PROJECT 89

Adjusting Cam Timing

Time: 8 hours

Tools: Sockets, Allen sockets, ratchet, torque wrench (foot-pounds and inch-pounds), pry bar or big flathead screwdriver, gasket sealer, timing wheel, heavy wire pointer, dial indicator and mount, piston stop

Talent:

Cost: $

Parts Required: Slotted cam sprockets

Tip: Modifications to the engine components will determine the range of changes you can safely make to the cam timing.

PERFORMANCE GAIN: More power where you want it.

If you've spent any time reading the projects in this book, you're pretty familiar with the fact that many components and settings on a stock sportbike result from a manufacturer's compromise—to produce the most versatile motorcycle possible. Also of concern for the factories is the need to meet emissions restrictions. Consequently, more power can be derived from an otherwise stock engine by timing the cams. As with many performance modifications, what the wrench giveth, the wrench taketh away. Simply put, you can massage where you want the maximum benefit of your cam timing, but you will have to compromise in other areas. When you tune for improved midrange, the top end may suffer. Conversely, if you want to get the absolute biggest peak horsepower figure out of your engine, the bottom will take a hit. However, you can increase both midrange and top end with cam timing, but neither will achieve the absolute maximum available. There's that old compromise again.

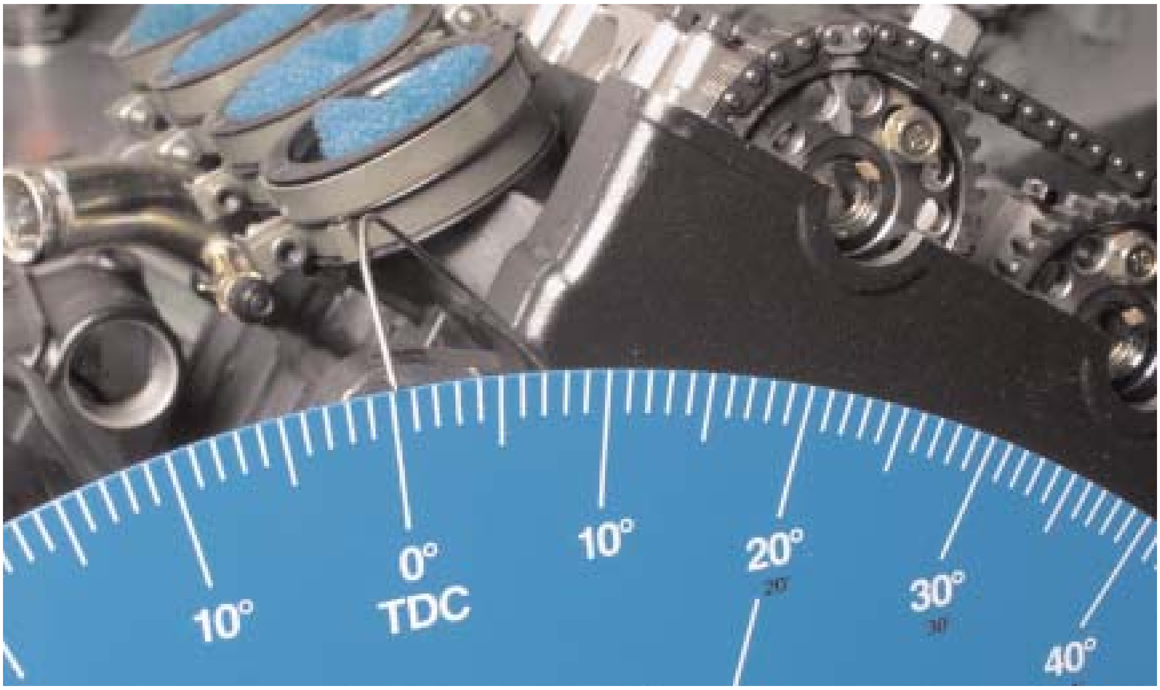
A piston stop threads into the spark plug hole to provide a consistent point for halting the piston's trip up the cylinder. Using some simple averaging, you determine the exact location of TDC.

