The Mark Ortiz Automotive

CHASSIS NEWSLETTER

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WELCOME

Mark Ortiz Automotive is a chassis consulting service primarily serving oval track and road racers. This newsletter is a free service intended to benefit racers and enthusiasts by offering useful insights into chassis engineering and answers to questions. Readers may mail questions to: 155 Wankel Dr., Kannapolis, NC 28083-8200; submit questions by phone at 704-933-8876; or submit questions by e-mail to: markortizauto@windstream.net. Readers are invited to subscribe to this newsletter by e-mail. Just e-mail me and request to be added to the list.

EFFECT OF CHANGING LOCATION OF JUST THE WHEEL CENTER

We run a 410 winged super sprint (World of Outlaw type car). Some guys claim that they have seen gains by using deeper backspaced wheels (particularly on the RR), and then using the axle spacers to achieve the same tire spacing that you would normally run. (measured from the center of the contact patch to a specific point on the chassis) My question is does the chassis, axle, or tire really know where the wheel center is, as long as the distance from the center of the contact patch to the measured point on the chassis is the same?

I see no reason to suppose there would be any effect from moving just the wheel center, or at least any effect that one could measure or detect when driving the car. The wheel center does have a little bit of mass, and the location of that small mass would change. There could be small changes in the patterns of deflection within the wheel and axle, but it would take sensitive strain gauging to measure those. Compared to the deflections elsewhere, particularly the very soft tires and suspension, they should not be significant.

It might also be possible for a person to think they had the same tire location, but measure or calculate this incorrectly, and reach an erroneous conclusion that way.

Overall, though, changing only the location of the wheel center shouldn't affect the car. If a driver thinks there's a difference, this could be attributable to "placebo effect", or it could be that the car really did go faster after the change, but it really was due to a better tire on the new wheel, or due to the track coming in while the change was being made to the car. It's always difficult to draw conclusions about a car change from lap time or car feel when racing on dirt, because the surface is changing so rapidly that it's impossible to get controlled back-to-back runs on identical racing surfaces. It is possible to get a better idea if we try the same change many times, but in most cases we'll be trying other things as well over a series of races, which again throws some additional ingredients into the pot. One testing technique that sometimes helps is to go back to the original setup and see if the lap times or car behavior go back to original. However, on dirt even this can be tricky, because usually the track first comes in and gets faster as it gets packed and dries from sloppy to tacky, then gets slower again as it dries from tacky to dry slick.

EFFECTS OF DROOP LIMITING

I have some thoughts/questions about droop limiting. This subject comes up from time to time on internet message forums, and I've never read a (or successfully derived and written my own) conclusive explanation on whether or not it "works". Even the way in which it "works" is never clearly specified.

I always approached droop travel in terms of the basic equations in Milliken - it should be proportional to bump, which is itself constrained by ride height/ground clearance and spring rate, but it is not a tuning tool all by itself. Hence when I see a race car with very limited droop travel demonstrated, say, during a pit stop, I would ASSume it is due to the car being fairly stiffly sprung in bump.

Conversely, internet lore seems to be that if you artificially limit droop, with tethers or modified dampers, it will decrease the peak roll angle of the sprung mass. Here's a direct quote from one such discussion: "If the inside can't extend any further, than the roll has to come from the outside compressing." I see. While I find the idea of a non-linear roll gradient interesting (especially in terms of camber compensation), I'm not sure the math supports this conclusion. Maybe what I should say is that I can do math that will support it, but I'm not sure if I'm basing it on solid assumptions.

To confuse me further, in your September 2007 newsletter, in response to question on rear shock droop travel on a Mustang, you wrote: "I can say this with certainty: when the inside rear suspension tops out, the rear roll resistance increases dramatically, and that makes the car looser (produces oversteer)."

My questions:

1. Specific to the September 2007 scenario, what is the relationship between inside rear suspension topping out and roll resistance? In other words, are there solid axle effects involved?

