Suspension Basics for BMW Motorcycles

by Ron Schmidt

History

BMW has been the leader in motorcycle suspension technology from the beginning of motorcycles. They were one of the first pioneers of telescopic forks and rear suspension in the mid 1930's, when rigid frames were common.

The /5 models beginning in 1970 were equipped to meet the desires of BMW's clientele of those days. BMW was then viewed as an old man's luxury bike, made to cover long distances in great comfort. The driveshaft eliminated the bothersome and messy chain drive common to lesser motorcycles. The engines were glassy smooth for their day, and made excellent torque in the rpm ranges where gentlemen operated them. They had reliability that made long distance touring a real possibility. The suspension was tuned for that customer; plush, long travel, lazy suspension that would be unnoticed rather than really appreciated.

As BMW began to look at a younger market (since the old guys were dying off!) the suspensions had to become more modern. The first big step happened in 1981 with the introduction of the Monolever rear suspension on the R80G/S. It was the first production motorcycle to have a single-side swing arm which improved the handling dramatically.

On typical driveshaft-equipped motorcycles, the chassis rises when accelerating and squats on deceleration. This reaction becomes more problematic as suspension travel and power increases. In 1988, with the introduction of the R100GS, BMW released the Paralever rear suspension. The Paralever system reduced the drive shaft reaction to throttle changes. It was a very noticeable improvement even on that bike which only made 50ish horsepower. The Paralever has had evolutional improvements but the basic idea has allowed BMW to produce drive shaft motorcycles with prodigious power output without launching the bike into orbit when the throttles are turned wide open.

For decades, front suspension technology on motorcycles had stalled at telescopic forks. Certainly there were detail improvements with the forks as time passed, but the very nature of the design is flawed. With the advent of the Oil Heads in 1994, BMW introduced the first mass produced update to front motorcycle suspension. The Telelever suspension has so many advantages over forks that it is a mystery to me why BMW is still the only manufacturer using something other than the old outdated forks. Advantages gained by the Telelever include reduced dive during braking, separation of suspension and braking forces (allowing the suspension to do its job even when the front brake is being applied), near elimination of "stiction" (stiction is the fork's resistance to movement caused by friction, which results in its inability to react to small inputs), diminished chassis geometry changes with suspension movement, and its ability to resist flex that would take a fork tube the size of a sewer pipe to accomplish. In my opinion, the Telelever suspension may be viewed in history as the most dramatic improvement to motorcycles since the first internal combustion engine was bolted into a bicycle frame.

When the K1200S was introduced in 2005, BMW changed the Telelever to a new system, the Duolever on the K series. It has the same advantages as the Telelever over standard forks. This double trailing arm system allows the engineers to design the exact arc they desire for the front wheel as it moves through its travel.

BMW now even offers push-button, on-the-fly adjustable suspension. What next?

2025? Totally active suspension? How about a sensor, mounted so that it can "read" the bumps in the road before the wheel actually gets there, can allow the suspension units to lift the wheel the exact amount needed so that it will stay in perfect contact with the road, or perfectly glide over an obstacle, then return the wheel to the road surface. It will be needed when BMW is building bikes that make 300 HP and have speed potential of 250 MPH. It may be sooner than 2025 at the rate BMW is going today!

Suspension Components

When we speak of suspension, the first thing most of us think of are springs and dampers. While this makes up the lion's share of today's seminar, let's not overlook some other important items.

Tires: Tires are the first part of any suspension system. The design of the tire and even the pressure you run can have a profound affect on the way your motorcycle handles. Stiff, low profile tires will give a sharper feel to the bike, as will higher tire pressures. Those of us who ride our GS's off the road will decrease the tire pressure to about 50% of the street spec when we are in the dirt. The tire then becomes a very active part of the suspension, but will wallow like an old pig if not re-inflated when pressed back into pavement duty. It still surprises me when we have a customer complain that his BMW needs new shocks when they come in with nearly flat tires. It is possible that the best dollars-per-unit improvement you can make to your BMW may be in keeping the tires inflated.

