Custom Cams

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Advances in technology are making custom-ground cams affordable even for the little guy

Cam designers have traditionally been a small lot of dedicated people who have found power sometimes through the applied use of mathematics, but just as often through the sheer redundancy of trial and error. Nowhere else in an engine do so many variables come into play as in the valvetrain, and controlling all those movements is, of course, the camshaft. Properly timing the interplay of events such as when to open and close the valves, ramp speeds, maximum lift, duration, and overlap is critical, but it is made more difficult because a change in any one of these events affects another in some way. That's why custom-ground camshafts have almost always been the territory of big-money racing teams—until now, that is.

Mike Jones is a second-generation racing cam designer. For years, he operated Jones Racing Cams out of California, working mostly with Chevrolet's Indy Car teams. Recently, however, he moved to the East Coast to team with noted head designer Don Losito of Ultra Pro Machining to form Ultra Pro Racing Cams. This new company plans to combine Jones' experience with Ultra Pro's CNC machining expertise to create custom cams for stock car racers that are affordable and tailored specifically to each racer's needs.

The point of this story isn't to push the idea that a custom cam is necessary for every racer. Certainly, it can be helpful for some, but off-the-shelf pieces from the big manufacturers are plenty good, too. It can be helpful to know exactly how a cam is made so that you know what to expect the next time you place an order. Plus, it can be helpful to know what information

Even if you are a budget racer, having a cam ground specifically to your needs may not be out of your range, thanks to computer modeling technology.

cam designers need to build the best possible bumpstick for your racer.

INFORMATION, PLEASE At first, you might think a custom cam designer would need to know the size and weight of every nut and bolt on your engine, but it isn't true. Jones uses a program he and his father have written (no, it isn't for sale) that helps him determine the best cam profile for any engine combination. Through years of experience, he has determined the main factors he needs to know. They are the engine's bore, stroke, rod length, static compression ratio, the carburetor and its flow, the planned rpm range, and the port flow numbers. Many of the things you might initially think are important are already factored in through the port flow numbers (valve sizes, valve seat angles, type of heads and intake manifold, and so on), or simply have no effect on cam design (weight of the rotating assembly, dry versus wet sump oiling, coated bearings, and so on) and are simply power adders no matter what cam you use.

"The biggest thing for the customer is to have the most accurate flow numbers possible," Jones says. "If the heads are unported, I already know most of the numbers for every head as they come from the manufacturer. If you are racing ported heads, that information gets critical because I don't know who has done the port job and how good it is. Then, I need good flow numbers across the range of valve lifts, not just the maximum flow numbers. Also, if you can flow the heads with the intake manifold attached, that makes the numbers even better."

There is nothing magic in Jones' proprietary software; it simply does the calculations for him. Because it takes specific amounts of air and fuel to make one horsepower, an engine's horsepower is effectively limited by how much air and fuel it can draw into each cylinder. By inputting the necessary information, Jones determines the maximum power potential of your engine combination and at what rpm that occurs, then designs a cam to fit that profile. This is the point where other limitations, such as engine restrictors or limitations of the track or handling, come into play.

"A lot of sanctioning bodies use the carburetor essentially as a restrictor plate to slow the cars down, and you have to account for that," Jones says. "Take a NASCAR Late Model Stock for example, since they are probably the most popular example of this. Because that two-barrel carburetor will only allow so much air, the engine's peak power will be at 6,500 rpm. But I know most racers are pushing well beyond

Cam designer Mike Jones uses his own software to determine an engine's maximum performance potential, and then designs a camshaft to fit it.

Jones determines the optimum lifter motion to suit the engine, and then CNC programmer and machinist David Taylor designs the cam to fit the desired lifter motion. Here you can see the differences in the shapes of a flat-tappet and roller-cam lobe designed to produce the same lifter motion.

Once the lobe programming is finished, a pattern is cut from aluminum bar stock on a CNC four-axis lathe.

On the left is the finished pattern, which is a life-size replica of the actual lobe. On the right is the raw material from which the pattern is cut.

