Tuning Honda Engines

Tuning & Optimisation

WITH CPL RACING

If you looked up **'tuning'** *in a dictionary, it would give you a definition of* **'to adjust; to bring into harmony'** *or* **'to calibrate'.**

Alternatively, the definition of 'optimisation' would be given as 'to take full advantage of'.

Therefore it is fair to suggest that tuning and optimisation are not the same thing, but why is this?

In the course of trying to extract more power from the engine of your Honda, you might fit performance enhancing parts to your engine, or employ a tuning company to do this for you. At some point afterwards, the newly 'enhanced' engine may be taken to a dyno tuning centre, for professional tuning of the fuelling, ignition and so on, within the electronic control unit (ECU), to suit those chosen enhancements. In this instance, what the tuner is doing is making the most of the current setup of the car by setting the fuel, ignition etc to suit the setup chosen by the customer, the resultant power output is an amalgamation of how well the chosen combination of parts can work and the correct setting of the fuel injection parameters within the ECU. In this instance, the tuner has only a limited amount of control over the end torque and power figures produced by the setup, as all he can do is 'tune' the parameters within the ECU to the given setup.

It is a common misconception that, by adding a collection of parts to your car, favourable or expected power gains will always be achieved. An important thing to remember though, is that, regardless of how expert or experienced a tuner might be, if the parts fitted to the car do not work well in combination, or just one part (such as an exhaust pipe) is causing a restriction or resonant pulses in the setup, then the power and torque gains that can be achieved will be limited. Provided an experienced tuner has a good dyno, an appropriately designed dyno cell and a good quality engine management system, then he can make the best of what he is given. A tuner is not a magician though. He cannot make good power and torque from an engine, if all aspects of the car's setup are not correct.

If optimum or expected power gains are not being achieved, it could be that, for example, there is too much exhaust back pressure, or insufficient airflow on the intake side of the engine. However, this is not adjustable within the ECU and it would require alteration or upgrading of 'hard parts' in the setup.

Although tuning the parameters within the engine

1

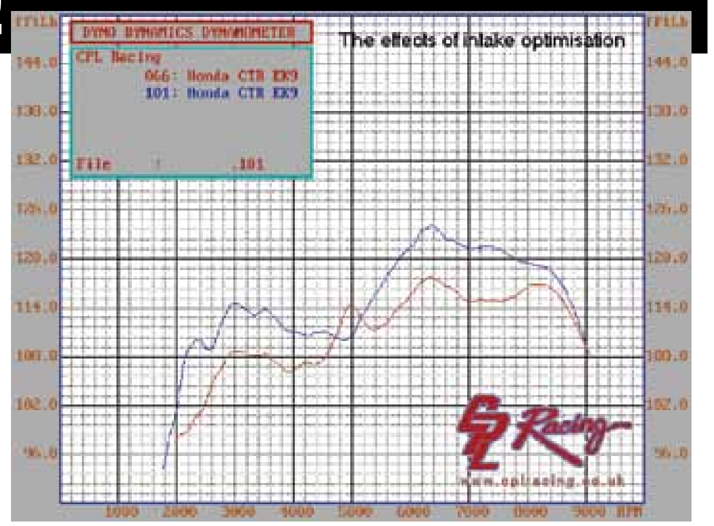
computer is sometimes seen as a form of optimisation, this only allows the tuner to optimise parameters that can be adjusted by the ECU/engine management system only. Therefore, this must be regarded as tuning, rather than optimisation.

So, let's go back to basics and look at how we extract power from an engine.

Extracting more power requires an increase in mean effective pressure and consists of improving volumetric efficiency (the efficiency with which each cylinder is filled with fuel and air mixture). For example, if you take a 2000cc four cylinder engine, in which each cylinder displaces 500cc, and you then fill this cylinder with 500cc of air-fuel mixture on each intake stroke, you would be achieving 100% volumetric efficiency, although, in reality, most road car engines would not achieve this figure. For reference purposes, it is worth noting that current Formula One engines are achieving a volumetric efficiency in excess of a staggering 130% .

