers!

OTHER FACTORS:

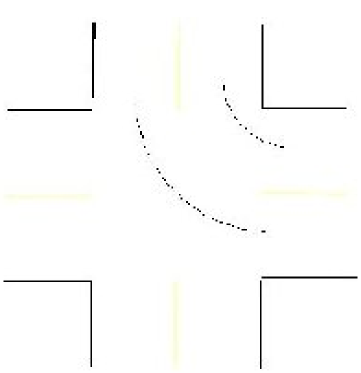
The frame geometry of the motorcycle can play a major role in how early on the "left side" phenomenon makes itself evident. On the Honda Valkyrie and the Honda VTX models, rake is 32° and trail is nearly six full inches. A long trail can cause the wear on the sides of the front tire to show earlier because of the "shear" effect in turns as your front wheel is pointed slightly in the direction of the turn. The front wheel has less a tendency to roll through turns and the shear force at the contact patch helps scuff the tire at the common lean angle. As a personal test, I ran an OEM D206 Dunlop on the front of a stock Valkyrie and got around 8K miles on it. When replaced, it had definite and prominent signs of left side tire wear. I replaced the tire with another D206 Dunlop and after about 3k miles, it began to show signs of left side wear as well. At that time, I replaced my stock triple clamp with a TBR triple clamp which reduced trail. From that time on, the left side wear was reduced to a great degree. The Avon with which I replaced that D206 now has over 15k miles on it and though there is some evidence of left side wear, it is not as pronounced as it is with some I've seen using the stock clamp. The Avon profile helps the front tire roll through turns with less shear.



Rake is measured as the angle of the steering knuckle off perpendicular with the bike upright, at rest and unloaded on a level surface. Trail is measured from where that angle intersects the level surface to the point plumb with the front axle. Factors that can affect trail: the angle of the forks relative to the knuckle; the distance of the forks from the knuckle; raising or lengthening front suspension to increase rake; lowering rear suspension to increase rake; loading the bike with a passenger; apply brakes (dive). Ever notice that it's harder to steer your bike when you have a passenger? It's because the extra weight compresses the rear shocks increasing rake besides making the bike heavier overall. Rake hence trail changes are also dynamic so should one change the balance of the rear suspension with the front (the rear flexes more than the front or vice verse in turns and causes the rake/trail to change while in a turn). Causing the front to dive less in turns with heavier fork oil or heavier springs will take some weight off the front wheel and lessen side band wear.

Trail is necessary for your bike to be stable going straight, but it is also necessary for turns since **trail causes your front wheel to steer *itself* into the turn**. Countersteer and trail's geometry effect resulting in a turn is discussed at Wikipedia in detail.
used to initiate the turn (the bike momentarily turns in the wrong direction) then once the bike leans shortly thereafter, trail causes the front wheel to turn *itself* into the turn which is what actually steers the bike in the desired direction.

OTHER THEORIES DISPROVED:



But what about road crown? Plausible and many claim it, but ***road crown plays no part whatsoever in left side tire wear.*** Though it does seem logical and also allows that in European left side driving countries, the crown is opposite which could explain *right* side wear there - road crown just doesn't hold up under scrutiny. The main reason the theory falls on its face - road crowns are simply not steep enough. If you examine a picture of the front tire upright, you can see that even a very steep road crown (one inch drop in one foot run) ***would not even contact the tire*** at the necessary angle to produce the evident wear. Typical road crowns are much much less (three inches drop per twelve foot run). In fact, if one examines the picture of the tire one can see that where a road crown would actually contact the tire, there is a ***PEAK*** rather than a valley (check our extreme wear pic at the top of this page). Plus, as described in the paragraphs above, road crown contact is mostly "rolling" contact which produces very little wear if any at all. ***Just so there is no misunderstanding, road crown plays no part whatsoever in left side tire***

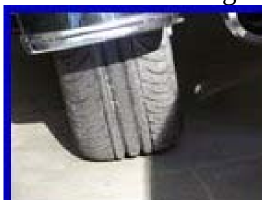
wear. *Road crowns, if they exist at all on a road, are completely inconsistent and vary greatly as to pitch, vary even more greatly in turns (road engineers do indeed "bank" turns), and crowns **in no way contact** the tire at 20° off horizontal where the wear occurs. Road crown does not cause side tire wear.*

STILL NOT CONVINCED?

Avon Rear with 13K courtesy GOZOOM Note excessive side wear due to heavy Valk Interstate rear end. Click for larger

If you are still not convinced that increased mileage is what causes one sided tire wear on the front tire of motorcycles, you'll have to come up with a theory that satisfies all of the evidentiary criteria. **A**) It will have to explain the fact that when riding upright, the tire's side wear bands do not contact the pavement (road crown, unbalanced/off center bike weight and even wheel misalignment won't work). **B**) It will have to reverse itself in countries where one rides on the left side of the road rather than the right (road crown still sounds plausible here but it was eliminated in "A" above).

In the case of right side driving countries like the USA, one does indeed ride farther on the left side of the tire than on the right side of the tire. At a simple single lane intersection that is common in most residential neighborhoods, negotiating a left turn will have you traveling TWICE the distance that you do making a right hand turn. That's at a simple single lane intersection. A double lane will have you making four times the distance. But even when you are confronted with nothing more than a left curving road, the radius of that left turner will be larger than if you were coming the other way on the same road making a right around that same curve. If you don't believe this, check out the How Stuff Works web site about your car's DIFFERENTIAL and why it's called a ***differential*** (your shaft driven two wheeled motorcycle does not have a differential, it has instead a "final drive" which drives only one wheel). Also note that Olympic runners start in different locations because the outside runners must run farther to the finish line. --


Car tires are not immune to left side wear. Here is a car tire on a GL1800.

