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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.

ANOTHER TIRE CARE TIP

In the past I have written in these pages about bagging tires and keeping them in cool, dry, thermally stable places. I recently read that it's also a good idea to keep them away from electric motors or generators that use brush contacts, as these generate ozone. I'm not sure just how significant this is, but it sounds logical.

PULL RODS, PUSH RODS, OR BOTH?

Do push rods or pull rods have an adverse effect on handling? If so, does each selection of rod induce oversteer or understeer in the chassis? I know a combination of pull and push rods was used by McLaren in the early 1990's, taking Senna to numerous victories. Has anyone tested using a combination of pull rods on one side of the car and push rods on the other (left and right)?

Push rod and pull rod suspensions are primarily packaging solutions. They get the shock or coilover in out of the airstream. They also allow convenient tailoring of rising-rate effects via rod and rocker geometry, and facilitate interconnections such as third springs and anti-roll bars.

However, it is also possible to provide most of these effects with outboard or direct-acting springs and dampers. The Z-bar on the rear of a Formula Vee, the camber compensator on a late Porsche 356 or '64 Corvair, the swing spring on a late Triumph Spitfire, or the coil spring above the differential on a Mercedes swing axle all do essentially the same thing as the third spring in a modern race car suspension.

It is a fairly common misconception that push rods or pull rods affect the dynamic load transfer (weight transfer). Actually, all the added forces are reacted within the car, and the only thing the tires "feel" is the wheel rate – the effective spring rate, at the wheel, in the modes of suspension movement being encountered at a given moment.

Another misconception is that inboard coilovers reduce unsprung weight, rather like inboard brakes. That is also erroneous. Anything that moves when the wheel moves is unsprung weight, whether it moves horizontally, vertically, or obliquely. So adding the rod and the rocker to the system is a disadvantage in terms of unsprung weight, and the part of the damper and spring that move with the rocker are still unsprung.

Ordinarily, we try to make suspension layouts on road racing cars symmetrical in their behavior, and the easiest way to do this is to make them symmetrical in their layout. It is possible to obtain symmetrical dynamics with push rods on one side and pull rods on the other, but that's doing it the hard way unless we are up against some very unusual packaging constraints. There might potentially be a reason in an oval-track car, perhaps a supermodified. I'm seeing a lot of pavement supers, midgets, and sprint cars these days with right side coilovers hung way out from the frame on outrigger structures. Rockers, or rockers with push rods or pull rods, could bring these inside the body, improve the effectiveness of a low front wing, and move the weight of the right side dampers lower and further left.

TRAIL AND STEERING FEEL

I'm on a Formula SAE team. In your August 2002 newsletter, you mention increased steering effort and also better ability to sense the amount of traction at the front wheels, if the steering geometry includes more mechanical trail. You also went into the difference in feel between pneumatic and mechanical trail near the point of breakaway. I am hearing conflicting advice from other sources on this question. Carroll Smith told us FSAE participants that ample trail is good. On the other hand, the first Milliken book suggests that mechanical trail masks the feel from the tire's self-aligning torque. We are confronted with driver complaints about steering effort, but we don't want a numb race car. Could you elaborate on the pros and cons of mechanical trail as it relates to steering effort and feel?

As I mentioned briefly in August, this is to some extent a question of personal preference, and drivers differ on whether they like the steering to lighten before true breakaway, or at the point of true breakaway. My own preference is for the steering not to lighten unless lateral force is actually going away.

This may be partly just my own conditioning, but I do think there is a rational or objective case for not having the steering lighten below the actual point of traction loss. Even if the driver can get used to the feel of the steering going light short of the limit, how is even the best driver to distinguish between lightening due to pneumatic trail reduction and lightening due to reduced grip? To some extent the driver can "interpret from context" but basically less force is less force, and your hands shouldn't be expected to know if a lightening in the steering is the tire doing its normal thing or the tire hitting pavement with less grip. With ample trail, you don't have to be psychic. Less steering force means less cornering force, period.

