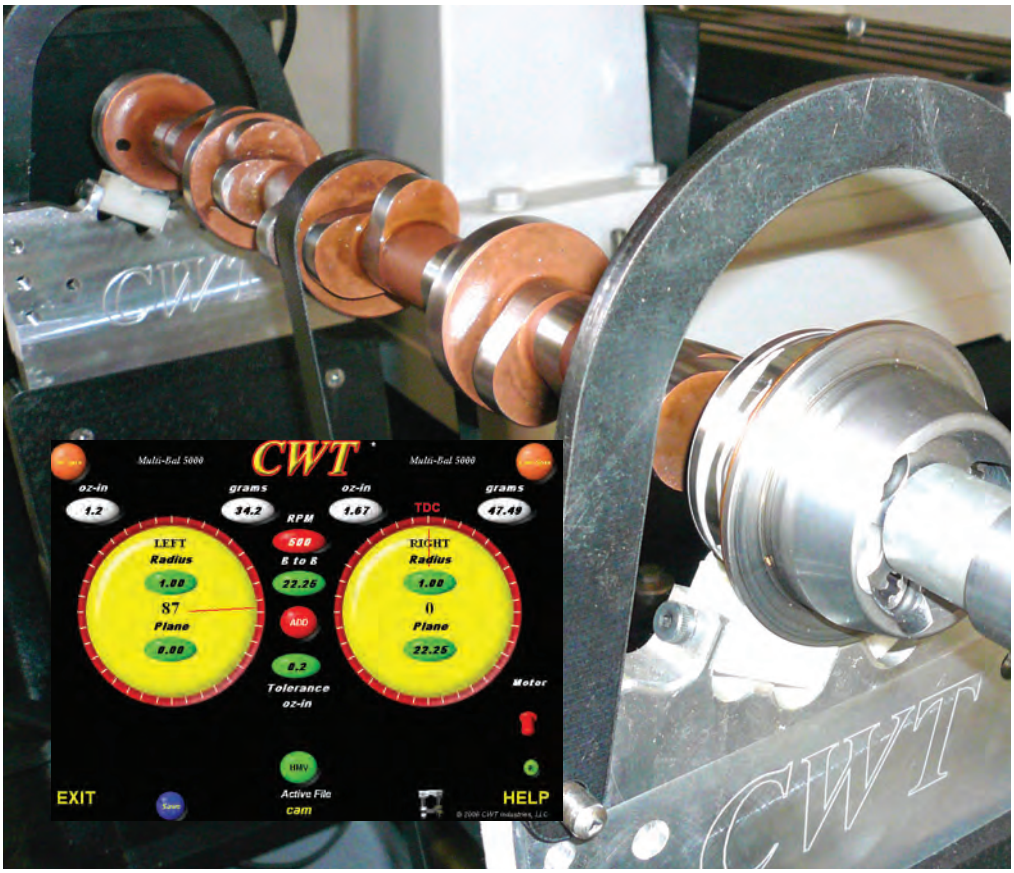

Unleashing horsepower is the name of the game!

BY **RANDY NEAL**

PHOTOS PROVIDED BY **CWT INDUSTRIES**

Camshaft Balancing

Everyone knows that the camshaft is a precision-made component that is machined to exacting tolerances and its primary function is to open and close intake and exhaust valves. We also know that camshaft manufacturers have engineers whose sole mission is to design lobe profiles that enhance the flow of the intake and exhaust gases. But how many of you thought balancing a camshaft would help horsepower increases — probably very few, so my challenge is to get you to open your mind to a new way of thinking.

As a related topic most of the performance community currently endorses "hi-tech coating" and "friction reducing" chemicals as plausible methods of making more horsepower, when in fact they only reduced the potential parasitic activities that restricted horsepower increases.

We clearly understood that as camshaft manufacturers designed exotic profiles, the rest of the valve train had to be modified to handle the increased lift and radical geometries. Valve springs, retainers, rockers arms, push rods and lifters have gone through tremendous changes either through increase structural designs and/or weight reductions. All of these modifications were to insure that the designed cam profile increased the performance of the engine.

One area that has not been generally studied has been camshaft balancing, or more importantly the characteristics of the camshaft when it is "out of balance". Most engine builders assume that due to the high level of design and machining accuracy that the camshaft is already within tolerance. Another misconception is the lack of understanding as to the applied forces and frequency of these forces that cause the camshaft to become unstable. And lastly, the camshaft rotates at the speed of the crankshaft, thus the actual rotation speed is of little or no concern. Wrong on all three counts!

So let's start with this statement: virtually every camshaft made is not balanced. We have tested hundreds of camshafts and have never found one that was balanced. As a matter of statement we rarely see two camshafts with the same profile that have exactly the same unbalance. Now you may be saying that just can't be true due to the accuracy of the new CNC cam grinders; but the balance problem does not generally come from the grinding operation, it actually started with the raw casting or billet blanks.

When the camshaft blanks are made, they have "center registers" placed at each end of the camshaft. The main bearing and base circle of each lobe are established from these registers. The axis of rotation and the "center of mass" is probably not the same. In fact this is generally what forces the camshaft to be out of balance, remember when the "center of mass" is not the same as the "center of rotation" there will be a balance error.

When a camshaft is out of balance, we need to know the magnitude of the unbalanced forces and their location relative to each other. The 60 mm Roller Camshaft shown above has been inspected on a CWT Multi-Bal 5000 Balancing Machine.

