Cam Lobe Centers Explained.

Doug Meyer

One of the least understood topics and regarding engine tuning and building continues to be the concept of cam timing and “lobe centers”. The opening and closing process of an inlet or exhaust valve as controlled by a cam lobe constitutes a complete “event” in the cycle of the engine. Like any event, it has a beginning and an end. Naturally, then it also has a middle or center. The location of this center in relation to the rotational position of the crankshaft is known as the lobe center.

The process of “degreeing” cams allows the engine builder to place the lobe center of a cam in the correct orientation with reference to the crankshaft. The opening and closing points and resultant figures of the cam, although important, are very difficult to reference to set cam timing and are, after all, the result of where the lobe center is placed. Therefore the lobe center is used to reference cam timing. The difficulty in measuring the opening and closing points is the result of the very shallow and gradual starting and stopping of the valve motion. How do you tell just when the valve motion starts and stops? If you pick a specific amount of lift at some height beyond the initial gradual motion and always use that amount as a marker for the beginning and end of the motion, the center will always be halfway between these points. Therefore, the lobe center is computed from a timing number derived at a specific valve lift. Any lift could be used to compute this, but in the Japanese motorcycle industry 1mm or .040” is traditional. U.S. (automotive) cam grinders have used .050”. This “checking height” must be used to minimize the effect of the shallow opening and closing ramps on the cam lobe. Without this, each builder’s subjective notion of when movement starts would be the defining factor of timing. One picture is worth a few thousand of my words so now refer to my crudely drawn diagram for
clarification.

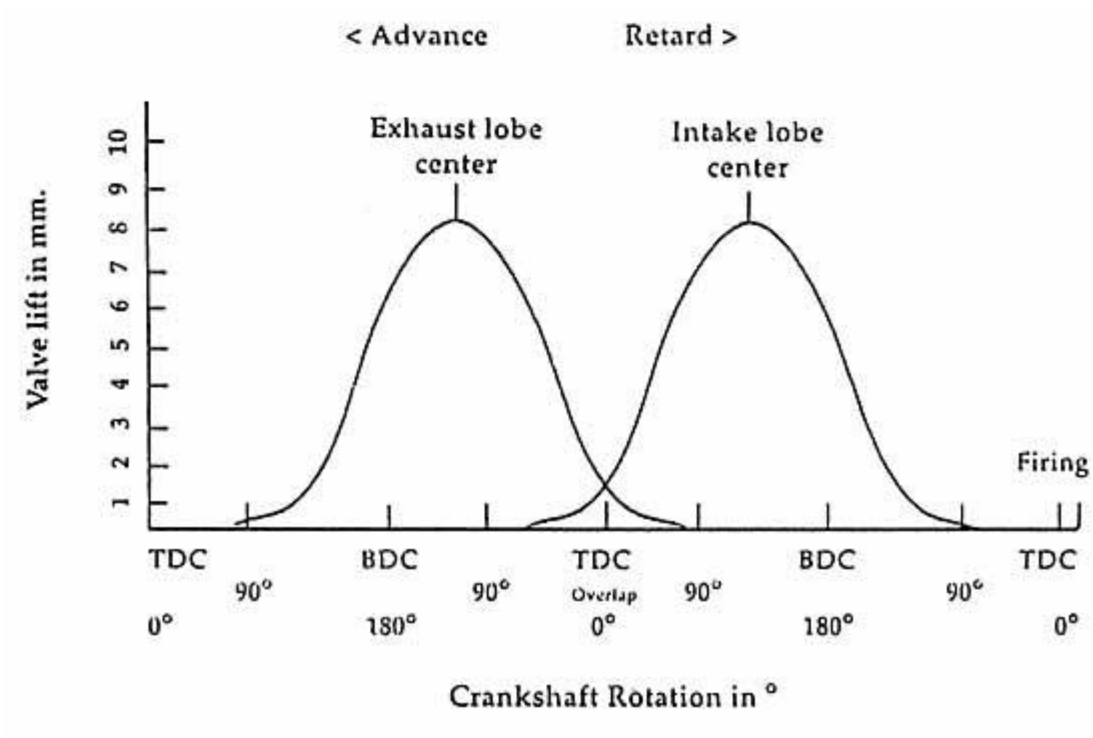

Illustration by Doug Meyer

The diagram graphically shows how these points lie in relation to the degrees of crankshaft rotation. The usable range of lobe center values for just about all commonly used engines is only about 15 degrees wide from about 98 to 112 degrees and for the engines we use, the right spread is even smaller than that. Small changes of one degree can have considerable effect on the power delivery characteristics of an engine.

Very generally speaking, the effect of moving lobe centers is as follows:
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. This condition would be indicated by higher numerical values on both intake and exhaust lobe centers. By moving only one cam the results are less predictable, but usually it is the intake that is moved to change power characteristics since small changes here seem to have a greater effect. With twin cam engines we have the luxury of moving the cams independently.

