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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.

NATURAL FREQUENCIES REVISITED

My January 2002 newsletter contained an error. I stated that damping a suspension system raises its natural frequency. Actually, damping a system reduces natural frequency. At damping coefficients exceeding critical damping (the amount of damping that makes the system return to static position in least possible time without overshoot, following displacement from static), the system is considered non-oscillatory. This means its damped natural frequency is undefined: it doesn't have one.

Usually, even relatively stiffly damped race cars are below critical damping, so they do have a damped natural frequency. This is given by the equation

where:

ω_n	-	undamped natural frequency
ω_d	-	damped natural frequency
c	-	actual damping coefficient
$c_c = 2m\omega_n$	-	critical damping coefficient
$\xi = c/ c_c$	-	damping ratio
m	-	sprung mass

We can see that as the damping ratio approaches 1, the quantity under the radical approaches zero. At critical damping, the quantity under the radical is zero, and so is the damped natural frequency. If the damping ratio exceeds 1, the quantity under the radical becomes negative, and the square root of a negative number is undefined for real numbers; hence the damped natural frequency becomes an undefined quantity.

Stiffening the damping and stiffening the springing have qualitatively similar effects on amplitude of suspension motion, but opposite effects on frequency. Stiffening damping or springing reduces amplitude: the suspension moves a shorter distance in a given situation. But stiffening springing increases frequency, whereas stiffening damping reduces frequency.

My thanks to Professor Jorge Pinto Pereira of the Escola Superior de Tecnologia de Setubal, Portugal for advancing my education on this.

QUADS ON PAVEMENT REVISITED

The April 2002 newsletter addressed the dynamics of quads (4-wheel ATV's) on pavement. Newsletter recipient Chris Petersen reports meeting a person who has raced quads on pavement, in the American midwest (Missouri or Iowa, he thought), on road courses, with pavement tires. This person told Chris that there is now a small local racing series for these machines.

This doesn't sound safe to me, but it sounds like it would be entertaining to watch – in somewhat the same way as sidehack racing, or gladiatorial combat. I'd like to hear from anybody with further information.

SPACE FRAME OR MONOCOQUE?

For cars like a D Sports Racer (DSR), what kind of chassis stiffness would you recommend? For a home builder of DSR cars, what type of chassis construction (spaceframe, monocoque, or a hybrid) would be most appropriate? I am contemplating building a DSR at home – but it might be easier to have a car builder fabricate the actual chassis and suspension components since I am lacking in the welding department.

I haven't been to an event where DSR cars have run for many years. I know from reading that some of the cars have become very professional, and some builders spend quite a lot on them. I believe it is still true that many people in this class build their cars rather than buy them, though.

There is no such thing as too much chassis stiffness, as a general rule. You can have too much weight. You can have too little access to the engine and other components. You can have too little room for the driver. You can end up with these problems in the pursuit of stiffness. But stiffness is never a disadvantage in itself.

You not only want a maximum of torsional stiffness as measured by applying a torsional load at the coilover or rocker pickup points, you also want good local stiffness at all the suspension and steering pickup points, and good rigidity in the suspension bits themselves.

I really have no idea what torsional stiffnesses the best DSR's are attaining these days, but off the top of my head I would think 5000 lb ft / deg would be a reasonable target.

Over the 40 years since the Lotus 25 demonstrated the superiority of monocoque construction by out-performing the space-framed but otherwise identical Lotus 24, a consistent pattern has

emerged. Monocoques beat space frames wherever they're allowed. Space frames prevail where the rules require them, or in some cases where the builders are wedded to tubular frames and monocoques are informally excluded through economics and culture.

The fact that space frames are still widely used, and that some people like them well enough to write rules requiring them, tells us that they must have some attractive features – and they do.

Advantages of tubular steel space frames include cost, repairability, improved access to components, and availability of instruction in the skills needed for construction and repair. There are a few places you can go to learn to work with carbon fiber or sheet aluminum monocoque structures, but it's much easier to find a welding class. It's also much easier to find a welder than than a composite technician, if you want to hire help.