I haven't seen your car, but a common problem in FSAE cars I have seen is excessive U-joint angularity in the steering shaft. In the quest for a short turning circle via short wheelbase, many

FSAE cars position the front wheels a lot further aft than they really ought to be from a weight distribution standpoint. This not only adds load to the front wheels, but often requires outrageous bends in the steering shaft. If your last car had this problem, consider moving the front wheels forward, while shortening the steering arm length to get more lock with similar rack travel. The reduced arm will add steering effort, but for a given turning circle you approximately get the difference in effort back again from the reduced front wheel loading, and the steering shaft can be much straighter.

KART SCALING

As part of my Mechanical Engineering degree, I have been tasked with redesigning a kart chassis to make it easier to manufacture. I want to understand some of the dynamics of the current kart so I can model the new one more effectively:

a) How can I measure corner weights without resorting to expensive electronic scales?
b) How can I measure the loads the chassis is exposed to as the kart corners? I want to understand how the chassis is stressed in the dynamic state so I could load up my model in a similar way and alter the model to achieve the same kind of handling characteristics.

That's some assignment. Karts have been around for over 40 years, and they were originally conceived as a simple, low-cost, easily manufactured item. Improving manufacturability of something like that, or simplifying it at all, is a real challenge.

There are many kinds of karts, but all of them are about as simple in terms of chassis design as a four-wheeled vehicle can be. You can simplify some of the more elaborate ones by making them more like the lower-class ones, but that's obvious.

I can at least offer some help with the scaling. You can't get away from the need to use four scales of some sort, but you can use bathroom scales, which are nowhere near as costly as electronic racing scales. Try to get four that read as nearly the same with you standing on them as possible, and calibrate from there as needed.

You will find that your diagonal percentage is greatly affected by whether all the scales are in a common plane, and whether the steering is centered. You will want to level the scales carefully and devise a repeatable regime for positioning the steering. You will also find that tire pressures affect wheel loads, so you need to have accurate inflation for repeatable wheel load measurements.

Most karts have adjustable front ride height. The simplest system consists of washers on the kingpins. You will find that this allows you to obtain almost any desired diagonal percentage.

If you are setting up for road racing, and you don't want wedge in the chassis, you can get fairly decent results by setting front ride heights so both front wheels come off the ground simultaneously when you jack up or lift the front end at a central point. Again, you will find that even this crude test is sensitive to tire pressures and steering centering. This doesn't tell you wheel loads, of course.

With a vehicle that has suspension, it is highly desirable to have platforms that allow you to roll the vehicle back a few feet and then forward again onto the scales, to settle the suspension. With a kart, you don't need to do that. You can just set the kart on the scales.

You will find that left and rear percentages do not depend much at all on steering centering and tire pressures. You can therefore easily calculate what the wheel loads would be in an unwedged condition (equal left percentage at both ends, equal rear percentage on both sides).

Driver weight is generally at least half of the total, so things change dramatically depending on who's driving.

Kart frames are deliberately made torsionally flexible, and somewhat flexible in beam as well. This design objective is a happy mate with low cost and ease of manufacturing; the simplest perimeter frame imaginable fills the bill. The frames receive torsional loads not only from bumps, but also from caster jacking as the wheels steer. Spindle lengths are sometimes adjustable with shims to vary the magnitude of this effect by changing scrub radius (steering offset). Caster jacking is used to unload the inside rear wheel in tight turns and help the vehicle rotate in yaw without a differential.

I expect you can determine stress levels in an existing kart frame while running if you can instrument it with strain gauges. I don't know if your school has the necessary equipment to do this. I would think buying it yourself would be tough if affording scales is an obstacle. Stresses in any vehicle depend greatly on operating conditions, and this is especially true for a vehicle with no suspension except tire and frame deflection.

It is a long-established tradition in motorsports to do laboratory tests on frames which do not necessarily faithfully reproduce running stresses but are easy to do. For a kart, relevant tests would be overall torsional stiffness and maybe yield strength, with load points where the axle and spindles attach, and beam stiffness and yield strength with load applied at the seat and support points at axle and spindle mounts.