With a single cam engines you must advance or retard the intake and exhaust together, usually using the intake lobe center as the reference and only the cam grinder can spread or close up the centers when the cam is ground.
Basically, here's how it's done in the real world. I'm not going to tell you what lobe centers to use, as this varies from engine to engine, just how to determine them.

Many engine builders take lobe center measurements with zero valve lash (clearance) so that all movement can be detected. In fact, the valve lash can actually be slightly negative, that is the valve can be held **slightly** open by the cam with the valve in the closed position. You may also do the calculation with the running clearance at the valve. The amount of pre-load or clearance on the valve has no effect on the lobe center number but will effect the opening and closing numbers. What IS important is that, for future comparison purposes, you always do it the same way with the same lash value. It is also very important that an accurate top dead center "TDC" reference be used when degreeing cams.

Therefore, this should be checked carefully and the degree wheel and pointer set accordingly. Take a great deal of care when setting up your degree wheel, pointer, method of turning the engine, and dial indicator. A change of one degree can be significant, so accuracy is very important. A dial indicator is used to measure the valve motion in hundredths of a millimeter or thousandths of an inch. Set your dial indicator so that the plunger pushes on the retainer or tappet and moves as nearly parallel to the valve travel as possible. It is not necessary to use any particular valve, use one that allows the easiest indicator set-up and that you can easily see from the same side as the degree wheel.

I recommend that you begin with the intake cam, since the intake is the most likely to be damaged by an insufficient amount of valve to piston clearance or incorrect timing.

Always start with the cam sprockets closest to the stock position.

Begin with the valve fully closed and with the dial indicator zeroed.

Double check the plunger movement to see that it moves freely, does not interfere with the cam lobe, rocker, or any other moving parts, and returns to zero when moved and released.

Rotate the engine in the correct direction while watching the dial indicator. Stop when the pointer shows 1mm of movement. Note this number.

On an intake cam, this will be a value before top dead center (BTDC). Continue rotating the engine, watching the dial indicator as the valve opens, then begins closing again. By counting the revolutions of the pointer and watching

it return towards zero, you can stop when the valve lift is still 1mm before fully seated, noting the degree wheel value at this point. On the intake cam this will be a value after bottom dead center (ABDC). It is important to stop at the correct point because you should avoid turning the engine backwards as this unloads the cam chain and can result in an erroneous reading.

To compute the lobe center, you:

A. Add the two opening and closing numbers noted

B. Add 180 to this sum

C. Divide this sum by 2

D. Subtract the smaller number of the two opening and closing numbers from this quotient.

The result is the lobe center. For Example:
Intake opens (at 1mm lift) 38 BTDC
Intake closes (at 1mm lift) 68 ABDC

38+68+180=286, divide by 2 =143, subtract 38 from 143 = 105
The lobe center on this cam is 105 degrees.

The method is the same on the exhaust except the opening number will be a value before bottom dead center (BBDC), the closing value will be after top dead center (ATDC) and again, subtract the smaller number.
For Example:
Exhaust opens (at 1mm lift) 60 BBDC
Exhaust closes (at 1mm lift) 40 ATDC

60+40+180=280, divide by 2=140, subtract 40 from 140 =100
The lobe center on this cam is 100 degrees.

Note that in both cases, it is the smaller of the two numbers that is subtracted.
Also note that the 286 and 280 degree values are similar to what may be the advertised duration of the cam. This number is called the "checking duration" as it is dependent upon the checking height used (in this case 1mm).

Remember, the opening and closing values (and duration) are dependent on the checking clearance and will vary based on this amount. The lobe center number will not. This is why published numbers are not a good way to compare cams. You must always know the checking height that was used to derive those numbers.

To change the lobe center, loosen the sprocket attach bolts and move the crankshaft slightly to alter it's relationship to the cam. Retighten the bolts and re-check. When the selected value is finally reached, tighten and loctite the bolts, then re-check one more time. With a little experience you will know which way to go to advance or retard a cam to achieve the desired lobe center.

Caution:
Moving lobe centers can drastically alter valve to piston clearance. And remember, the closest point is rarely at TDC. The most critical is the intake and usually occurs somewhere after TDC. Make all adjustments in small increments and **NEVER force the engine past any resistance until you know the cause.**
Changes to the power output are can be subtle, hard to predict, and frankly, most of this has been explored to death so it's unlikely you will find some "new power". But each engine is different and cam timing must be part of any fully prepared engine. Be careful with following "we always did it that way" thinking.
The advent of electronic fuel injection and four valve heads has changed the cam requirements of engines. Increased valve area means less "cam" gives you more flow. On an injected engine you no longer need to create a strong vacuum signal through a

carburetor throat for good fuel atomization. The injector is going to get the fuel in there instead of flow across a jet. The only way to optimize cam lobe centers is through extensive and careful dyno or performance testing.

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