My next door neighbor builds sprint car chassis. He does a lot of the hands-on work himself, including machining and fitting parts, but he hires others to do the welds. They do the welding in his shop, with his equipment. He maintains control of design, often without drawings of any kind, and the welds are professional quality. He currently has one welder who works day hours, more or less full-time, and another who fabricates for a Winston Cup team and moonlights in the sprint car shop in the evenings.

Partly, your decision will depend on precisely what cars you have to beat, and how much you really care about winning. I'm sure you understand that you are contemplating a hobby here, and a learning experience, rather than a career – at least in the short term, with this project. You can certainly have fun and gain worthwhile experience building a tube-frame car.

It's pretty certain that monocque construction is the path to best performance from the firewall bulkhead forward. For the rear of the structure, much will depend on your choice of powertrain. For some time, a Kohler was the engine to have. I think I heard a few years back that some guy in Wisconsin had built his own engine specifically for DSR and was having success with it. That is definitely not an approach for the faint of heart or the thin of wallet. Over the years, people have used an incredible variety of powerplants for DSR cars, including single and multiple motorcycle and snowmobile engines, Mercury outboard engines, SAAB two-strokes, rotaries, Fiat-Abarths, you name it.

Checking the rule book (mine is from 1999 and may not be 100% current) I see that SCCA is still encouraging diversity. DSR has five separate displacement limits: for two-strokes, anything-goes atmospheric four-strokes, two-valve-per-cylinder four-strokes, automotive-based four-strokes, and rotaries. There are two minimum weights – a lighter one for chain or belt drive cars. There is no limit on tire size – only a minimum wheel diameter of 10 inches. Obviously your first step will be to think through all these possibilities. You may find that different options give an edge on different tracks, so your choice may vary depending on where you plan to compete the most.

Ordinarily, the rear portion of a monocoque sports-racing chassis consists of two box structures running alongside the lower portions of the engine. These need to be as large in cross section

as possible, to maximize rigidity. This inevitably conflicts with access to the sides of the engine. If you are using an automotive-based engine, mounted longitudinally, a monocoque can work pretty well. If you are using a motorcycle engine, and you need to be able to get the side covers off without pulling the engine, a space frame design starts to look more attractive.

So you are faced with a complex set of interdependent decisions. The decision of type of frame structure is one of them, and they all lean on each other. You need to come up with an integrated package that satisfies your personal design objectives and makes sense taken as a whole. The people who wrote your rules intended to give you an interesting puzzle. Have fun with it.

TIRE CARE

It is sometimes said that lap time is 50% tires and 50% everything else. There can be no doubt that those four little patches of rubber are vital to control of the car. Yet it is surprising how many racers ignore the advantages to be had from tire care.

Tires vary in their sensitivity to age and care. As a rule, real racing tires are more sensitive than street tires. Yet all tires will benefit to some degree from proper care.

All tires contain solvents. Over time, these evaporate, and this contributes to hardening of the rubber with age. One way to slow this process down is to store your tires in the heaviest plastic garbage bags you can find, and tie or twist-tie the bags. Plastic bags are somewhat porous, and they tend to get torn when used to store tires or wheel/tire assemblies, so it’s not a bad idea to double-bag.

Tread compounds also harden due to polymerization. Heat cycling speeds this process dramatically. Effect of heat cycling is related not only to how extreme the temperatures get, but also how fast the tire is heated and cooled. Consequently, it helps to warm tires as gently as possible when you first go out on the track, and cool them as gently as possible at the end of a run. It helps to store tires at the coolest and most stable temperature possible.

Contrary to popular belief, moist air does not build more pressure per degree of temperature rise than dry air or nitrogen, *provided all water is in the vapor state*. Water only causes disproportionate pressure rise if it is in the liquid state when pressure is set. That said, it is surprisingly easy to have liquid water in a tire. Chief sources of this are mounting lubricants, condensate in air tanks and hoses, and condensation in the tire itself if pressure is set at low temperature and the tire was inflated in muggy weather. Inflation gas can even absorb atmospheric moisture through the tire rubber. So there is a point of diminishing returns on keeping moisture out of tires, but it’s hard to know when we’ve reached it. Therefore, it makes sense to err on the side of dryness. This means using either dried air or dry nitrogen for inflation, and purging after mounting and before racing.