DON'T CHEAT ON YOUR CAM

BY STEVE TANZI

It's not every day that I get to break away from the somewhat normal rigors of running a camshaft company to write an article about something I'm so very passionate about; camshafts and how they work. When I read the title of this article and I asked myself the question, 'How do you cheat on your cam?' the answer became self evident.

It's something that is done more often than you can imagine and as a matter of fact, the evolution of our industry has been to strengthen and alleviate valve train related inaccuracies to better interpret and/or translate that which has been designed. Whenever we make a change to any one of the components within the valve train, it affects the other components until it ultimately affects the power produced by the engine. So let's start at the beginning and examine just exactly what a camshaft is and what exactly it is meant to do.

A camshaft, broken down into its singular configuration, is nothing more than a lobe. And a lobe is a modified eccentric, a circle within a circle, not sharing the same center. It is a device commonly used and specifically designed to transfer circular motion into vertical motion. This motion is carefully designed to occur at specific intervals, lift per degree of rotation, which coincide with the four cycles of an internal combustion engine. And without these perfectly timed series of events occurring precisely when they are intended, we have nothing more than oddly shaped pieces of steel. These lobe designs are methodically calculated by only a handful of men like Harvey Crane, Harold Brookshire and Hans Herman, to name a few, whom have spent their lives analyzing engine designs and creating that motion which when transferred properly as designed, begets the power sought and needed to win.

And as you can imagine, there have been literally thousands of lobe designs created in our lifetime. Every automotive manufacturer and each camshaft company invests countless hours and cubic dollars into research and development designing lobes specific to applications, so they can add these profiles to their library. This can make the selection process seem a little overwhelming at times, because who's to say who is right. There are so many variables that affect selection even at the lobe level that ultimately, selecting the perfect camshaft company with that perfect lobe becomes a challenge. There are tight lash lobes, loose lash lobes, fast action lobes, symmetrical lobes, asymmetrical lobes, constant velocity lobes, inverse radius lobes and other designs too numerous to mention. So now that you understand that even something as simple as a lobe, let's say for argument sake, 264 degrees @ .050" and .420" lobe lift, which is as common a lobe as you've all seen throughout the pages of the different aftermarket camshaft manufacturers catalogs, can all appear to be similar except for the dynamics of the design, which is completely invisible to the naked eye.

Each camshaft lobe designer is like an artist. They have their own style and theory as to how they believe the rest of the components respond to their design. These designs are, for the most part, theoretical in nature and very specific to valve train weight, RPM range and application. So you can either blindly purchase a cam based on the recommendation of a friend and put it into your race car's engine and wonder why you don't run as strongly as your buddy, who purchased the same camshaft profile from a different manufacturer. Or, you can establish a relationship with someone within a camshaft company that you respect by virtue of their experience, and rely on their recommendation as to the dynamics of that lobe as it applies to your valve train. The later of the two always costs less in the long run and tends to keep you on the track in a competitive manner with fewer problems.

So now that you have selected the camshaft and you know that some extremely intelligent engineer has spent hours upon hours of time cramming numbers into a computer so that the lash ramps, acceleration, velocity, dwell, radiuses and decelerations have all been taken into consideration to provide you with the best design possible, how do you transfer this motion? Well, the answer is simple. Eliminate geometric discrepancies and keep the driving side of the valve train stiff. The object here is to transfer motion and to eliminate as much valve train deflection as possible in doing so. In my time, I have seen the pendulum swing from light weight components to ultra light weight components and then back to heavier and stiffer components and finally, after fifty years of development, I think we're finally figuring the internal combustion engine out... for now.