Notice that the left side of the camshaft is 1.2 Ounce-Inches (34.2 grams) out of balance and the right is 1.67 Ounce-Inches (47.4 grams), also take notice that the un-balanced units are not opposed (87 degrees) to each other. This will cause the shaft to

CAMSHAFT BALANCING

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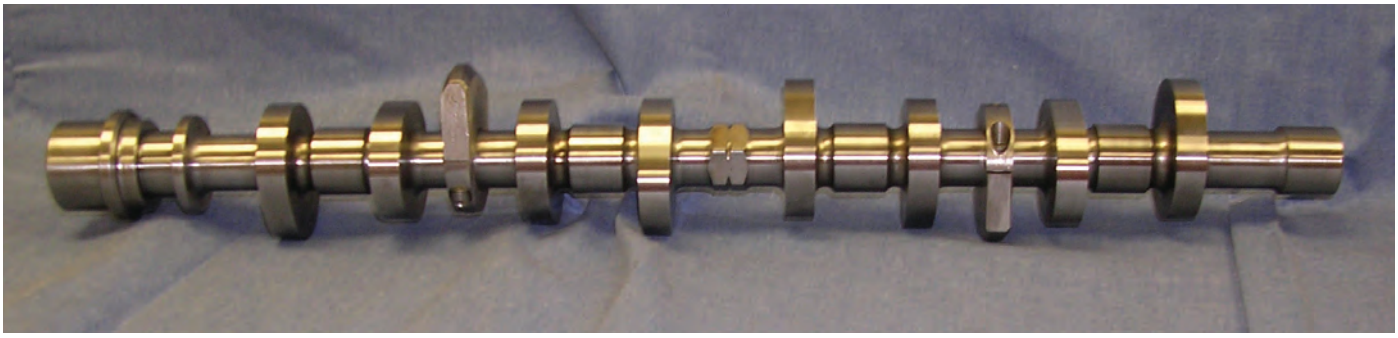
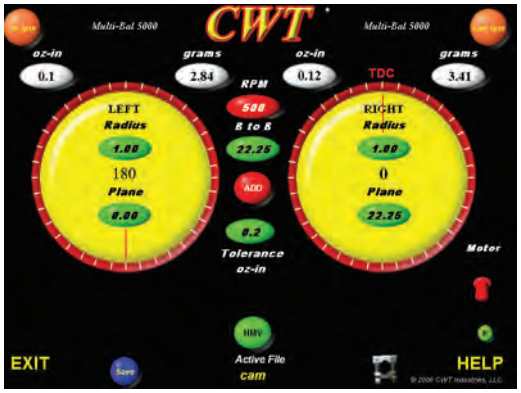
Camshaft with bolt on weights that can be used if the camshaft has the room between lobes.



combine the out of balance forces causing a bending moment as opposed to a cancelling effect. Notice the corrected report below showing the out of balance has been minimized and the residual unbalance is in couple (180 degrees opposed) which helps to cancel the effects of the two opposing forces.



Now back to the first unbalance report; given the camshaft running at an rpm of 4000 (1/2 of crankshaft 8000 rpm) the left side of the camshaft is generating a force of 34.3 pounds and the right side is 47.6 pounds and both are hammering at 66+ times per second. This may be enough to cause the camshaft to become "excited" and set up a vibration pattern that will motivate the roller lifter to bounce on the surface of the lobe. Ultimately the valve will respond to all of this activity and most likely it will cause the valve to follow a path that is not equal to the designed cam lobe profile. Also while the lifter is bouncing on the cam, the rest of the valve train has been linked to this physical activity. This may cause the valve spring to also become "excited" generating an inconsistent travel pattern commonly known as "valve spring float".

The ultimate result is that the engine will not perform as intended. In all probability, at an unknown moment, at an undetermined rpm, the engine will make less power. We have seen this on the power curves when plotting the horsepower/torque on the dynamometers. Some engine builders have determined that these anomalies can be related to ignition/fuel and/or flow characteristics of poorly designed intake systems, and they could be right.

However, when the intake system is modified and the same rpm related anomaly is re-plotted then there is strong evidence that the valve train is the potential cause and the vibration of the camshaft has the ability to cause these results.

In all fairness, balancing the camshaft may not eliminate all or any of the valve train issues due to the fact that there are several other moving objects that may have natural frequency issues that could become excited from surface speed activities (rocker flutter, valve spring float, push rod deformation and excess end-gap clearances). But by balancing the camshaft you have eliminated a known variable that will not be a part of your quest for the ultimate performance of your engine.

For the skeptics out there who still believe that the camshaft harmonics have no relevance to horsepower gains, I agree that it will not make power, it simply unleashes it. There is no discussion that can be supported that says balancing any rotating mass will cause any object to perform in a negative manner.

Correcting the unbalanced camshaft can be achieved by several methods; the first is to modify the timing gear by removing or adding material as specified by the balancing machine. The second is to remove weight from the core of the main bearing area or add weight by first drilling holes into the main bearing and replacing it with Heavy Metal.

If the weight is excessive you may have to add external weight to the shaft itself. This can be achieved by using an adaptor that is added to the rear of that shaft which locates a counter weight that is modified by the required amount to balance the assembly. ■

Randy Neal from CWT Industries in Norcross, GA, has over 30 years of experience in the industry and is considered a leading expert in engine balancing and understanding shop profitability.

For more information, please contact Randy Neal, 800-449-1849 or e-mail randy@cwtindustries.com