The Mark Ortiz Automotive

CHASSIS NEWSLETTER

PRESENTED FREE OF CHARGE AS A SERVICE TO THE MOTORSPORTS COMMUNITY

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.

March 2003

FREE SEMINAR MARCH 17

For readers in the Charlotte area, I will be presenting a one-hour talk at UNC Charlotte, in Fretwell 126, Monday, March 17, at 12:00 noon. The title is "Minding Your Anti: Understanding Roll Centers, Jacking Forces, and Other Factors in Weight Transfer". This will not be a purely standard treatment of the subject. I will include discussion of "lateral anti" and shed important light on the much-discussed topic of lateral roll center location and migration. This is a free presentation of the UNCC student SAE chapter.

TIRE WARMERS LESS EXPENSIVE THAN I THOUGHT

In the January issue, I mentioned I'd found tire warmers, supplied by Chicken Hawk Racing , 866-HOT-TIRE or www.chickenhawkracing.com. I said they had a standard model for around $1500 and an adjustable one with temperature readout for around $2000. I was under the impression that those prices were for a single warmer, but actually they're for a set of four.

INDEPENDENT REAR SUSPENSION FOR DIRT?

QUESTION:

Would there be any advantage to running an independent suspension on the rear of a dirt car? This refers primarily to a modified, but would it help on a dirt Late Model, also? We were wondering if a design similar to a Corvette would work.

ANSWER:

There is no doubt that independent rear suspension can work very well on dirt. This is provable not only by theory, but by example. Independent rear suspension is used with great success in off-road buggies, rally cars, and Unlimited hill climb cars at Pikes Peak. The only place IRS isn't used on dirt is in oval track racing.

The biggest single reason for this is that in most classes, and in most sanctioning bodies, independent rears are illegal, presumably for cost containment. I'm not sure about the high-dollar mods that D.I.R.T. runs in the northeastern US, but in IMCA, UMP, NASCAR, and WISSOTA, there are specific rules against independent or "sports car" rear ends. They don't even allow quick-changes.

Down here where I live, we have the Carolina Modified Tour, which runs similar cars, but with quick-changes permitted. For Late Models, the rules vary. I haven't checked all the sanctioning bodies that run these cars, but WISSOTA abolished all suspension rules in the Late Model class a few years back, after previously prohibiting independent rears. To my knowledge, everybody still runs live axles, partly so they can go on the road and race in other series, and partly because they are mostly car buyers, not builders, and no Late Model builders offer independent rears.

Far as I know, all sprint car and midget sanctioning bodies, including World of Outlaws, now require beam axle suspension front and rear.

So the first obstacle to overcome is to find a sanctioning body that will let you run IRS. You have to think about not only what the current rules are, but also how the organization is likely to react if you are successful with an independent rear, and everybody else faces the prospect of having their cars obsoleted. You will have to invest a lot of time and money in building your own car and developing it. If it's outlawed as soon as it starts winning, you take a big loss.

You will face another problem that besets all innovative owner-builders: when you tear up equipment, you can't just order replacement cars or parts; you have to make them. If you have a heavy schedule and are running for points, or you're on tour, this is a major concern.

Twenty years ago, there were some attempts to build independently suspended sprint cars. These efforts were mainly the work of backyard builders, who had little formal training. They attempted to build systems that looked like what they'd seen on road racing cars of the era, with little real understanding of what they were doing. I recall one case where the builders didn't realize they'd still need tire stagger, and blamed the suspension when the car went straight into the wall the first time they ran it.

The lesson here is that a mediocre concept, executed and set up well, will beat a superior concept, executed or set up poorly. Independent suspension has the potential to win races on dirt, but only if it's done right. Since you'll be pioneering a new idea, you won't be

able to rely on conventional wisdom; you'll have to study sufficiently to understand the principles of the system. I will be happy to help you as a consultant, but those actually doing the project will need considerable knowledge as well.

Okay, assuming you aren't daunted by the practical aspects of trying something radical, and assuming you've found a class where IRS is legal, what are the pros and cons of IRS, and what sort of design would be best?

Independent rear suspension is good, but it is a mixed blessing in some respects. In general, overall weight is greater for independent suspensions than for beam axles. However, unsprung weight is much less for an independent suspension, especially if the brakes are inboard, and most Late Models run to a minimum weight rule that requires them to add ballast. So in terms of weight, the only drawback to IRS is that you have somewhat less ballast to move as desired. There is a big benefit in roadholding, meaning ability to keep the tires in contact with the track, and minimize tire load variation, on bumpy surfaces - and dirt tracks are often bumpy, though not always.

