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: markortiz@vnet.net. Readers are invited to subscribe to this newsletter by e-mail. Just e-mail me and request to be added to the list.

MORE ON LAST MONTH'S TOPIC

Last month's newsletter contained a minor error. To reduce the longitudinal or X-axis forces on the wheel bearings during braking, the caliper should be below center rather than above. I am sending out revised April issues with this issue, and the archived April issue incorporates the correction. Thanks to Eric Zapletal in Australia for catching me on this.

Also, Ramon Mendoza at Bridgestone/Firestone pointed out that caliper location has some effect on steering feel. Centrifugal force acting on the caliper during cornering creates a torque about the steering axis. When the caliper is ahead of the steering axis, this adds steering effort. When the caliper is behind, it reduces steering effort. In general, the increase is better than the decrease, because the driver is somewhat better able to feel the lightening and heavying of the steering as the front tires dance back and forth across the limit of adhesion. We might also conclude that having the caliper closer to 6 o'clock or 12 o'clock might be desirable in this regard, as it would reduce the magnitude of the effect.

THE NEW NASCAR TIRE

A number of people have written me with questions about the new NASCAR Nextel Cup tire.

NASCAR has a new tire. The common thread is a new soft sidewall. What happens to spring and shock rates to adjust for sidewall flex?

On the NASCAR commentaries the announcers say the teams are adjusting their tire pressures by ½ to 1 pound increments. I am assuming the increase in pressure makes the tire stiffer, hence making that corner stiffer – lowering the pressure vice versa. I would assume that these small adjustments are from the optimum pressure required to give good tire footprints with even temperatures. Would the same scenario apply to other radial tires, including street tires, or are the NASCAR tires unique in their sensitivity to changes?

Darrell Waltrip described the old tire (hard sidewall and compound) versus new tire (soft sidewall and compound) as hard Jello versus soft Jello. Larry McReynolds said that teams were looking at control arm angles. It would seem to me that the tire needs to be tilted out at the top (positive camber) to compensate for the sidewall flex.

I don't have any special information on these tires. I'm relying here on what's publicly available.

I understand that the teams are using significantly higher pressures with the new tires. I've heard figures as high as 7 psi more. I am therefore unsure whether the sidewalls really do flex that much more, as the tires are actually run.

All tires are quite sensitive to pressure. Part of the reason small differences matter so much in racing is that the competition and on-the-limit operating conditions make small changes in car balance more noticeable to the driver.

A tire has an optimum pressure for greatest lateral grip and another, lower, optimum pressure for longitudinal grip. Above or below optimum, grip diminishes. This effect is more important than the effect that pressure has on tire loading by softening or stiffening a corner of the car.

The key to understanding tire pressure settings in stock car racing is to recognize that the tires are all overinflated when hot, and this is unavoidable because if they are run any softer they are unmanageable right after leaving the pits. If tire warmers were allowed, this might not be so. But under existing rules, softer inflation improves grip once the tire is hot – not so much because it makes the carcass a softer spring, but more because it results in hot pressure closer to optimum.

Anyway, to adjust spring rates for a more compliant tire, yes you would go stiffer. Or maybe you wouldn't if the rules include a minimum spring rate and a minimum ride height, and you're trying to get the car to run lower. But barring special considerations, you'd go stiffer.

As for camber and control arm geometry, in general more compliant tires want more aggressive camber when cornering, and are also more tolerant of camber when running straight. On an oval track car, that means more positive camber on the left front and more negative on the right front.

Pavement stock cars were already surprisingly aggressive in terms of "camber gain". Front view swing arm lengths substantially less than the track width have been the norm for years. This is much shorter than used in any other kind of racing. I don't know how much shorter they can go.

One point I've thought the NASCAR folks are missing has to do with left front suspension geometry. On banked tracks, and even on relatively flat ones when running big bars and soft springs, the left front suspension compresses in the turns, rather than extending as it would in pure roll. In such a condition, a geometry that places the front view instant center near the centerline of the car actually hurts cornering camber instead of helping it. To get the car behavior and tire temperatures we want, we then have to run extremely aggressive static positive camber. We could actually get more favorable camber change in the turns with an instant center to the left of the car. That would involve having both arms slope up toward the frame, the upper one more steeply. If that isn't possible with legal spindles, a long front view swing arm with an instant center far from the car (implying control arms close to level) would give a smaller unfavorable camber change than the short front view swing arms usually seen.