With relatively inexpensive horsepower there for the taking, why don't more riders take advantage of it? Because cam timing is an exacting process best undertaken by a pro—it's not for the faint of heart. More is at stake than just changing the precise point at which the valves open. Get your timing wrong, and the pistons and valves will try to occupy the same space at the same time. The engine will grenade, the owner's heart will break, and the credit card companies (and parts retailers) will make lots of money. So, before attempting to perform this modification by yourself, consider observing an experienced mechanic who has done the job a few times. Maybe entice him (with food and drinks) to observe you as you muddle through your first timing experience.

Another issue you might want to consider about cam timing is that the numbers you get from other riders or the Internet or a shop may not be the right ones for you—if you're looking for maximum power. All engines are different and require slightly different tuning. So, when you get timing numbers from someone, make sure that their engine is in a mechanical state of tune similar to yours. Any modifications like raised compression (be it by pistons or milling engine parts) will have an effect, not just on the timing numbers, but also on the numbers you're able to safely use without fear of metal-on-metal contact. (A side note about increasing compression by milling the head or removing the base gasket: These modifications change valve timing. Consequently, you must retime your cams just to get back to stock timing.) So, with all these variables in play, consider this project more of an overview on cam timing rather than a step-by-step explanation.

Although it is possible to time the cams with the engine in the chassis, the tight working space makes this tough job tough. Having the engine mounted in a stand or on a bench will ease the process. You'll also want the valve cover and spark plugs removed. If you haven't set the proper valve clearances, do this before attempting to alter timing. Maintenance always comes before upgrades. Check to make sure that the OE timing marks for the crankshaft and cam sprockets line up before proceeding. This check will usually set your engine to top dead center (TDC) for the number 1 cylinder. When the crank is in this position, attach the timing wheel. Mount the sturdy wire pointer somewhere else on the engine. A nearby side-cover bolt will usually work. Bend the wire so that it aligns with the 0 (zero) on the timing wheel.

Finding the actual TDC on the piston will be the first step. Because this involves turning the crankshaft both forward and backward, you will first need to loosen the cam sprocket bolts then remove the cam chain tension adjuster and the cams. (Look to the valve adjustment project for more information.)



Setting the timing wheel on the crankshaft and mounting a sturdy wire pointer are imperative for accurate cam timing. If you bump the wheel or pointer, you will need to verify TDC before continuing with the project.

Once you have the cams removed, hold the timing chain to remove its slack and rotate the crank approximately 90 degrees forward. Insert a piston stop into the number 1 cylinder's spark plug hole. Rotate the crankshaft forward until the piston contacts the stop. Write down the number the pointer indicates on the timing wheel. Now, turn the crank backward until it contacts the stop. Note this number. Now add the two numbers and divide by two. With the piston still firmly against the stop, adjust the needle on the timing wheel so that it points to the number you calculated. Remove the piston stop and set the crankshaft at TDC as defined by your now calibrated timing wheel and pointer.

Before you swap the cam sprockets, you need to mark with a pen where the stock sprockets line up with the cams. Remove the sprockets from the cams. If you're installing aftermarket sprockets instead of slotting the stockers, lay the new sprockets over the OE ones so that the center of the slotted hole is over the old sprocket's bolt hole. Line up the teeth on the sprocket, and mark the new sprocket in the same location as your previous pen mark. Line up the new sprockets on the cams and bolt them down. Install the cams according the factory recommendations.

In order to change the cam timing, you need to first calculate where the cams are centered. Set up and zero a dial indicator with its plunger in contact with one of the intake valves' buckets. The indicator should have a range that exceeds the maximum distance that the valve will be depressed. Also, the plunger should be angled as close to parallel with the direction of the valve's movement as possible. Because the initial movement of the valve is difficult to measure, mechanics generally measure the crank rotation required to lift the valve 1 mm.

Once the dial indicator is set, slowly turn the crankshaft forward until the dial indicator reads a 1-mm lift. Stop and note the number on the timing wheel. Now, continue to rotate the crankshaft forward. You will need to count the number of times that the indicator's needle circles the gauge before reversing direction as the valve starts to close. Count down the same number of turns on the indicator until the closing height is at 1 mm. Write down this number. Give the numbers a logic check to make sure that what you've recorded makes sense. An intake valve will open before top dead center (BTDC) and close after bottom dead center (ABDC). Exhaust

The dial indicator needs to be solidly mounted to the engine. Make sure that the plunger moves parallel to the valve and has enough range to track the valve through its maximum extension.

