ABOUT TIME

Camshaft timing: what it means, and how to get the best from it.

LAST month I looked at what a camshaft consists of and how it operates. This month we'll cover what the duration figures on a camshaft mean (234, for example), plus how altering the camshaft timing can affect your engine's performance — for better or for worse!

Commonly, a camshaft manufacturer will give you timing figures for his cam as follows: 25-69 inlet and 69-25 exhaust. Now whilst this may initially sound baffling, it doesn't have to be if you sit and think carefully about what it means. Let's start with the inlet cam lobe figures 25-69.

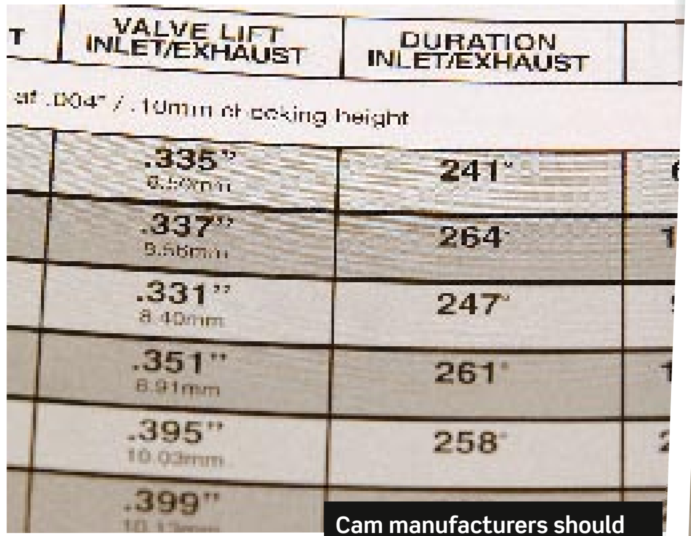
25 is simply the point that the inlet valve starts to open before the piston passes the top. This is known as 25 degrees before top dead centre (BTDC for short). The 69 is the amount of degrees after bottom dead centre that the valve closes again — in this case 69 degrees after bottom dead centre (ABDC for short). If we add the two figures together and then add 180, we get the cam's duration. So for the inlet we have 25+69+180 = 274 degrees of duration.

With the exhaust cam lobe figures we start at 69. This is simply the point that the exhaust valve starts to open before the piston reaches the bottom. This is known as 69 degrees before bottom dead centre (BBDC). The 25 is the amount of degrees after top dead centre that the valve closes again, in this case 25 degrees after top dead centre (ATDC). The duration of this cam can be worked out exactly the same way as the inlet, and in this case is the same 274 degrees of duration.

Interestingly, using that 274 degrees of duration we can now figure out where peak lift should occur — all we have to do is take our duration figure and halve it, so 274/2 = 137.

If we now remove the amount of degrees the inlet valve was open for before the piston reached top dead centre (25), we are left with the figure for full valve lift on the inlet — in this case 112 degrees ATDC.

Are you all with me so far? Good, because not only can we ascertain full lift from those figures, we can also ascertain how much overlap the cam design will have. We simply need to add the inlet valves opening and the exhaust valves closing positions together, so in this example we have the inlet valve opening at 25 degrees BTDC and the exhaust valve closing at 25 degrees ATDC. So 25+25 = 50 degrees of overlap where *both* valves are actually open, thus overlapping.



Cam manufacturers should list duration figures, making choosing a new cam easier

Words: Stewart Sanderson

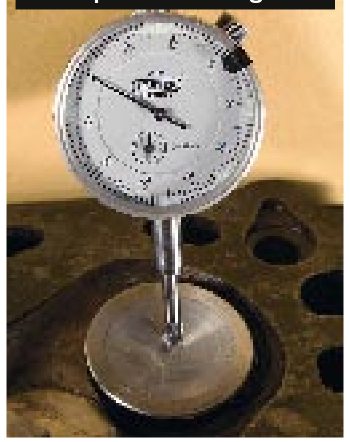
CAM TIMING FOR PERFORMANCE

So, now you know how the camshafts work and what the various timing figures mean, what differences do different timings make to the actual performance of the engine?

Well, we tend to find that in most scenarios a good spread of power is found by timing our peak valve lift area to occur at the point of maximum piston speed. This speed is determined by the stroke of the engine but is usually found between 105 and 118 degrees after top dead centre in the majority of four-cylinder engines. You normally find that the manufacturer has timed his cams close to this area.

From here we can advance or retard our cams. Let's say we have our inlet cam dialled, as per the earlier example, so that peak lift is occurring at 112 degrees ATDC. If

Measuring valve lift helps you to work out how much overlap the cam design has



Vernier pulleys will help you get every last bhp out, and get the timing 100 per cent spot-on, too

Even cylinder head mods can affect optimum cam timing figures

we advance the cam 4 degrees, we will move it backwards from 112 to 108 degrees. This will make the valve open to its highest point earlier on in the intake cycle, and this tends to improve low-end torque.

Don't forget that by moving the peak lift point of the valve 4 degrees you are also moving the opening point of the valve to 4 degrees sooner too, thus increasing the time your valves are overlapping. This can become a power struggle as overlap affects low-end torque in a negative way, so often you will have to move the exhaust as well so it also hits its peak lift sooner, thus keeping the overlap the same as it was before.

If we retard the inlet, we would move it forward 4 degrees to 116 so it now reaches peak valve lift some 4 degrees later than standard. This will normally improve the top-end breathing ability of the engine while also decreasing valve overlap.