Anti-squat in independent systems is different than in live axles. In a live axle system, we can separate rear jacking forces under power into thrust anti-squat and torque anti-squat. In a typical Late Model, torque anti-squat is the lift we get from the torque arm, and thrust anti-squat is the lift we get from the geometry of the linkages at the ends of the axle, which most commonly attach to birdcages (brackets that can rotate on the axle). With independent suspension, we only have thrust anti-squat to work with, because axle torque reacts through the differential mounts and does not act through the suspension.

This leads some people to suppose that overall anti-squat is necessarily less with independent suspension, and that therefore independent suspension would be at an inherent disadvantage compared to current state-of-the-art dirt Late Model live axles. I question this myself, although I do agree that in theory at least, a live axle can probably be made to lift more under power than an independent system. As I have mentioned at various times in the past, the advantages of anti-squat are often over-estimated, and it is possible to get ample lift from an independent system.

It is safe to say that the live axle has some edge in terms of anti-squat properties, particularly as regards the potential to manage variation in anti-squat properties as grip varies. However, current systems do not exploit the possibilities in this area as fully as they could, so this potential advantage of the live axle is hypothetical until somebody decides to exploit it. These possibilities might be a future newsletter topic.

Compared to current live axles, an independent system could have similar, or at least adequate, anti-squat, and much better adhesion over bumps. The independent system might reasonably be expected to compare most favorably on a bumpy track, and least favorably on a smooth and slippery one.

For Late Models, there are rules about transmissions, at least in WISSOTA. They have to be mounted to the engine, so transaxles are out. That means the diff would be an IRS quick-change, with either a spool or a Gleason.

You mention Corvette rear suspensions. There are two basic styles of independent suspension used on Corvettes. The C2 and C3 used the halfshafts as upper lateral or camber-control links, a lateral link sometimes called a strut rod below the halfshaft to complete the camber-control linkage, and a trailing arm for toe location, longitudinal location, and brake torque reaction. A variation of this system, with a third lateral link for improved toe control near the front of the trailing arm, was used in second-generation Corvairs.

The C4 and C5 Corvettes have a 5-link system. There are three transverse links to control camber and toe, and two longitudinal links to provide longitudinal location and react brake torque. On the C4, the halfshaft is still used as the upper camber control link. On the C5, the model currently in production, the halfshaft is only used to transmit power, and the five links are all purely suspension parts. Similar 5-link systems are used on the Viper and most purpose-built race cars. On some current race cars, two pairs of links are combined into upper and lower a-arms, with a toe-control link. The system then visually resembles a front suspension.

If I were designing an independent rear for any form of racing, including dirt oval-track, I would use a five-link system, or the a-arm and toe-link variation of the 5-link. Using the halfshafts as camber control links saves a little weight and cost, but it compromises geometry. Specifically, it forces you to choose between a high roll center or meager camber recovery in roll. Also, the consequences if you break a shaft or U-joint are particularly nasty, though of course they aren't pleasant regardless.

One key decision is whether to use inboard or outboard rear brakes. The advantage of inboard brakes is that you reduce unsprung mass, and thereby maximize the system's roadholding advantage on bumps. The advantage of outboard brakes is that you can have ample anti-squat under power, without having excessive anti-lift under braking. A lot of anti-lift in braking tends to cause wheel hop when used with generous rear brake bias, and many dirt drivers like to use a lot of rear brake to get the car to turn in. Typical 4-bar Late Model rears have more than 100% anti-squat and zero or negative anti-lift.

To get such properties with an independent system, you need geometry that makes the hub travel rearward approximately .15" to .20" per inch of suspension compression, and makes the upright rotate rearward approximately 0.6 to 1.0 deg per inch of suspension compression. In terms of side view geometry, this means a side view instant center something like 80" behind the rear wheel, and at or slightly above ground level.

That's with outboard brakes. With inboard brakes, you'd want the hub to move rearward no more than .10" per inch of suspension compression, unless the driver never uses a lot of rear brake. Upright rotation doesn't matter with inboard brakes. Probably the simplest

approach would be to make the whole upright move along a line inclined about 5 deg rearward, and not rotate at all.

In either case, I'd consider having a bit more anti-squat on the left than on the right, to make the car gain wedge under power.

For lateral location, I'd try instant centers between 70 and 100 inches from the wheel and try to keep the force line slopes between zero and 10 degrees, upward toward the center of the car, in all combinations of ride and roll. This would correspond to a static roll center height of 3 inches, give or take an inch. I would try to make the lower control arms as long as possible - all the way in to the center of the car if possible - and have the upper arms shorter than the lowers by as much as needed to achieve least possible force line slope changes in both ride and roll, with perhaps a bit more emphasis on roll than ride.