To alter the cam lobe's center, you need to loosen the sprocket bolts and move the crankshaft slightly.

valves will open BBDC and close ATDC. (Note: Some mechanics will turn the engine backward to measure the point where the valve is 1.5 mm from closed, then turn the crank forward until the valve is at the 1-mm testing height. By turning the engine backward, you must account for any possible free play in the timing chain or you'll risk incorrect readings.)

Now get out your calculator to find the cam lobe centers. Total the valve opening and closing numbers plus 180. Divide this number by 2. Finally, subtract the smaller of the measured numbers from the quotient. If the valve opening number is the smaller of the two measured numbers, the equation would look like this:

$$((V_{open}+V_{closed}+180)/2)-V_{open}=\text{Cam Lobe Center}$$

If your numbers for the intake at 1-mm lift were 30 BTDC open and 68 ABDC closed, your equation would work like this: 30+68+180=278, 278/2=139, and 139-30=109. The intake lobe center is at 109 degrees. Although you can't go wrong subtracting the smaller number from the quotient, just for clarity's sake: The smaller number on an exhaust cam will be V_{closed}.

By calculating where the cam lobe centers are, you now have the tools needed to begin altering the timing. The most common method for altering timing is to adjust the intake and exhaust cams as a pair. Doug Meyer of Muzzys Performance Products sums up the primary options pretty succinctly in his tech article "Cam Lobe Centers Explained" when he writes: "Advancing the intake and retarding the exhaust ('closing up the centers') increases overlap and should move the power up in the rpm range, usually at the sacrifice of bottom end power. The result would be lower numerical values on both intake and exhaust lobe centers. Retarding the intake and advancing the exhaust ('spreading the centers') decreases overlap and should result in a wider power band at the sacrifice of some top end power." So, now that you have the location of your engine's lobe centers, you can guesstimate what those magic numbers could do to change your power band.

Any changes you make to the cam timing should be small ones, as adjustments of even 1 degree can have profound effects on your engine's performance. Only alter one cam at a time by taking it through all of the measurements prior to Loctiting the bolts down. To make the changes, simply loosen the cam sprocket bolts on a cam and then shift the crankshaft slightly. Tighten the bolts and recalculate the lobe center.

Regardless of whether you are trying to develop your own cam timing numbers or are using the hot setup recommended by a fellow mechanic, you must check your valve clearance with the piston before you crank over the engine. The most critical valves are the intakes, but you should also check the exhaust. Checking at 10 degrees before and after TDC will give you a good idea of how close you've cut it. (Some mechanics will go the extra mile to make sure that everything is safe by checking at 5, 10, and 15 degrees before and after TDC.) For intake valves you want no less than 1.25-mm clearance. On the exhaust side keep it to 2 mm. To measure the clearance, simply set the crankshaft to the appropriate degree. If you encounter any solid resistance while turning the crank, stop and determine what the problem is. Don't force it. With the dial indicator set up on the valve bucket as it was for the timing, take a pry bar or large flathead screwdriver and press the valve down until it contacts the piston. Note the reading. If the intake clearance is too tight, you will need to retard the timing until you reach a safe point. If the exhaust clearance is too tight, you will need to advance the timing until you reach a safe point. You only need to check one intake and one exhaust valve, since the others should all be the same.

When the timing is set to its final values and you've checked the valve-piston clearance, you'll want to remove the cam sprocket bolts one at a time. Clean the threads of any oil. Apply Loctite to the threads and torque the bolt to the cam. Remeasure the timing once more after you've locked all of the bolts to make sure that nothing changed. Once you're happy with the valve timing for the engine, all you have left to do is close up the engine and reinstall it in the frame—easy work, compared to adjusting the timing.

To make sure that the valves aren't going to butt heads with the piston, you need to measure the valve-piston clearance at 10 degrees both before and after TDC.