The Mark Ortiz Automotive

CHASSIS NEWSLETTER

PRESENTED FREE OF CHARGE
AS A SERVICE TO THE
MOTORSPORTS COMMUNITY

January 2010

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.

USE RIDE HEIGHT TO TUNE CORNERING BALANCE, OR ANTI-ROLL BARS?

I have a FF1600 (i.e. no ground effects) and the person who runs the car and I differ on how it should be set up:

1. *He first gets the handling roughly right by raising the rear ride height and then fine tunes the handling with the rear ARB. This assumes the ARB is already of the required size,*
2. *I think the car should be kept flat so the CofG is as low as possible and only use the ARB*
3. *He says that having the car flat will require an harder rear ARB (which is true) and this in a turn lifts the rear inside wheel more*
4. *My response is that if the handling is the same the weight transfer must be the same. This means the rear roll stiffness is the same so the inside wheel will be lifted by the same amount.*

So who's correct? Point 4 isn't quite true because a lower CofG will affect the handling but the general principle still applies. I could try this out in the workshop but this would be a lot of unnecessary effort if the answer is already well known.

Basically, the questioner is correct here. The tires don't know if the load transfer comes from geometry or springs or anti-roll bars.

Raising the rear ride height affects handling mainly by raising the rear roll center. This adds load transfer, just like stiffening the rear bar does.

In general, the car will go fastest with both ends as low as possible. How low we can go will generally be determined by the need to avoid bottoming, with perhaps some additional influence from aerodynamic considerations. Both of these factors may call for slightly more ground clearance at the rear than at the front.

It is common for race cars, especially rear-engined ones, to have lower natural frequencies in ride in the rear than in the front. That will mean the rear suspension deflects more at the bottom of a dip than the front suspension.

To get good air flow under the car, it generally helps to have the under-car space open up a bit toward the rear. This will generally reduce both lift and drag.

But the idea is still to run both ends of the car as low as these constraints will allow. It is not a good idea to balance the handling by running either end higher than necessary.

ROLL CENTER AND ANTI-LIFT IN TRIANGULATED 4-LINK BEAM AXLE

I am in the process of converting the rear of a front wheel drive rallycross car from its present format to a solid beam axle, primarily to save weight. Tthe current set up actually works very well, but by removing both the rear chassis rails and floor and replacing these with a light weight semi space frame setup clad in either aluminium or a carbon /Kevlar sheet we can achieve a considerable weight saving, and by adopting the triangulated 4 link set up direct the loads favorably into the car.

My question is twofold: if we adopt a set up similar to the Satchell link with the angled links at the bottom of the axle tube and the tubes parallel to the car's centreline at the top, where will the roll centre be? Also, if from necessity from a structural standpoint the angled links slope upwards in respect to the ground will this affect anything except braking squat or anti squat on this un-driven axle?

Secondly, how do we ensure that with a fully rose jointed set up there is no bind over the full suspension travel? My mockups seem to indicate that some compliance may be necessary.

To find the roll center, find the point where the centerlines of the two diagonal lower links intersect. In a symmetrical geometry, there will be an intersection somewhere aft of the axle. If the linkage is not symmetrical, we approximate by finding where the two lines cross in top view, and averaging their heights (z coordinates) at that (x,y) location. We then construct a line containing that point, parallel to car centerline in top view and parallel to the parallel upper links in side view. Where that line intercepts the axle plane (vertical transverse or y-z plane containing the axle line), that's the roll center.

If the upper links are horizontal, and the lower links slope up toward the front, the car will have some anti-lift in braking. If the lowers slope up toward the axle, the system will have pro-lift in braking. With front wheel drive, there will be no anti-squat or pro-squat at the rear, because there are no ground-plane forces at the rear tires.

Regarding binding, to minimize that, the points where the lower links attach to the axle should be as close to each other as possible. Depending on packaging and structural constraints, it may also work to have the lower links converge at their front ends instead of the axle, or to use either three trailing links or four parallel ones, and use a diagonal Panhard bar.