This does not always apply to all lifters from what I can see, but I will tell you something that I have noticed. Mechanical flat tappet camshafts seem to benefit from light weight lifters in terms of being able to reach higher RPMs. This is obviously as a result of the fact that there is less inherent deflection in a mechanical flat tappet valve train because the lobe design, which is specific to follower diameter, takes less valve spring to control. However, on the other side of that coin, because we are turning racing engines tighter these days, more valve spring pressure has been introduced to achieve higher RPMs. Therefore, the components can be lighter, both the lifter and the pushrod, than the ones selected for a solid roller camshaft. But the composition of the components must come from more complex materials as a result of the greater loads. In a mechanical flat tappet valve train, until recently, the materials dictated the loads we were able to impose. Cast iron camshafts were only capable of sustaining very specific loads, because of the relative simplicity of the composition of the types of grey iron used in the production of camshafts. We learned that by adding specific alloys like chromium and/or nickel in small amounts to the iron, we could produce camshafts that could withstand greater valve train loads, which resulted in higher RPMs and fewer camshaft/lifter related engine failures. We have even ground camshaft cores from 8620 alloy steel to mimic flat tappet lobe configuration to further address the stresses imposed by higher loading. Additional processes such as plasma nitriding and advanced operations such as cryogenics treat materials to enhance both the surface and the substrate of the camshafts and other load baring components to levels not previously seen in our industry. Even specially designed coatings have made their way into our industry from the aero space sectors to give diamond like hardness to components not normally associated with hardnesses in that realm, adding to the further reliability of mechanical flat tappets. All this being said, we are now being able to transfer motion from the camshaft lobe through the various components of the valve train more reliably. Take for instance how well a Cup Car performs with a mechanical flat tappet camshaft. Keeping in mind there is nothing low tech about the components and their valve trains cost a fortune. Every single component has been derived from thousands of hours on Spintrons and/or valve train simulators and nothing goes on the car unless it receives a clean bill of heath from their in-house engineering staff. Roller lifters, on the other hand, are and have been the subject of many changes throughout the evolution of valve train design, but those design changes have been primarily focused on their ability to handle greater loads. As a result of cylinder head development, which has increased the air flow through ports at lift figures never even imagined several years ago, more valve train stability has become a very realistic concern. Camshaft lobe designers have continued to push the design envelope by creating taller lobes while attempting to keep the dynamics of the valve train in mind. You could say that the old adage of trying to cram ten pounds of manure in a five pound bag was never more apparent in terms of these newer designs. Furthermore, because lobe development actually has design parameters that more or less keep the designers in a box, we have been witness to camshaft cores growing in size as well. This increase in journal diameter has two reasons, one to add rigidity to the cores as a result of the increase in valve spring pressures needed to control the valve train; and two, to be able to accommodate taller lobe designs without having to grind into the core, making the ramps of the lobe seem less severe. In any event, because of these advancements, more aggressive lobes and the increase in loads required to control these new designs, roller lifters have actually become larger. Traditionally small block Chevys used .842″ diameter roller followers with .750″ wheels. Now it is not uncommon to see .904″ diameter bodies with .812″ followers or larger in Chevys with no detrimental effect on performance and an increase in reliability.

Pushrods follow the same suit. In the old days, .065″ wall thickness, 5/16″ diameter chrome moly pushrods were suitable for most mild performance applications. Then we started imposing more loads, in the form of more aggressive lobe designs and as those loads increased so did the outside diameter and wall thickness of the pushrods. They grew from 5/16″ to 3/8″ and even larger in some cases. Wall thicknesses grew from .065″ to .080″ to .095″ and even larger, while still allowing the pushrod to not only transfer motion but to transfer lubrication to the upper end of the valve train. These improvements also took on new shapes, such as single tapered and dual tapered or ellipsoidal designs. Ultimately, these design changes made pushrods better equipped to distribute the loads more evenly over the entire length of the pushrod. Bending and flexing or pushrod deflection, caused primarily by the extreme compression loads imposed by an accelerating valve train, were nearly eliminated. Valve train harmonics which occur naturally in some components like pushrods and valve springs, have their own

modulus of elasticity or ability to return to their original form after being subjected to severe loading. By creating stiffer pushrods, we have virtually eliminated valve train deflection and a source of harmonics and therefore created much more accurate timing events as seen by the engine during operation.

Now we've made it to the top of the engine, the last in a series of weak links in terms of the ongoing battle to transfer the design from our signal generator, the camshaft lobe, to and throughout the entire valve train. Rocker arms are not so much the problem as much as how they are attached to the cylinder head. Even though there are some rocker arms that are better designed than others, their job is to transfer motion and to do it with little to no deflection. However, the problem is primarily in how they pivot and what attaches the pivot point to the head. In the old days, a rocker arm pivoted on a stud that was pressed into the cylinder head. We improved that design by creating a stud that screwed into the head and then we took it one step farther by increasing the stud's diameter. But as loads increased, we found that somehow the gross lift figure as calculated mathematically, was not the same as what the engine was seeing at the valve. After further investigation and with reasonable deduction, we determined the studs, no matter how they were attached to the cylinder head, were moving back and forth. So the stud girdle was invented and did contribute to creating more stability when stud mounted rocker arms were used. And yes, they are and can be used in flat tappet mechanical type valve trains, and are not limited to solid roller applications. However, the best way to attach a rocker arm to the cylinder head is to mount a solid foundation to the head commonly referred to as a platform, and have the rocker arm pivot on a shaft as opposed to a single point fulcrum. This dramatically reduces the amount of deflection that is produced by lowering the arc of motion. Imagine a rocker arm mounted on top of a flag pole, I think you get the picture. Now we are at the rocker arm itself. Remember, its job is to transfer motion and that would be the case if we were talking one-to-one here. But we are transferring and amplifying that signal as received at the pushrod side of the rocker arm to the valve stem by increasing the ratio. To do this, it is necessary to increase strength or stiffness without increasing weight, thereby not upsetting the moment of inertia. All of the things we have spoken about in this article have been tried, modified, tested, engineered, re-engineered and applied to our industry for the sole purpose of providing accurate timing points as designed by those who design lobes. The valve train is a complex mechanism, but that does not mean we need it to be complicated. Very intelligent men with very sophisticated computer programs design these lobes taking many variables into consideration, so that you can receive the best product for your application. You paid for it, so you should get what you paid for; all you have to do is transfer the motion. So as you can see, the bottom line is "don't cheat on your cam".