

Why an engine needs more advance as its speed increases

When the compressed mixture inside a cylinder is ignited it takes time for the flame front to reach the piston and for the expanding gases to start pushing it down. The time that this takes changes according to a number of variables such as mixture strength, how well the cylinder has filled (dependent on volumetric efficiency and throttle opening), compression ratio and combustion chamber shape. Given the same circumstances of mixture strength, cylinder filling and CR, the time taken for the mixture to fully ignite and burn is the same regardless of engine speed. At increasingly higher RPM however, the time available for this burn to take place is correspondingly less, so it follows that you have to start burning the mixture earlier in order for it to push on the piston at the right time. This is the basis for increasing ignition advance.

Too much of this and the burning mixture hits the piston as it rises (pinking or pinging), too little and the flame front reaches the piston far too late and does not do a good job of pushing the piston down and the engine behaves like a herd of turtles. One of the reasons a diesel engine does not perform at higher RPM is that it has compression only ignition, so there is no way to increase the effective ignition advance.

How this is achieved

The distributor as fitted to conventional ignition systems does not just distribute the spark amongst the cylinders and switch the coil; it also contains a centrifugal mechanism that advances the ignition timing automatically as engine RPM rises. Normally there are a pair of weights within the distributor which under the affects of centrifugal force tend to be thrown outwards, this tendency is greater as RPM increases. The weights are shackled by two small springs that restrain them progressively. As the weights move outwards they exert a turning force on the top of the distributor shaft relative to the driven part of the shaft, this moves in the same direction as the distributors rotation thereby causing the points/electronic trigger to actuate earlier and advancing the ignition timing. As engine speed increases the weights overcome more of the spring's tension and advance the timing still more. There is normally a stop of some kind that limits the amount of advance that the distributor can supply. This centrifugal mechanism is usually hidden away underneath the baseplate of the distributor.

Vacuum Advance

Under conditions of light or closed throttle, the volumetric efficiency of an engine is quite poor, and cylinder filling is affected to the extent that the effective compression ratio is much lower than the static or calculated compression ratio. In these circumstances the mixture will burn much more slowly than with a fully filled cylinder and the flame front will reach the piston quite late. This can dramatically cut the overall efficiency of the engine and its economy. Under these conditions the engine will tolerate and indeed benefit from advancing the timing by up to 15 degrees over its normal setting.

The device that usually performs this trick is called the vacuum advance device. The way this works is to exploit the partial vacuum that is present in the inlet manifold when the throttle is closed or partly closed. A tube is connected from the manifold to a sealed diaphragm in the distributor, which in turn is connected to the distributors base plate. The suction deflects the diaphragm which turns the base plate against the direction of rotation of the distributor thereby advancing the timing, this gives much better throttle response on part throttle, and far better economy.

Many people who tune engines disconnect the vacuum advance mechanism, and indeed on some distributors it is very hit and miss in operation and can cause anomalies in the timing. All in all however for a road engine, the vacuum advance retard should be retained if it is possible to do so (not always easy with sidedraught carbs). This will have a dramatic affect on economy and driveability especially on small throttle openings and when 'off-cam'.

Why a modified engine requires timing changes

A standard production engine has to run acceptably well over a wide range of operating conditions, poor fuel, towing of trailers/caravans etc. and yet still deliver good economy and flexibility. Consequently the engine is tuned to give good low down performance and will use conservative timing and fuelling settings. It also has to cope with poor quality fuel and changes in altitude that can seriously affect the engines behaviour.

A tuned engine generally is not designed to give good performance below 2500-3000 RPM and indeed below this level, the volumetric efficiency of the engine is seriously affected. The more extreme the cam profile, the worse this situation becomes. This means that the effective cylinder filling at lower RPM is poorer than with a standard engine.

As explained earlier, in these conditions more ignition advance is required to overcome the slow burning of the mixture. If this advance is supplied by retaining the standard distributor and simply increasing the static timing, then the overall advance will be too high by the same number of degrees, this is obviously undesirable and can wreck your carefully modified engine. Not increasing the static advance however will lead to a very sluggish engine until quite high RPM is reached.

The engine speed at which maximum advance is reached also needs to be earlier for a tuned engine, say 3500-3800 RPM, on a standard engine maximum advance may not be reached until much later, say 4500-5000 RPM. This means that both the amount of advance, and the rate at which it is applied will not be satisfactory in a modified engine if the standard distributor is retained in unmodified condition.

Establishing static advance requirement

The static advance requirement for a modified engine is very much dependent on the duration of the cam fitted. Below is a table of advance requirements and expected idle speeds for a range of cam specifications. **ON NO ACCOUNT** use these settings before the maximum advance on the distributor has been correctly limited.

<u>Cam duration</u>	<u>Advance</u>	<u>Idle speed expected</u>
270	10-12	600-800
280	12-14	900-1000
290	14-16	1000-1100
300	16-18	1100-1200
310+	18-20	1100-1400

When establishing static advance the golden rule is never use less than **10**; never use more than **20** degrees. The engine may well tolerate more than **20** degrees at idle, but the moment the throttle is opened and cylinder filling is improved it will pink heavily. One problem often encountered when using more static advance than standard is that the engine may 'kick-back' when starting causing the starter to slow dramatically, this can be confused with a flattened battery or duff starter motor. You may need to compromise by the odd degree or two if your engine will not tolerate the required degrees of advance at start-up.

Static advance implies a measurement taken when the engine is stationery, however it is usually set at idle in order that any latency in the distributor drive gear is taken up. A rough setting can be made when the engine is still, but it **MUST** be set at 1000RPM or lower with the vacuum advance disconnected so that any latency is taken up and the centrifugal advance has not yet started its operation.

Establishing maximum advance requirement

Notwithstanding the compression ratio and other factors, the characteristic that determines the maximum advance setting is the shape of the combustion chamber and the position of the spark plug. Below is a table indicating the desired maximum advance for the various common combustion chamber shapes.

<u>Type of chamber</u>	<u>Example</u>	<u>Max advance</u>
Semi-Hemispherical	Jaguar/Lotus Twin cam	40-44
Carotid/heart	'A' Series,'B' series	34-35
Bathtub	Pre Xflow	34-36
Bowl in piston	Xflow	35-37
Closed	Pinto	38-40
Wedge	Imp	36-38
Open Wedge	Rover V8	36-38
Pent-roof 4 valve	Vauxhall16v,Zetec,Cosworth YB	30-32

Note how little advance a four valve, pent roofed combustion chamber needs, this is because of the very short and equal length flame paths from the centrally placed plug promoting a very fast burn. Engines with a faster burn time have a much higher RPM potential, the faster the burn, the less advance requirement, and therefore the fewer problems at high RPM. This is why Grand Prix engines have many small cylinders; these have small combustion chambers that have very fast burn times, allowing much higher RPM than engines with fewer large cylinders.

Below is a chart showing the typical and ideal advance requirements for a modified engine, the engine speed at which maximum advance should be reached is 3500-3700RPM, advance should start at around 1300RPM and be all-in by this figure

Typical Advance Curve for Modified Engine