Note that this does not apply for the right front, nor does it work for road courses – which brings us to a related question from another reader:

CONTROL ARM ANGLES IN FORMULA 1

I've just been watching F1 qualifying [this was written in September 2003], *and I noticed that the front upper wishbones on the Jaguar slope down from the chassis to the uprights. I had seen some*

cars with them roughly level before, but the ones on the Jag had a very pronounced drop to them. This seems to fly in the face of conventional wisdom of camber gain in bump. Is it because the tire construction is different, or are the suspensions getting to the point where there just isn't enough travel to worry about camber gain? After seeing this, I looked at the other cars again. Most wishbones were angled in the "normal" direction, with the Ferraris' being the most pronounced. Is Jag onto something (points don't seem to reflect this)?

I must confess that I share the questioner's mystification regarding the front upper control arm angles we have been seeing on F1 cars over the last ten years or so. This season I'm noticing a similar slope on the Williams cars. More commonly, the arms are very close to level, much more so than they were up to around 1994.

It is true that geometry makes less difference when the suspension moves very little. I am fond of quoting Colin Chapman's famous aphorism: "Any suspension will work if you don't let it."

In spite of that, I find it hard to imagine why a designer would want camber to go toward positive as the suspension compresses and toward negative as the suspension extends – except, as noted above, on the left wheel in an oval track suspension, when the left suspension compresses in the turns.

Tires do have different preferences regarding camber, but none of them like to be tilted out of the turn. They all like to be tilted in the direction of the turn at least a little, and they all like to be close to upright when running straight. Front view swing arm length is therefore a compromise between creating a camber change that compensates for adverse camber change due to roll in cornering (I prefer to call it camber recovery rather than camber gain), and minimizing camber change when roll is absent, or over bumps when cornering.

If the front view swing arm length is "negative" (instant center outside the track width, on the same side of the car as the wheel), we get camber change greater than the roll angle in cornering, in the wrong direction, and also get camber change in ride. The camber change in ride can be beneficial in certain circumstances -- specifically in braking on the front wheels, when negative static camber is used. Of course, this approach also requires more static negative camber to get acceptable outside wheel camber in cornering, and this produces more unfavorable camber on the inside wheel than we'd have with more conventional geometry. Overall, I don't see a gain.

If the control arms are close to horizontal, that makes the system insensitive to ride motion, which is good, especially in high-downforce cars. I am still inclined to allow a bit of camber change in ride, to reduce camber change in roll – just not a lot – and limit roll with high wheel rates in that mode.

It should be mentioned that camber characteristics also depend on the angle of the lower arms, which are hard to see from trackside on an F1 car due to the wings. It would be possible in theory to have the upper arms slope down toward the spindles, and still have the camber go toward negative in compression, if the lower arms sloped the same direction but more steeply. However, this would produce a very high roll center, and I very much doubt that the F1 teams are doing that.

ARM ANGLES IN TRIANGULATED FOUR-BAR BEAM AXLE REAR

I run a figure-8 car – we have to turn left and right. We have to run a stock four-link rear end. Ours is out of a '78 Impala. We have moved some of the suspension points, but my question was what angle I should run the lower trailing arms. I'm trying to get the tops around 10 degrees.

For readers unfamiliar with this setup, this is a live axle locating linkage with four semi-trailing links, and no purely lateral links. The upper links converge to a point above and slightly behind the axle. The lower links converge to a point well forward of the axle, and lower. These two convergence points define an axis about which the axle moves in roll. The roll center is considered to be the point where this axis of rotation intersects the axle plane (vertical plane containing the axle centerline).

There is no theoretically ideal angle for any of the links. Ordinarily the lower links slope up a bit toward the front. In a three-link rear, this would produce roll oversteer (rear wheels point toward the outside of the turn when the car rolls), but in this type of linkage we just get reduced roll understeer. If we level the lower links out in side view, we actually get more roll steer.

The side-view angles of the links also affect anti-squat under power and anti-lift under braking. Leveling out the lower links reduces both of these effects. That can help the car if wheel hop under power or in braking is a problem.

My general-purpose recommendation is to run all the links close to factory angles, or level them out a little. I wouldn't make any of them steeper. I wouldn't aim the lowers down at the front. There are no miracles available here, but as long as you don't make the geometry extreme in any regard, you won't have a disaster.