



Datsun camshafts & Valve Timing by Racer Brown

Chapter Two

Changing Valve Events Around

Of course, there's a great deal more to it than this simplified version, some of which comes later. Now let's start at the commencing again and see how by changing the valve opening and closing points, the entire character, personality and performance level of an engine can be changed, for better or worse.

Exhaust Valve Opening

What happens if the exhaust valve is opened earlier than normal; that is, at a piston position further away from BC? Obviously, the "blow-down" period is extended, which is some times beneficial in an engine that consistently operates at higher engine speeds. Most of the useful work applied to the piston during the power stroke is used up by the time the piston reaches about 80 to 90 degrees before BC, so very early exhaust valve opening can rob the engine of some power...most noticeable at lower engine speeds. This practice also releases additional heat to the exhaust system, which makes control of oxides of nitrogen emissions very much more difficult. Early exhaust valve opening points are usually associated with longer valve open periods (longer duration's) in race engines where control of exhaust emissions is not a factor (yet). If kept within reasonable limits, the exhaust valve opening point has less effect upon general engine performance than the exhaust valve closing point and the intake valve opening and closing points.

Later exhaust valve opening with the piston closer to BC of the power stroke helps engine performance at lower engine speeds by capturing more energy applied to the piston. Of course, the "blow-down" period is reduced, which may (not always) reduce maximum power output at the top end of the engine speed range. Very late exhaust valve opening points, when combined correctly with other valve events, can help exhaust emissions by containing cylinder heat for a longer period, allowing more time for the heat to dissipate within the cylinder before releasing the exhaust gases. Particularly, this reduces oxides of nitrogen (NOx) emissions, but carbon monoxide (CO) and unburned hydrocarbons (HC) are reduced as well. Properly done, this will improve engine performance as well through most of the engine speed range, if not all of it.

Intake Valve Opening

Next in sequence, the intake valve opening point. Ah! The romance of high valve overlap periods! Early intake valve opening accomplishes half of that. When the intake valve opens early (with the piston further away from TC on the exhaust stroke than normal), the engine will usually immediately respond by being rough and balky at low engine speeds. This occurs because of the greater dilution effect the exhaust gases have on the air/fuel mixture charge as the mixture attempts to enter the cylinder. As engine speed increases, the velocity and inertia of the mixture charge overcomes most (not all) exhaust gas dilution and helps power output at higher engine speeds. Very early intake valve opening points will kill performance in the low and mid-range speeds, making engine power and response acceptable only in the highest engine speed ranges. Early intake opening points are associated with relatively long intake valve durations in

race engine applications. Later opening of the intake valve (with the piston closer to TC on the exhaust stroke) smooths out engine operation during idle and off-idle conditions, and in the low and mid-range engine speeds. Engine vacuum, necessary for vacuum booster operations of power brake systems, etc., doesn't go down the drain with later intake valve opening points, assuming the other three valve opening and closing points are within reason. Some power may be lost at the top end of the engine speed range, but it may be worth this penalty to get better low and mid-range performance, better idle and off-idle characteristics, perhaps even an improvement in fuel economy if the throttle is treated with some respect. Very late intake valve opening points have shown to be beneficial in reducing exhaust emissions, which can be accomplished with a general improvement in performance level.

Exhaust Valve Closing

The exhaust valve closing point constitutes the other half of the long valve overlap romance. Late exhaust valve closing (piston further away from TC on the induction stroke) contributes its share to evil engine operation at lower engine speeds. This occurs because the air/fuel mixture charge is exposed to two paths: One, it can enter the cylinder, become trapped there and perform some useful work; or, it can enter the combustion chamber only long enough to march right out the exhaust pipe, thereby escaping unused, except for some slight cooling of the exhaust valve in passing. High valve overlap periods are one reason why race engines will tolerate high compression ratios and full, or nearly full spark advance at relatively low engine speeds. Under these conditions, maximum cylinder pressures are quite low so there isn't much chance for an abnormal combustion condition to develop. As engine speed increases, late exhaust valve closing does allow a higher percentage of exhaust gases to be evacuated from the cylinder because of the direction of exhaust gas flow and the inertia of the gases. However, there is still some "bleed-off" of the air/fuel mixture, which could conceivably limit maximum power output. Late exhaust valve closing by itself, or in combination with early intake valve opening, detracts from acceptable low and mid-range performance, driveability, fuel economy, etc. Very late exhaust valve closing could easily contribute to a loss of maximum power, as well as all the other disadvantages.

Earlier exhaust valve closing brings with it smoothness and docility, although not necessarily dullness in performance level. It makes engine operation much more civilised at lower engine speeds and could help top end power as well, and contributes to overall engine flexibility, particularly if it is combined with a later intake valve opening point. Very early exhaust valve closing can reduce exhaust emissions and again, if all other factors fall in place, this can be accompanied with a higher performance level.

Intake Valve Closing

Now we get to the intake valve closing point. AHA! This is the one that can make it or break it. Intake valve closing point probably has more influence on engine operating characteristics than the other three valve opening and closing points combined. Late intake closing (with the piston further away from BC on the compression stroke), if optimised for a race engine, can beneficially capture a larger volume of air/fuel mixture within the cylinder before a pressure-reversal condition could cause reverse-pumping of some of the mixture past the closing valve, generated by the rising piston. Optimising the intake valve closing point in a highly sensitive engine can be very itchy indeed. Later intake closing points are acceptable and necessary at consistently high average engine speeds for the above reason. But at low engine speeds, this practice is purpose defeating

because reverse-pumping action, if not killed outright, is at least seriously wounded, again by the direction and inertia of the tag end of the air/fuel charge. Very late intake valve closing makes the effects of reverse-pumping worse and through a broader engine speed range, and can make engine response so lazy it may never be able to pull itself to its most favourable engine speed. Late intake closing usually relates to longer intake valve durations for race engines. Believe me, late intake closing does nuthin' at all for exhaust emissions except to increase them. A fine balancing act goes on here, particularly if we try to avoid the trap of a "peaky" engine; that is, one that operates at its best at high engine speeds, and then only through a relatively narrow speed range. The bike boys call this "comin' up on the cam." But if the intake closing point is delayed too long, you will undoubtedly find some satisfying profanity to go with it and you'd probably get better results by pushing the whole soggy mess off a cliff.

Earlier intake valve closing is what brings an engine to life, gives it flexibility, range and muscle at just about any reasonable point in the speed range. It helps idle, off-idle and part-throttle steady-state cruise conditions possibly more than you could imagine. This occurs because no appreciable reverse-pumping action takes place, allowing a larger volume of air/fuel mixture to be trapped in the cylinder and put to work at lower engine speeds. Very early intake valve closing is beneficial in reducing exhaust emissions, improving fuel economy, etc., and is usually accompanied by a performance increase.

There is one dreaded word that rears its ugly head in the area of valve timing for any specific application: Compromise. It's a compromise between what you want and what you can get, or are willing to accept. It's a trade-off of something, someplace, for something else, someplace else. If there is a direction indicated, it is certainly toward conservatism. The sorriest, soggiest engine in the world is one that is "overcammed." Unfortunately, this is a trap that is all too easy to fall into, and the best words of advice are to avoid it in the first place.

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