However, you will recall that overlap is often beneficial at high engine speeds so we have another battle on our hands... Time to retard the exhaust as well perhaps?

Instead of just altering the points of peak lift and keeping the overlap the same, we could start moving both cams in opposite ways. This will have the effect of increasing or decreasing the lobe separation angles. Increasing the lobe separation angle will generally broaden your power band while reducing peak torque and lowering your idle quality, but it's also a great solution to decrease detonation.

Decreasing the lobe separation angle will generally increase the torque while dropping the power band somewhat and damaging the idle quality, not to mention the fact it will normally lead to more chance of detonation.

It's all experimentation and no figures are available to suit all engines; they all vary and results depend upon many things including other modifications like exhaust, cylinder head and turbocharger work.

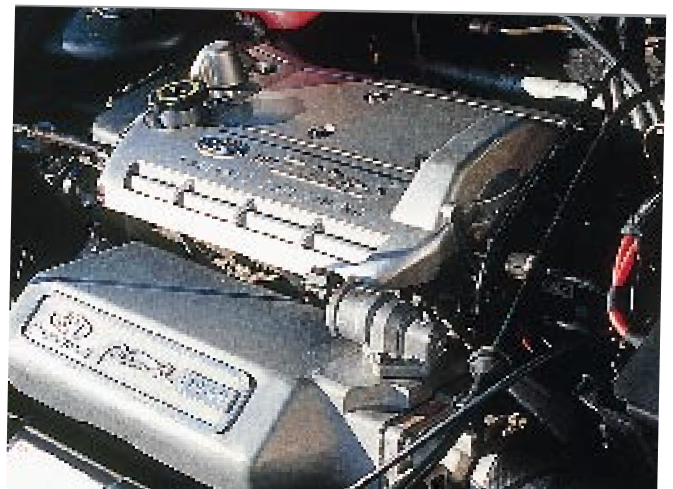
As mentioned earlier, the camshaft will only work perfectly at one engine speed, you just have to choose that particular speed and where the compromises must lie... Or do you? No. There is a solution.

VARIABLE VALVE TIMING

A system was developed many years ago that allowed us to have the best of both worlds — a nice, lazy torquey cam profile for low engine speeds, with a nice race-type cam for high engine speeds.

Its operation varies from manufacturer to manufacturer and has many different names such as VVT, VTEC, VVI and VANOS, not to mention DOUBLE VANOS.

The systems around vary somewhat from the simple ones that simply adjust the camshaft timing by acting on the pulleys in some manner, to the far more useful and advanced systems that actually change the lobe being used dependant on rpm. As you can imagine, these systems are the future for obvious reasons.



The Racing Puma and Focus ST170 both have variable valve timing that comes into effect at a certain rev range

CAMSHAFT TERMINOLOGY

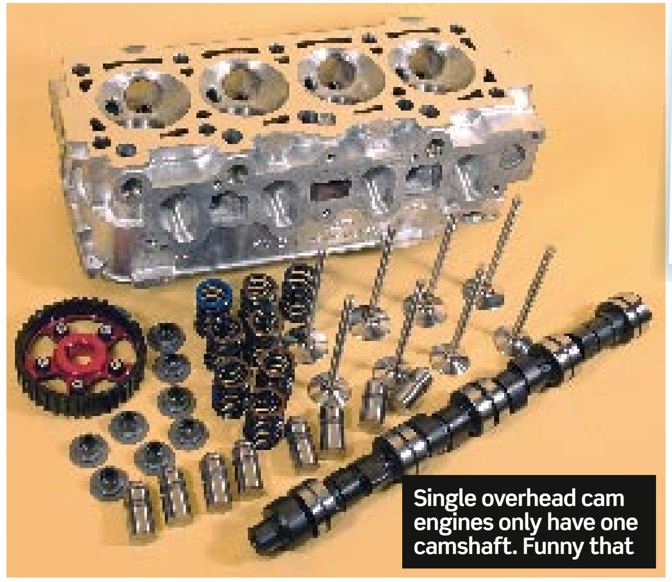
SINGLE OR DOUBLE?

It is worth noting that there are various camshaft configurations used in engines today, but most notable and common are the single (SOHC) and double overhead camshaft (DOHC) configurations

SOHC ENGINES

This particular configuration is an engine with only one camshaft per cylinder head.

Engines with two heads such as the V6 and V8 will generally have two camshafts fitted (one for each head). The camshaft lobes act upon rocker arms that in turn press down on the valves, thus opening them. The valves are closed again by extremely strong springs fitted to them.



Single overhead cam engines only have one camshaft. Funny that

These springs are extremely strong because the valve is accelerated open incredibly quickly by the follower and it's the spring that keeps the valve in contact with the follower at all times. This is of most importance when the valve is supposed to be closing at high speed as this is largely down to the ability of the spring.

Most modern engines are now 16-valve twin-cam engines

DOHC ENGINES

This particular configuration is an engine with two camshafts per cylinder head. Again, a V-configuration engine would have four cams — two for each head. It is normal practise to use a double overhead camshaft configuration with an engine that has four or more valves per cylinder as a single camshaft simply cannot operate this many valves, normally due to the spacing of them around the cylinder.

It is worth noting though that there are a few double overhead camshaft configurations that, rather oddly, only operate two valves per cylinder such as the Ford DOHC engines found in some Sierras and Granadas of the early '90s.

Late-model 2-litre Sierras use a twin-cam engine, but it only has eight valves

CONTACT

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NEXT MONTH

Everything you need to know about engine management.