MEASURING GRIP

I have a non-aero RWD racecar equipped with a good data acquisition system and data on plenty of tracks. I would like to assess the level of grip of each track. The idea is to be able to quantify what the driver or we usually say about a track, i.e. this one is a low-grip track, this one is a very high-grip one, etc. I would ideally classify each track in categories or something like that…

It's easy to explain but the related question is now 'What's grip?'. To stay with simple things, for me, grip can be considered as a coefficient of friction, i.e. the ratio between vertical force and horizontal force applied on the tyres. But how can I measure 'grip' with usual sensors. The relevant sensors I have now on the car measure lateral and inline aceleration, 4 wheelspeeds and 4 damper displacements. I would be happy to add a few sensors (if not too expensive) to my system to achieve our goal. However I don't think that adding 4 tyre slip sensors for example would be an option.

The data I have is a series of fast laps on various tracks. Using this data would be the first preference, but if not possible asking to the driver to drive a dedicated lap could be a second option.

The tyre is the standard championship slick tyre, so it's always the same. To be fair the aero package on our car is almost nothing. We have a very small rear wing but you can consider that the global level of downforce is negligible.

Our championship is made of 12 rounds on various tracks and they are pretty much the same in the calendar every year. We go often testing on the same tracks but during the season we are not allowed to test on the championship tracks. The maximum number of tests per year on a same circuit is 4 times but more often we go testing once or twice a year on a same test track.

When you have little lift or downforce, use the same type of tire on two or more different tracks, and other aspects of your package don't change, you can reasonably compare track surfaces by comparing accelerometer readings. The accuracy of this method depends considerably on exactly how consistent the tires, car, driver, and everything else are.

You can also get a good idea whether you really do have negligible downforce or lift by comparing suspension displacements and accelerometer readings for high and low speed turns on a given track.

If you want to prevent turn banking from leading you to false conclusions, an accelerometer for the z axis might be a worthwhile addition. However, when there is little aero downforce, you can get pretty much the same thing from a math channel that averages the four damper displacements.

Absent downforce or lift, and absent z accelerations, limit lateral (y axis) acceleration is a good measure of the tires' mean lateral coefficient of friction, and limit longitudinal (x axis) acceleration in braking is a good measure of the tires' mean longitudinal coefficient of friction, <u>if</u> we have the handling and the brakes well enough balanced so that we are using all four tires reasonably fully.

A track doesn't offer the same grip level at all points, but if we're after a general characterization of the surface, we can take an average of all the peak regions of lateral or rearward acceleration. We don't want to take the average acceleration for a whole lap, because the car isn't necessarily grip-limited all the way around the track. Sometimes the car is power-limited instead. On a high-speed track, more of the lap will be done in a power-limited state, and the accelerometer readings will be reduced accordingly. We want to try to pick segments or points where we can be confident that the car is grip-limited, and average those. It is best to pick sampling zones where the car is as purely as possible in lateral or longitudinal acceleration, not both at once. Generally, the longitudinal accelerations will be greater than the lateral ones.

A given track's grip level will also vary with age, and with weather, and even from race to race on the same weekend. Therefore, it is best to average readings from a number of outings, if the aim is to characterize the track.

Comments above assume that we're dealing with dry conditions, and that we are throwing out "outlier" data, such as data we might get after a car has been dropping oil, or after a car has thrown dirt onto the racing surface, or when the car is balked by slower traffic, or when the driver is dicing with another car.

One fact that helps us is that it is impossible to use the tires more than fully, so if we look at the best values from a run, we can be confident that those were situations where the coefficient of friction was the limiting factor, and not something else. (Or at least that's true if there was no contact with anything but the track and the air!) Looking at laps with quick times is a good start.

Using this method in the wet is probably less advisable, simply because we encounter so many degrees of wetness that it's hard to get an "apples to apples" comparison between one track and another. Our accelerometer readings in the wet will also vary according to the driver's success in finding productive ways to use off-line unworn pavement, and the magnitude of this effect will depend on how fresh or polished the track is on the racing line, how smooth the pavement is in the unpolished state, and how much traction-reducing dirt, marbles, and debris are on the off-line areas.

It will be apparent that there are substantial uncertainties and variabilities. I'm sure you'll find that the coefficient of friction is not precisely predictable. (That in itself is worth knowing.) However, with enough of the right kind of data, differences among the tracks should become visible.