1b. Have the Smithees folks in Australia [referring, I believe, to persons basing their thinking on the writings of the late Carroll Smith] *been right all along when saying that when a damper reaches full droop, all of the remaining load on that side is instantly transferred to the other side? My gut feeling is that if running out of travel caused two wheeled motoring, there would be a travel component in the basic lateral load transfer equation... and there isn't such a term.*

2. Regarding limiters that prevent the suspension from extending fully... the scenario I am picturing is a car in steady state cornering, below the point where it has transferred all of its load from the *inside to the outside, which results in a sprung mass roll angle of X degrees. If at 80% of that roll angle, the inside wheels run out of travel, the lateral load transfer is not high enough to cause/support two wheeled motoring, so the inside wheels will remain on the ground. So now what happens when the lateral acceleration increases up to the delimited example? If the outside continues to compress with increased lateral load, and the inside remains on the ground, this seems to be lowering the dynamic CG.*

When the suspension at any corner of the car runs out of travel in either direction, the suspension at that corner becomes much less compliant: any attempt or tendency to move the suspension beyond that point meets with much stiffer resistance. This is true if the outside suspension bottoms out, as well as if the inside suspension tops out. In banked turns, it is even possible to have bottoming on both sides of the car at once. Cresting a rise, it is possible to top out both sides at once. It is possible to top out or bottom out anywhere from one to all four corners of the car.

It is possible to have a condition of travel limiter contact, but no travel limiter load – that is, a condition where the travel is just barely used up, but the suspension would not move further, even without the travel limiter. We might call this the point of takeup, or impending takeup, or impending bottoming or topping out.

At the point of impending takeup, the travel limiter has no effect on the car at all. The travel limiter starts to affect the car as we start to load the travel limiter. The more we load it, the more it affects the car.

So it is not correct to say that all the load is on the outside wheel as soon as the inside one tops out. Rather, all the load is on the outside wheel when the inside wheel reaches the point of impending lift. This often requires an additional increment of acceleration, although the two thresholds may be reached so close together in time as to appear simultaneous.

When we top out the inside suspension at just one end of the car, any lateral acceleration beyond the value required for impending takeup meets with added elastic roll resistance, just at that end. That does increase load transfer at that end and decrease it at the opposite end.

All types of suspension are subject to these principles, but there is a bit of a difference in the case of a beam axle. Usually, the travel limiter is some distance inboard of the wheel. This means that when we hit the limiter on only one side of the car, further roll does involve some further displacement of the near wheel, although not as much as the far wheel.

For example, if we have a beam axle with the shocks midway between the wheel plane and the car centerplane, and we top out the inside shock in cornering, roll beyond that point involves compression at the outside wheel that is three times as great as the extension at the inside wheel. In effect, the axle has to pivot about the topped-out shock.

If the car has independent suspension, a topped-out shock, or the equivalent, stops displacement at that wheel, and further roll can only occur by compression on the opposite wheel.

Either way, the effect on elastic roll resistance for the wheel pair is a dramatic increase. When we top out the inside suspension, the car does lose ride height and c.g. height as it rolls further. Conversely, if we bottom out the outside suspension, the car gains ride height when it rolls further.

When we bottom out or top out one or both wheels on a side of the car, the effect on elastic pitch resistance for a right or left wheel pair is also a dramatic increase, and this is very important. Topping out the inside suspension on a road racing car has an effect similar to left-stiff spring splits on an oval track car: braking while cornering de-wedges the car and loosens it (adds oversteer); applying power while cornering wedges the car and tightens it (adds understeer).

By "tying down" the suspension in droop, we have a way to make the car "inside stiff" in both right and left turns.

Furthermore, we don't have to tie down the front and rear at the same point, or with the same degree of rigidity. If we only want to tighten exit, we can tie down just the front. If we only want to free up entry, we can tie down just the rear.

And, since the car does corner a bit lower, we do get slightly reduced c.g. height. Whether it's smarter in this regard to just run the car lower statically will depend on how bumpy the turns are, compared to the straightaways, and whether we can run the car lower statically and still be legal.

It will be apparent that this isn't simple, nor a magic way to make any car faster. Using this is tricky. The suspension doesn't know if it's getting topped out or bottomed out due to a crest or dip in the road, or a bump or hole, or braking, or cornering, or power, or banking, or variation in aerodynamic loads. It doesn't know if it's getting topped out or bottomed out due to displacement in roll, pitch, heave, warp, or some combination. When it hits the limiter, it hits the limiter, and from there it's rigid, or much stiffer.

Consequently, using travel limitation of any kind to control car behavior is a strategy to be approached with great caution. Using this strategy makes it harder to get acceptable car behavior in all conditions, and tuning a car using this strategy tends to yield highly track-specific, and condition-specific, setups.

Reasons to put up with this include not only tuning entry and exit balance, but also working ground clearance rules and controlling under-car aero effects.