BALANCE ACHIEVEMENT
PART TWO:
WEIGHTS AND PERCENTAGES

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Last month we talked a bit about how to measure our weights and calculate the percentages we so often talk about. We also looked at how to calculate wheel weights if we know our percentages and total weight. Finally, we put those equations together to help demystify some of the wheel weight relationships that we hear about from time to time. This month we're going to continue our study on percentages by looking at nose weight. What we're going to try to do is to understand what things drive the range of nose weights we tend to run on our karts and also understand how we should adjust to get the nose weight we want and when we might change it. At first glance it might seem that this is far too simple to devote an entire article to since it's easy to believe that more nose makes a kart turn better and less makes it more pushy but as we will see, there is quite a bit more going on than that.

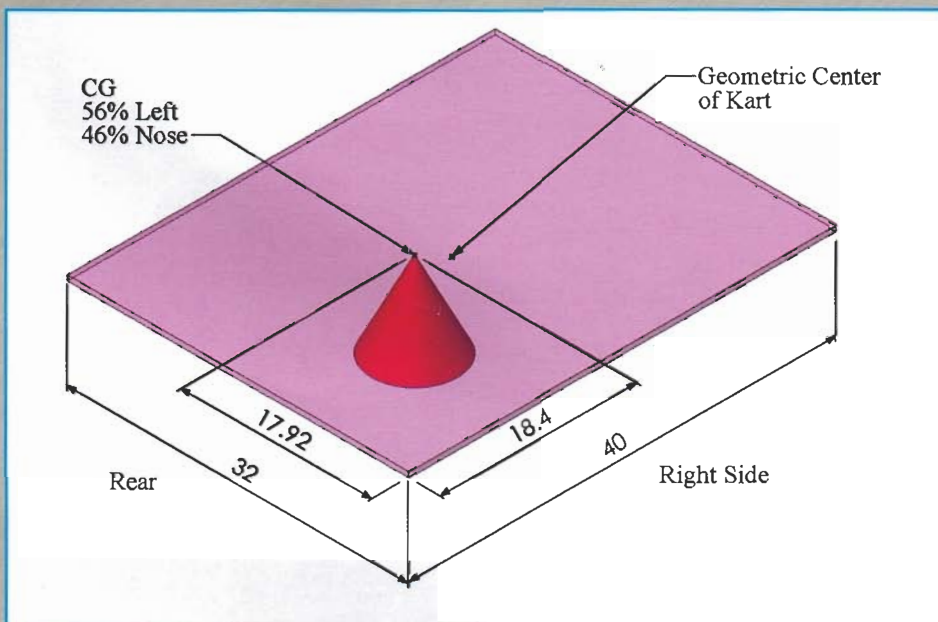
Let's get started by looking at why a given kart will work best within a given range of nose weight. Simply put, the range of noseweight that works best on a chassis most of the time is a result of what basic static percentages the manufacturer wants to have their chassis work with combined with how they've designed the relative stiffnesses of each of the corners of the kart (LF, LR, RF, RR). Given these two design parameters there is a given range of nose weight which will help the chassis stay balanced over the majority of tracks and track conditions. Just so there is no confusion, by balance I mean that the kart is not pushing and is not loose; not that the LF and RR have any particular wheel weight relationship.

What do we mean by what range of static percentages the manufacturer wants the kart to work with? Some manufacturers feel that running percentages which fall into a given range will yield a kart which has more potential for speed. For example, some manufacturers like karts which use very high crossweight whereas others do not. In the same way, some prefer higher or lower left and still others like higher or lower nose. From this desired range is the first step which sets the amount of noseweight a chassis will want.