Initial steps in improving volumetric efficiency can be relatively straightforward. For example, you could remove any restrictions that might exist in the intake tract, by perhaps substituting the air-box for a good quality air intake. You could swap the inlet manifold for a better flowing alternative. Or you could improve the airflow through the inlet ports by porting the cylinder head. Additionally you could remove any flow restrictions that might exist on the exhaust side. However, removing flow restrictions is only a small part of improving volumetric efficiency in an engine. In reality, it is important that the

2



above improvements are made, before proper tuning of the engine can begin, if optimum power and torque gains are to be the objective, which inevitably they nearly always are.

See figure 1. Red line indicates torque before exhaust optimization and blue line indicates torque after exhaust optimization.

Another easy way to increase the volumetric efficiency of an engine is to reduce the air intake temperature, because, if the temperature is lower, the oxygen molecules are closer together and therefore more will enter the cylinder. You may remember from the first of our technical articles, 'Evaluating Performance', we published the results of a test, which showed the detrimental effect on performance of an air intake system that allowed high intake temperatures to enter the engine. If the temperature of the incoming air can be kept to a minimum, then it is clear that the power will increase, similarly, if it can be kept at the minimum temperature consistently, then the best power will be maintained.

See figure 2. Red line indicates torque before intake optimization and blue line indicates torque after intake optimization.

In addition, since most Hondas have aluminium intake manifolds, which are bolted directly to the cylinder head, heat passes from the head to the intake manifold thereby raising the inlet manifold's temperature. If we can reduce the temperature of the inlet manifold, then the temperature of the air passing through the air intake will not increase to such an extent as it passes through. One way of reducing the inlet manifold temperature is to fit a good quality heat-shield gasket, such as those produced by Hondata. Fitting one of these gaskets will insulate the inlet manifold from the cylinder head, thus reducing the amount of heat that passes from the head to the manifold.

Image 3 shows a Hondata heatshield gasket for a Honda K20A engine.

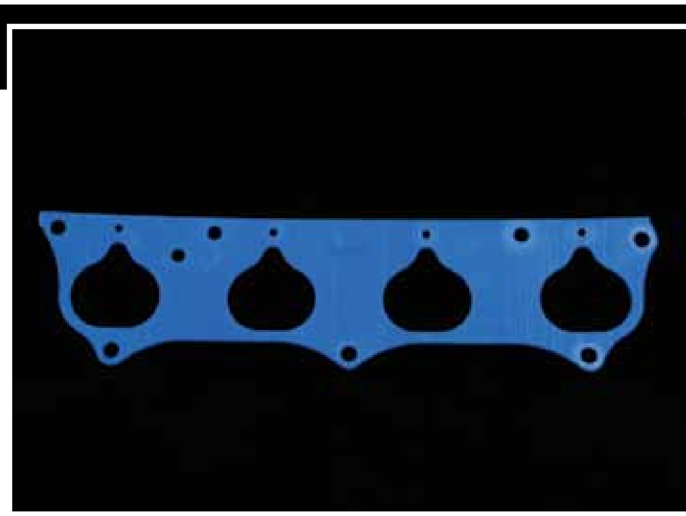
If it were not already obvious, increasing the volumetric efficiency of an engine is what forced induction does to an engine, by literally forcing air into the cylinder under pressure. The Honda VTEC engines respond particularly well to forced induction.

Moving on from improving volumetric efficiency, the next step is to take a closer look at what is actually happening in the engine when the valves open and close.

