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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 answers to chassis questions. Readers may submit questions by mail to: 155 Wankel Dr., Kannapolis, NC 28083; by phone at 704-933-8876; by e-mail to: markortiz@vnet.net. Topics are also drawn from my posts on the tech forums at www.racecartech.com and www.rpmnet.com. Readers are invited to check out these sites, and to subscribe to this newsletter by e-mail.

Mark Ortiz

CHROME MOLY IN STOCK CARS

Recent discussions of frontal impact deaths in stock cars have produced allegations that some of the more advanced teams in Winston Cup, which build their own chassis, are now using chrome-moly (4130) steel in their frames, supposedly including even the large rectangular main rails. I have no way of verifying these reports, but I have noticed that various other classes in racing are allowing thinner-walled tubing in roll cages when 4130 is used. I am told the material is making major inroads in dirt Late Model construction as a result of this, as it allows considerably lighter cars.

Most stock car classes, including Winston Cup, neither require 4130 nor give it a wall thickness break. Therefore, there is no weight saving to be had from it. The reported reason for using it in Cup cars is to gain stiffness.

These developments prompt me to offer some information about what 4130 will and won't do for a car, and some of the less-recognized properties of the material. All this information has been published before. I would particularly like to tip my hat to Carroll Smith, whose book *Engineer to Win* offers considerable insight into this and other materials-related matters.

STIFFNESS

First thing we need to emphasize, and this will come as a shock to many racers, is that 4130 offers *no significant stiffness advantage* over mild steel! The gain is 1% or less. That's assuming equal wall thickness and weight, and identical design. If the frame is built with lighter gauge tubing to save weight, it will actually flex MORE.

Note that *stiffness* means resistance to deflection under load, short of the point of permanent deformation. Stiffnesses of all steels are remarkably similar. The best spring steels are less than 3% stiffer than mild steel, and 4130 as normally used in frames is actually closer to mild steel than to spring steel. Resistance to permanent deformation is called *strength*, and that's where chrome-moly offers potential gains. In normal use, a car frame is a *stiffness-limited structure*, and therefore does not gain performance significantly from the use of 4130, unless the rules allow us a frame or cage weight reduction. This applies until we crash the car. At that point, we suddenly have a *strength-limited structure*.

STRENGTH

Steels may be very similar in stiffness, but they differ dramatically in strength. Strength can be expressed in terms of *ultimate tensile strength, yield strength*, and *impact strength*. Ultimate tensile strength refers to tension load required to pull the material completely apart. Yield strength refers to tension load required to permanently deform the material. Both ultimate tensile strength and yield strength are measured by applying a gradually increasing load to the material. Impact strength, on the other hand, is measured by striking a sudden blow, of known magnitude. If the material deforms, but doesn't fracture, it passes. If it actually breaks, it fails.

The distinctions between these different kinds of strength are of great importance in race car construction. For portions of the structure that are close to the driver, we mainly want to prevent the wall, track surface, or whatever the car hits, from intruding into the cockpit. This means we want yield strength. A little deformation may cushion an impact, but we don't have room for large deformations. For portions further from the driver, we want a structure that deforms in a controlled manner, preferably outer portions first, absorbing energy as it crumples. To achieve this, we need graduated yield strength – more as the deformation approaches the driver. In both cases, we need impact strength; the structure can only do its job if it doesn't come apart on impact.

Mild steel does not respond to heat treatment; its carbon content is too low. Consequently, its properties remain about the same no matter how we weld it, heat it, or cool it. It never becomes brittle, as long as we don't introduce impurities while welding. Its yield strength is moderate, but its impact strength is good. In a crash, it deforms and absorbs energy, while resisting being torn apart or fracturing. This makes mild steel a good choice for most portions of a stock car frame. There is no significant stiffness penalty compared to 4130, and greater deformability when the car takes a hit.

Therefore, there may be a case for using 4130 for the cage in the driver's compartment of a stock car, but not for the front or rear clips.

4130, on the other hand, will harden when heated above its *critical temperature* and cooled rapidly. Cooled slowly, it remains soft. In the hardened condition, 4130 has great tensile and yield strength, but POOR IMPACT STRENGTH. It's hard and strong, but brittle. 4130 tubing, as supplied, is not in the hardened condition. It's *cold drawn and normalized* – fairly soft. In this condition, it will usually bend on impact and not fracture, just like mild steel, and it is somewhat stronger. But when we TIG weld 4130, we get a hard zone, not at the weld but half an inch or a little more from the weld. This happens because this region is heated enough to produce hardening, and is close enough to cool metal to be cooled abruptly after welding. The result of this is the failure pattern commonly seen in crashed 4130 frames: the tubes bend, the frame diamonds and twists, but there are some fractures near the welds. Not at the welds, but an inch or less from them.

Most people who build 4130 frames simply live with this. But there is a solution. After welding, heat the joint and the nearby metal to a dull cherry red with an oxy-acetylene torch, and allow to air-cool slowly. In warm ambient temperatures, just letting the area cool naturally is often sufficient. In colder ambient temperatures, or for insurance, a sheet metal or foil shield loosely fitted around the joint will slow the cooling sufficiently to avoid hardening.

Another approach, seldom considered nowadays, is to gas weld the joint instead. 4130 tubing was originally invented about 75 years ago for the aircraft industry. TIG welding was unknown. Aircraft structures were gas welded. Gas welding heats the metal surrounding the weld more than TIG welding does. This compounds distortion problems, but it does alleviate the problem of having very hot metal near cool metal that can quench it. In many cases, this will automatically eliminate the brittle zone.

REAR STAGGER VERSUS STATIC CROSS

We run a Late Model on pavement and have a question about the relationship of cross weight to stagger. In 1999, we used about 1.25 inches of rear stagger with 54% cross. In 2000, we increased our stagger to 2 inches, thus having to jack more cross into the car to keep it the same. How do you know when you have hit this balance right? I hear guys talking at the track about how much stagger they run, and it seems to vary widely.

Stagger loosens the car through the entire turn. Most people report the biggest effect on exit, at least on pavement. Stagger has greatest effect when the rear tires are loaded the most, but the effect goes away when the wheels spin.

Static cross has more effect when cornering force is moderate, meaning it does affect entry and exit more than mid-turn. Springs, conversely, affect mid-turn the most. Static cross tightens the car, except that the effect can reverse on entry if you slow the car mainly with the rear wheels.

Stagger has more effect when grip is good. Static cross has more effect when grip is poor. So the way you blend stagger and cross affects how the car's balance varies as track conditions change. A car with modest stagger and modest cross will go loose on slick more than the same car with more stagger and more cross.

So usually, consistency improves with more stagger and cross. The penalty comes in tire drag, especially down the straights, which increases as you add stagger.