Chassis: There is not much that we can do about the chassis design, unless we are Troy the Welder, but it is a fact that different frames and swing arms flex differently and therefore are part of the suspension. On the Airheads, we often braced various parts of the frame and swing arms, resulting in improved handling that even mere mortals could appreciate. On the latest BMW's it would take the likes of a Valentino Rossi to even notice if the parts were stiffened. Stiffer is not always better. One of the Japanese racing bike manufactures controls the stiffness of the frame in various areas to allow some flex for better handling. So, Mr. Rossi might not even like it if Troy stiffened his new BMW.

Springs: Springs control the ride height of the motorcycle and the ability to allow for different loads. On most BMW's there is a way to adjust the spring preload to some extent so that the ride can be optimized for a light rider or two-up operation with luggage.

Dampers: Dampers control the speed and frequency at which the suspension operates by changing the kinetic (moving) energy to thermal (heat) energy. Without the damper, the suspension would oscillate as each movement occurred, resulting in decreased vehicle control.

Dampers on BMW's fall into two main groups. On airheads, older K bikes, F and G models, and the R1200 HP-2, the front dampers are integrated into the forks. On the rear of the above mentioned models, and on both ends of all the rest of the bikes, there is a more common shock absorber, around which the spring is located. The HP-2 uses an air spring and air dampened rear shock.

Seat: We know that a seat isn't part of suspension, but a bad one sure can make you miserable. We have sent dozens of seats to our friend Mike Harris for inexpensive mods that might improve your riding enjoyment more than any suspension changes you could make! Let us know if we can help you with this most important item.

Terms and How Components Work

The black science of adjusting suspension is a broad and often argued subject, right up there with oil, politics and religion. We are going to discuss some basics of spring and damper adjustments today. This is a 90 minute seminar—each of the items we will discuss could be argued for days!

Before we start to adjust springs and dampers, we need to know what each part does and how it affects the ride and handling of our motorcycle. These adjustments can make a dramatic change in your bike. There are some basic setup rules to follow, but a large part is personal feel. Different riders will want different setups and each is as correct as the other. So, much of the setup is going to be decided by what you like. With aftermarket suspension units, you might be able to get the suspension so far off that it could be dangerous. BMW units adjust over a narrower range, so you almost can't make such a big mistake as to cause any safety issues.

Spring Rate: The Spring Rate is a measurement of the stiffness of the spring. The rate is engineered into the production of the spring. It can be controlled by the type of material the spring is made of, the diameter of the wire, the heat treating of the wire, and how closely the windings are together.

Single Rate Springs: On a single rate spring, the spring will yield the same amount for each unit of force applied to it, i.e. if it moves 5mm when 10kg is applied to it, it will move 10mm if 20kg is applied.

Progressive Rate Springs: These springs are wound in a manner so that some of the coils are closer together than others. The progressive nature results in more movement initially and less movement as the spring compression continues for the same force applied. So, in our example above, the spring might move 5mm when 10kg is applied to it, but only move 4mm for the next 10kg, resulting in a total of 9mm at 20kg rather than the 10mm of the single rate spring in the example.

A similar progressive nature can be accomplished by stacking single rate springs of differing rates together. The advantage of progressive springing is that it allows the suspension to feel softer on the small bumps, but still be able to allow a broader variance in the load carrying ability and reduce dive on heavy braking.

Spring Preload: Once the spring rate has been chosen, a preload must be adjusted. The spring must hold the motorcycle up to some specific ride height. If the preload is insufficient, the bike will ride too low. If too much preload is applied the bike will sit too high.