The next factor which determines what range of nose weight with which a chassis will best work is how the manufacturer wants the tires to load and unload. By this we mean how they tune the relative stiffnesses of the kart. I realize that many think of the entire kart being stiff or soft but this is a broad oversimplification that greatly understates the amount of effort and design that takes place in developing a great chassis. In reality, there is the stiffness of each of the four corners which controls the speed at which the tires load and unload, the stiffness of the waist of the kart which connects the front and rear and impacts the torsional stiffness of the kart as well as how much the kart will droop and flex between the front and rear axle, and finally there is the relative stiffnesses between the front and rear which helps determine which end of the kart will tend to transfer the most weight. By tuning these stiffnesses the manufacturer can tune how the kart turns down into the corner, how it performs at the apex, and how it runs off the corner.

As we have seen, there are two fundamental things that have the largest bearing what nose weight ranges we will tend to run on a given kart and have it balance properly: the desired range set forth by the manufacturer and the way the chassis loads and unloads the tires. Now we will look a bit deeper into the things that affect how a kart will respond to nose weight adjustments. The first variable which impacts how a kart will respond to noseweight adjustments is the overall and relative stiffness of the chassis and its parts. While we cannot completely separate things out this way, it is a good general rule that changes in stiffness will have the greatest effects at locations on the track where lots of weight is moving around. This should make sense because when very little weight is moving then the stiffness of the components moving that weight will be less important. If the front is very stiff then it will tend to load very quickly at turn-in and may tend to turn better with more noseweight. At the same time, if the front end is relatively soft then in will tend to load more slowly and may not turn as well with more nose weight. While corner entry tends to be more about the stiffness of the front end, corner exit is additionally affected by how the LR reloads from the center off. If the kart really plants the LR hard from the center off then the kart's tendency to turn better with more noseweight will tend to diminish somewhat versus one which doesn't plant the LR as hard. It is possible that if the LR plants hard enough from the center off then things may turn around and go the other way causing the kart to push rather than helping it turn better.

at which it can be supported and it be parallel to the ground. In order to illustrate this, let's look at figure 1. Here we have a flat plate which represents our kart. It is 32" wide (which is width at the rear tire centerlines when we run a 6" LR and an 8" RR and have a tread width of 39"), it has a 40" wheelbase and we have 56% left and 46% nose on it. With these percentages we can calculate the exact CG position and it is shown with dimensions as being to the left and behind the geometric center of the kart. At this point we have the entire kart sitting on a point and it is perfectly balanced so that it remains parallel to the ground. The CG is the only place where we can support the kart by a single point and have it balance and for this reason is a point on the kart where we can assume the entire weight of the kart is pointing downward.



This leads us into our second major factor in how noseweight affects balance. Here we will be focus more on the static percentages on the kart and also those locations in the corner where less weight is transferring so that the fundamental front-to-rear balance plays a more predominant roll than the instantaneous loading which is so sensitive to relative corner stiffnesses. When we talk about static percentages what we mean is the percentages we calculate from scaling the kart. Using these nose and left percentages, we can determine the location of our kart's center of gravity (CG) and for our discussions we will ignore the height of the CG above the ground. The front to back position of the CG helps to determine how the basic physics of forces work together with tire physics contributed to the kart's overall balance. The basic physics go something like this: the further back our CG (in other words, the less noseweight we run), the looser the kart will tend to be and likewise, the more nose we put on it the less loose (or more pushy) the kart will tend to be. You will immediately notice that the "physics" effect can, on certain karts, be totally opposite to the stiffness effects. In order to understand why the basic physics of balance tell us this, we need to understand exactly what the CG is all about because when we raise or lower noseweight what we are really doing is moving the CG forward or rearward. The CG is the point on the chassis