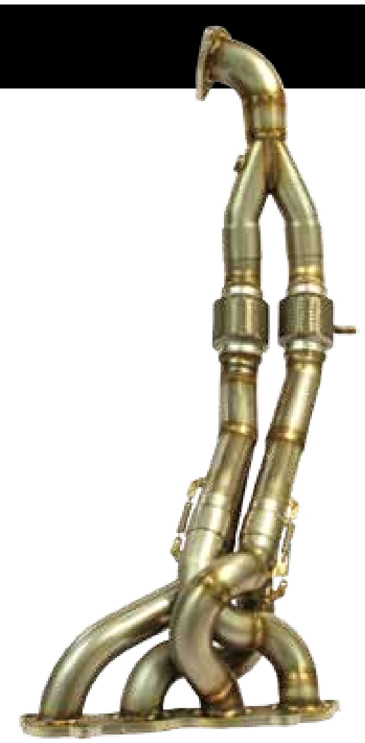
With a traditional intake system, if you start from the engine, you have the length of the individual runners, then the plenum, then the pipe from the plenum to the filter. Each of these lengths can be important, although the runner length usually dominates.

As the intake valve closes, a slug of air hits the back of it. This creates a compressive pulse, which is bounced up the runner. It then exits the runner, inverts and comes back down the runner. Ideally, this would hit the intake valve, as it opens. If you get the timing of this correct, then the in-rush of air would raise the volumetric efficiency by overfilling the cylinder. Obviously, this can only be optimum over a small engine speed range, as the speed of the intake valve closing varies as the engine speed increases. Of course, the cam profile and timing has to work together to close off the cylinder at the correct time. Just one of the advantages of Honda engines is that the VTEC

3



4



5

6

system offers two cam profiles and therefore offers the possibility to make what we have just explained over a larger rev range. The latest Honda I-VTEC engines provide even greater potential by offering 50 crankshaft degrees of variable intake cam timing, which means you can vary the point, at which the intake valve closes, over the whole engine speed range.

An example of varying the length of the intake pipe can be seen in the two torque curves in figure 2

A similar phenomenon occurs on the exhaust side of the engine. Varying the pipe lengths, diameters etc. on the exhaust manifold, produces similar pressure pulses on the exhaust side. We can make use of these during the valve overlap period, by lowering the pressure in the exhaust manifold at the correct time, which can, in turn, encourage more intake charge into the cylinder, again increasing the volumetric efficiency.

Figure 4 shows a well-designed Type R FN2 exhaust manifold.

So, does all 'tuning' yield favourable power gains? Well actually no, as we have discussed, if the parts fitted to the car do not work well in combination, or one or more parts is causing a restriction or resonant pulses in the setup, then the power and torque gains that can be achieved are be limited.

It is clear that a well 'optimised' setup, with thought to overall combination and good ECU calibration as a total package, will give much better results. This might mean taking things further, than the tuner advising you on which off-the-shelf branded product to fit to your car, and could mean fabrication of bespoke parts, such as an intake or exhaust, cylinder head modification or maybe analysis of which camshafts would work best with your existing or proposed setup.

Recently, a customer came to our workshop with an EK9 fitted with a B16B engine. It was already equipped with aftermarket camshafts, exhaust system and air intake. The setup was tuned using a Hondata engine management system on the dyno, at his request. Aware that the existing setup had room for improvement, the customer took our advice and allowed us to modify the cylinder head, fit different camshafts better suited to his setup and also allowed us to fit a new exhaust system. The car was then re-tuned on the dyno.

It is important to note that this car had the same 'level' of modifications at the start, as it did once we had carried out our recommendations, i.e. complete exhaust system, air intake, Hondata engine management and camshafts. Yet, as can be seen from the dyno chart in figures 5 and 6, the improvement in performance of this 1600cc car is considerable and clearly demonstrates the difference between merely 'tuning' and giving the tuner the opportunity to 'optimise' the setup.

Figure 5 shows the B16B dyno chart (bhp) before and after optimization, and figure 6 shows the torque before and after optimization.

NEXT ISSUE: We will be taking optimisation further, by looking in detail at cylinder head modifications.

CPL Racing has been working with Total Honda Magazine since its launch to bring readersa valuable insight to tuning Honda engines.
If you have missed any part of the Tuning with CPL series, please visit www.totalcarmagazines.co.uk/cplracing.htm to catch up.