Compression Damping: The damper unit is designed to resist compression. When the tire hits an object on the road, it is forced to move up. The tire, wheel, and all the suspension components have mass. When that mass is moved it will continue to move until some force stops it. If we were to have a spring stiff enough to stop the movement in a reasonable amount of wheel travel, it would have to be so stiff that the ride would be very abrupt and uncomfortable, even dangerous. The damper slows the movement of the wheel and other components by changing the kinetic energy to heat energy. As the damper is compressed, oil in it is forced through orifices, causing pressure and therefore heat inside the damper. This heat is dissipated though the damper unit and into the air that cools it. So, we can run a substantially softer spring and still control the wheel movement as the suspension is compressed.

There are two main types of compression damping: high and low speed. High speed damping addresses sharp edged impacts like running over a board in the road. Low speed damping is to help with stability issues such as when transitioning from a straight road into a turn, or when going into a dip similar to crossing an intersection.

Rebound Damping: After the suspension is compressed and the force that compressed it is gone, the spring will begin to push the wheel back to its static position. This movement is called rebound. The rebound damping is to control that movement. Without the damper, the spring would return the wheel back to static, but the movement would not stop there. Rather it would continue until all the energy was expended, which would be well beyond the static position; usually it would be stopped by the collision of internal parts of the damper as it came to the limit of its travel. That stop would be abrupt, dangerous, and very hard on the equipment. So, just as with the compression damping, oil in the damper is forced through orifices, causing pressure and therefore heat inside the damper. This heat is dissipated though the damper unit and into the air that cools it.

Unlike the compression damping, though, the rebound damping is very consistent. The force is supplied by the spring, which is a set value, and the kinetic force of the suspension, wheel, tire, etc., which is also mostly consistent. Therefore, high and low speed rebound damping is not usually adjustable separately. Position damping characteristics can be set during the shock manufacturing though, because we know there will be more force supplied by the spring when the suspension is compressed a lot than there will be when it is compressed a little.

Suspension Setup 101 for Stock BMW Suspension Units

Most BMW's have an adjustment for the spring preload on the rear; some have spring preload adjustment on the front. A few have rebound damper adjustment on the rear; fewer still have rebound damper adjustment for the front. The adjustments make a difference, but are limited to a range where you can't make them dangerous by mismatching the adjustments.

BMW still tends to calibrate their suspension to the soft side on the springs and the fast side on damping. In almost every case, you will probably be adjusting the suspension toward the stiffest spring and slowest damping if you are planning to ride hard or carry a load.

Start with the spring preload to adjust ride height. Put the motorcycle on the centerstand so that there is no load on the suspension. Take a measurement from the axel (or center of the wheel) to a point on the frame, perpendicular to the ground above it. Then, load it as you intend to be riding it, i.e., put all your weight on it, plus your luggage, passenger, dog, etc. Roll the bike off the stand and repeat the measurements. This might be easier if you have a friend take the second measurements! The difference in the two measurements is called "sag".

A good rule of thumb for sag is as follows. For casual riding about 1/3 of the total suspension travel is good. For sportier riding about 1⁄4 of the total suspension travel works well. So, if your R1150GSAD has 8" of front travel and you are on a sight seeing ride, set the sag to about 21⁄2". If you are going to try to keep up with Thane (good luck!) set it closer to 2". Do the same for the rear suspension.

If your bike has adjustable rebound damping, adjust it as follows: Turn the adjuster SOFTLY clockwise until it stops. Then, turn it anti-clockwise SOFTLY until it stops. Count the clicks or, if it does not click, count the turns. Be accurate if you are counting turns, there is a lot of difference between 2 turns and 2 1/3 turns! Then turn the adjuster back half way between fully closed and fully open. Go ride the bike, paying particular attention to what it does in the most aggressive high-speed cornering you intend to do. If the bike feels like it is wallowing, turn the damper clockwise 1⁄4 turn and ride it again. Keep doing this until the wallow goes away. Once you damp the wallow out, don't turn the adjuster in any more as it does make the ride quality on smaller bumps less compliant.

Suspension Setup 201 for Aftermarket BMW Suspension Units

Due to the various options for aftermarket suspension, a specific set-up procedure for each would be outside the scope of this seminar. However, we can help with some basics.