Machinist Tony Ellis checks the pattern before handing it over to Jones.

The patterns are used to make masters, five-inch steel discs that the cam grinder uses to cut the desired shape into the lobes.

that—usually around 7,200 rpm—to get the gear they need in the car. So instead of designing a cam for peak power, I'll want it to make the best possible power all the way to 7,200 rpm. We'll try to make that horsepower line on the dyno sheet as flat as possible. Now we don't have the best possible peak horsepower number, but the car runs better on the track because it holds its power better and doesn't lay down at the flagstand."

Another interesting problem Jones is helping many racers combat is spec tire rules. "I recently worked with a guy who was racing a dirt car that was having problems breaking the tires loose coming out of the turns," Jones explains. "His track limited the tire size, and the engine was simply overpowering the tires when he put his foot on the gas. Then, to make things worse, on the straights, when he could use the power, the engine was laying down.

"We didn't want to get rid of the torque the engine was making, but we did want to move it to a place in the rpm range where it would be more useable," he continues. "The engine was making peak horsepower at 6,500 rpm and peak torque at 4,200 rpm. We estimated at the rpm the driver was coming out of the corners, it was making around 500 ft-lb of torque! So I put the numbers into my program and started playing with them. I designed a cam with a wider lobe separation that moved the peak torque out to 5,000 rpm. The goal was to give the driver more manageable torque coming out of the turns, and then gain as he went down the stretch. Again, we gave up a little bit on the peak torque, but in this situation it's OK because the car couldn't handle it anyway."

THE PROFILE Once Jones knows what he needs, the next step is to map out the optimum lifter location along 360 degrees of camshaft rotation. That's because the lifter motion relates directly to valve lift (with a multiple for the rocker-arm ratio). He then takes that information, along with the lifter size and the base circle

Depending on your needs, there are several core options to choose from. These cores are all designed for the ubiquitous Chevy small-block. From the bottom is an iron core for flat-tappet cams, an experimental steel core for Winston Cup applications, a steel core for roller-tappet applications, and finally, on top is a steel core for Trans-Am racing with giant 55mm base circles.

Jones checks every core to make sure they are straight before setting it up on the grinder.

Here you can see the final setup. The master is mounted to the grinder (left) and guides an 18-inch follower. The follower and the grinding wheel are the same size and follow the same path so that the final lobe shape matches the master exactly—only on a much smaller scale. If Jones is grinding a camshaft with concave bases on the lobes, he uses a smaller 5-inch follower and grinding wheel.

of the cam, to CNC programmer David Taylor. Taylor can then use this information to design a cam lobe that fits it. It may seem a little backward, but this method means Taylor can easily design lobes for both flat-tappet and roller cams to fit this profile.

Once the profiles for both intake and exhaust cam lobes are programmed, aluminum patterns are cut on a four-axis lathe from solid 2.5-inch bar stock. These patterns, 1:1 models of the final lobes, allow Jones and Taylor to check out the final product before cutting steel. If the patterns past muster, they are used to cut the masters. Masters are 5-inch steel discs that are mounted to the cam cutting machine to cut the lobes. Over the years, Jones has collected a truckload of these masters, so unless somebody requests a proprietary lobe profile, it's likely he has the profile you need, and the previous steps won't even be necessary.

CUT AND RUN The final step is to grab the appropriate blank and start grinding. Once all the design work has been done, this is actually the least technical part of the entire process. There is one surprise here, though. Jones can actually build cams with inverse curves in the base of the lobes. He does this by using a 5-inch cutting wheel instead of the standard 18-inch wheel. The small concave curve this creates at the base of the ramp allows Jones to significantly slow the speeds at which the valve lifts off the seat and closes on the seat—the most critical events of the cycle. Of course, cutting cam lobes with a 5-inch grinding wheel is much more time consuming than with a big 18-inch wheel, so as you might expect, the costs are greater. Still, Jones has found many applications where the concave base is worth it. ***CT***

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