Besides the fact that the left radius is larger which means you will probably go faster causing more stress on your tire than you would going the other way, there is more visibility when making lefts than rights which will add to your tendency to make the turn faster as well. Failure to negotiate a left turn will have you going off the the road onto the shoulder or into a ditch. Failure to negotiate a right turn will have you crossing into opposing traffic. Though neither scenario is appealing, there is a subliminal advantage to left turns (riding shoulders and ditches is better than crashing into trucks head on) and this will have you going a bit faster on lefties too.

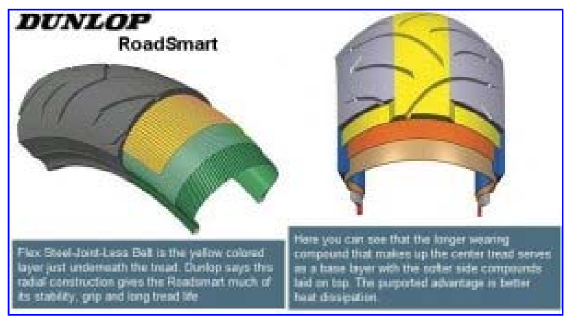
The increased radius on left turns means more distance is traveled turning left than turning right on the average riding day. That is plane geometry and plainly undeniable. Because of the natural tendency to make left turns faster (admittedly this is subjective and open to debate, but is plausible for reasons given) there will be more stress placed on your tires as they travel that longer left distance. Increased left side tire wear is evident, though, on both the front and rear tires but because the front tire shows less evidence of

flat band center wear (which disguises the side wear bands on the rear tire), side wear is more evident to the eye up front and leaves you to wonder, "Why does the left side† of my front tire wear out first?" Now you know.

† Of course, if you live in Singapore, you'll say, "Why does the RIGHT side of my front tire wear out first?" And now you know as well!

Single compound front.

Single compound front.



Dunlop RoadSmart is dual compound rear only.

Dual Compound Tires

Pirelli Diablo Corsa III (rear only)

Michelin Pilot Power 2CT (front and rear)
Michelin Power Race 2CT (front and rear)

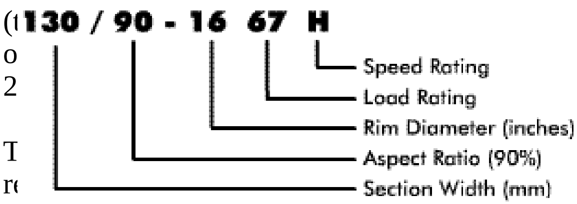
Dunlop RoadSmart (rear only)
Dunlop Sportmax GP (rear only)

Bridgestone Battlax BT45 (bias ply rear)
Brigestone The Battlax BT-021 (rear only)

circumference of a tire is necessary for a speedometer, always measure the tire, never depend on this formula to give exact readings for a bike tire.

NOTE ON TIRE SIZES - The standard formula may not work for bike tires...

After installing a Metzeler 200/60-16 tire on the rear of my VTX I tried to set my Sigma digital speedometer² on my VTX using this formula...



(t per inch plus wheel diameter = total height in inches
o
2 4 | 9.44 + 16 = 25.44 inches total height

T ameter then x 3.14 for circumference. However, the sigma
r(ured the tire with a tape. The formula for a Metzeler 200/60 - 16 yields 79.9 inches (2029mm) for circumference, but the measured circumference of the tire is actually 81.39 inches (2067mm). Using the measured 2067mm for the sigma gives dead on readings as checked by radar. Wazznt able to accurately measure the diameter since the tire is mounted but math reveals the formula should give 25.44 inches (646mm) as diameter and the actual measured circ would yield 25.92 inches (658mm) (81.39 / 3.14) as diameter.

I was finally able to measure a new mounted Avon 180/70 x 16 as 80.8 inches (2054mm) while the formula yields 25.92 inches as diameter and 81.39 (2067) as circumference. However, the Metz 200 is a little pinched on the five inch rim which causes the increased height. Measured width of the Metz 200 on this rim is 7.625 inches (193.67mm) while the Avon mounted measures 7.25 inches (184.15mm).

Metzeler 200/60-16	**Diameter**	**Cicumference**	**Width**
by formula	~~25.44in (646mm)~~	~~79.90in (2029mm)~~	7.87in (200mm)
as measured	25.92in (658.2mm)	81.39in (2067mm)	7.625in (193.67mm)
.	.	.	.
Avon 180/70-16	**Diameter**	**Cicumference**	**Width**
by formula	~~25.92in (658.2mm)~~	~~81.39in (2067mm)~~	7.08in (180mm)
as measured	25.75in (654.1mm)	80.8 in (2054mm)	7.25 in (184.15mm)

Metzeler also reports that the tread depth on the 200 tire is 6.5mm while I was able to measure variance from 4.8mm at the outer edge to the deepest which is 5.4mm. Here is a copy of the size comparison from the Metz web site courtesy of Blue Elf of the VTXOA.

ME880		(A) Measuring Rim	(B) Rims Permitted	(C) Max Width	(D) Max Diameter	(E) Load Capacity	(F) Max PSI	(G) Max Speed	(H) Tread Depth	(Z) Tire Weight
180/70HR16	R	5.00	5.00-6.00	175	664	908	42	130	9	20.28
200/60VR16	R	5.50	5.50-6.25	197	659	963	42	149	6.5	N/A