The best single rule of thumb I can give you is to set the suspension as soft as possible to meet your needs. While this will probably be stiffer than is possible with the OEM suspension, setting it stiffer than necessary makes the bike feel busy and can lead to other problems like head shaking. A stiff, busy bike will make you fatigue faster and demands more attention to ride. That is not good, whether on the street, track or trail.

Because the damping on most aftermarket shocks is stiffer than BMW's settings, we can reduce the sag some and still control the wheel movement. I usually set up closer to 25% wheel movement sag for easy riding and about 20% for sportier riding.

Many of the aftermarket units also have mechanical ride height adjustment afforded by an adjustment to the unladen length of the shock, not by spring preload. Unless clearance is an issue during cornering or going over obstacles, I would not add to the ride height. It raises the center of gravity of the bike, which is not a good thing. If you are experiencing clearance issues, raise it only the minimum necessary to eliminate the problem. If you are trying to get over a 25" log with your GS, you are in need of a trials bike, not a longer shock!

Rebound damping adjustment follows the same as described in 101 above. However, be aware that you can go too far and end up with "pack down". Pack down is when a series of bumps are hit in rapid succession and the damper does not allow the suspension to return fast enough. When that occurs, the damper keeps getting shorter until the suspension becomes so stiff that it will not respond to the next bump.

Many of the aftermarket shocks have separate adjustments for high and low speed compression damping. The low speed addresses issues such as bottoming on the down side of elevation changes, or excessive suspension movement when diving into a fast turn. Slow the damper as little as possible to eliminate the transgression; any more just limits the suspension movement unnecessarily. The high speed damping addresses more abrupt disturbances such as square sided hits. I have found that too much high speed compression damping makes the suspension less compliant which results in poor ride quality and a skittish feeling which is not confidence inspiring.

The Inevitable Sales Pitch

BMW uses some of the highest quality suspension available on their motorcycles. Their longevity is superb; and they perform wonderfully within the parameters that BMW expects their motorcycles to be operated.

However, due to the soft nature of the BMW OEM suspension, you may find that you might not be able to damp the entire wallow out, or that even with the spring preload set to maximum you cannot obtain the desired sag, or that you bottom the suspension regularly, particularly on the GS models when used off road and loaded for camping. This is where the aftermarket comes to your rescue.

Through out the years, all of my personal BMW's have eventually been outfitted with aftermarket suspension units. I seem to ride a bit outside the box that BMW wants their bikes used within, so in each case the change has been positive. Perhaps this is due to almost 400,000 miles riding them, or lack of intelligence, but in every case the performance and comfort improvements have been noticeable and appreciated. So, here are my findings, based on actual experience from my miles and looking at scores of customer owned bikes.

If the bike has forks rather than a Telelever or Duolever front end, a progressive spring or a multiple single rate spring set is a must. I have used many brands, but you just can't go wrong with Works Performance stuff. They have done all the home work and their suggestions will be right on the money if you give them accurate information. Race Tech makes a device called an "Emulator" which emulates a cartridge style fork. They make them to fit some of the airheads and many of the early K bikes. They are pretty close to magic.

For the rear of any BMW, and those with Telelever front suspension, I recommend Works Performance as well. I used to be a big fan of Ohlins, but have found that while they work superbly, they seem to have all too frequent seal failures. If the seal fails in your garage it is just an inconvenience. When it fails in the middle of nowhere it is worse. Here in the shop, we have had customers bring in some of the newer brands of shocks and have found that they do not fit at all, or are set up so that they need to be removed to adjust them! There may be products out there that work as well and are as reliable as Works Performance products; there may even be others that will custom build a shock for your needs, then guarantee that you will be happy with them or they will modify them at no charge for the adjustments. There might even be some that have been servicing the needs of motorcyclists in general and BMW in particular for 35 years here in the USA. Let me know if you are aware of one that meets all these parameters. I don't know of any others.