Now that we understand the CG a bit better, we can get back to what its position tells us with respect to noseweight and balance. Before we go further, we need one more piece of information about the CG when we corner: just as the entire weight of the kart can be thought of as acting through the CG, so can the lateral force be thought of as acting entirely through the it as well. So then, if we're generating 300 pounds of lateral force then we could put a little arrow at the CG and say that there is a 300 pound force acting there. As we move the CG back we increase the rear weight and also increase the amount of total grip we can make with the back tires, however, at the same time we also move the point where our 300 pounds of force is working rearward so that those rear tires need to generate more grip. By moving the CG rearward we've added rear grip and we've added the need for rear grip and at the same time we've lowered front grip and lowered the need for front grip. The last piece of information that we need is that tire physics indicate that the amount of extra grip we make due to the added rear weight will be less than the extra amount of lateral force that the rear tires must generate due to having moved the CG back. For this reason, as we move the CG rearward the back end of the kart will work less efficiently (not as much extra grip made as there is extra grip needed) and the front end will work more efficiently (less grip is lost than there is the need for grip). This is why basic physics and tire dynamics tell us that decreasing nose weight (moving the CG rearward) will tend to make our kart looser. Before we go on, we need to understand a little bit more about tire physics and things that can affect them which can modify the very basic relationship we have discussed thus far. What we said earlier is true as long as both front tires are capable of producing similar amounts of grip to both rear tires. If, for example, we had 5.5's on the front and 8.00's on the back there would be some point below which tire physics would indicate more nose to help it turn and above which tire physics would indicate less nose to help it turn and this point would be a bit less than 50/50. In the case of most oval chassis which run right side tires which are the same and lefts which are close, the point where things reverse will range in the 45% to 50% range which is unfortunately where we most often run our karts which means the only surefire way of knowing which way to go is to test.

At this point hopefully everyone isn't terribly confused. I know it's difficult to see how the different things are happening but with nose weight, as with many things in karting, two things may be working in opposite directions and which one dominates may differ from chassis to chassis (and at times from condition to condition on the same chassis). Given all this, what do we do with our nose weights to tune our chassis? The first step is to identify where our balance problem is. If it is pushing or loose right at the instant of turn-in then things are less complex.

In these first few feet of a corner nearly all karts will turn better with more nose weight. Unfortunately, after we're ten feet into the corner the dynamics get much more complex and so does our job of figuring out which direction we need to go to adjust the balance of our kart. Here our first task is to figure out whether our kart has characteristics which overcome the effects of basic physics and tire dynamics or not. This may seem a subtle thing to figure out but probably the best indicator is this: if the kart is setup with a good baseline setup, then when something is not right and it's not balanced, is it nearly always loose or does it more commonly push? I don't mean what it does in the first practice when the track hasn't come in, but once the track has come in and the kart has a chance to work well. If the kart is nearly always loose then it is likely that the chassis is designed such that more nose will tend to make it turn better and if the kart has a more common tendency to push then it is more likely that more nose will make the push worse. As we covered before though, use this as a starting point because there are things about individual tracks and the way different karters prepare their tires that can cause a kart to go the other way at times.

From these examples and this discussion we can begin to see a few of the reasons a manufacturer might choose to design a kart to take a given amount of nose weight. They combine the natural balance of the kart along with the way they've designed the front end and that yields a range of nose weight which allows the kart to work best. Normally, the range of adjustment for nose weight is approximately one to one-and-a-half percent. Given this, a chassis which was designed around 44.5% nose will often run pretty well between 44% and 45% or so, and likewise, a chassis designed around 46% will typically work pretty well between 45.5% and 46.5%. Okay, so what happens when we get outside this range? Depending on several factors, it is possible that nothing bad will happen. On our kart designed around 44.5% nose, there will be a few karters who are successful in the 46 to 46.5% range but this will be the minority. What happens most often when a chassis taken outside of its nose weight range is that it will get finicky. The result will be that the kart may be fast on the out-of-range nose but if the track changes just a bit the kart won't be user friendly and will require tire or setup changes. Another result of getting outside the range is that the kart may pick up a tendency to be loose or to push most of the time. The result of this entire discussion on nose weight ranges and chassis design leads us to the conclusion that nose weight is something we'll most often want to stay relatively close to the manufacturer's recommendation, probably isn't something we'll adjust over a broad range when we do make adjustments, and probably isn't something we'll adjust often either.

Think about it. Next month we'll look at part three - left side weight.