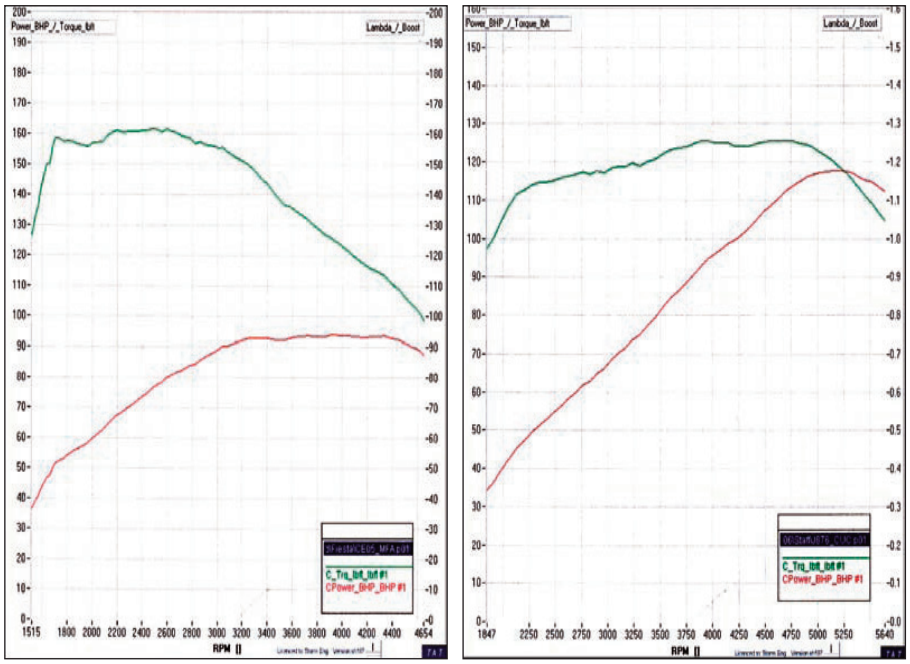
Torque and Power part 2

In the March issue of Autobiz, part one of this Tech Tip explained the differences and relationship between torque and power. In this second installment, the Institute of the Motor Industry (IMI) sets out to further examine the nature of torque and power in diesel and petrol engines and to shed some light on what remapping is and what it can do.

Petrol and diesel engines have always had very different properties. Diesel is renowned for good, low end torque and petrol for high revving, quick acceleration. With modern designs, these differences have become less obvious. The rough running diesel has been mostly cured by high pressure common-rail injection and the refinement of the petrol engine's valve timing mechanism, has improved power output and flexibility. Here, we will look at the two engines in terms of torque signatures and how engine performance can be improved in both. There are fundamental differences between petrol and diesel engines, which give them very different torque curves.



A typical torque (green) and horsepower (red) curve for a diesel engine, on left, and a petrol engine, on the right.

The most obvious difference is maximum torque. The diesel engine produces maximum torque at around 2000rpm, whereas the petrol engine does this at over 4000rpm. This gives a very different driving experience and performance. The initial surge in a diesel is followed by a sharp reduction in engine torque, which encourages the driver into a gear change. The petrol engine, by contrast, produces a relatively flat torque curve, which gives a continuous long pull feel to its acceleration. So why is this?

The diesel engine has higher peak and average combustion pressures and this means that the piston/crank assembly has to be more substantial and therefore heavier, which limits the maximum speed of the engine. Speed is also limited by a slower combustion process. Petrol engines are lighter and with lower cylinder pressures. They produce less torque but gain their superior power by producing it faster. Modern design allows engines to breathe effectively, even at high engine speeds.

The power/torque graph above is from a naturally aspirated Honda 2 litre type R. As you can see, the torque curve is long and relatively flat, due, among other things, to variable valve lift and timing.

Improving petrol engine performance

There was a time when what goes on under the bonnet was well understood not only by the professional mechanic, but by enthusiastic amateurs. With a fairly basic toolkit, a weekend project could reap a large improvement in an engine's performance. Currently, due to the computerisation of the engine and stringent legislation, would-be petrolheads are often limited to cosmetic changes. Real gains in engine performance can only be achieved by quite involved engineering and ECM reprogramming, but it must still pass its NCT emissions test. This limits the modification to improvements in volumetric efficiency.

Volumetric efficiency

If a piston moves slowly from top to bottom with the inlet valve open, we would expect the cylinder to be full of charge at atmospheric pressure, or 100% volumetric efficiency. As the engine speed increases, the time available to fill the cylinder is reduced. At 6000 rpm, a typical induction stroke takes 1/200 of a second, and this reduces the volumetric efficiency. Pressure charging can produce volumetric efficiencies over 100%. Engine designers take into consideration every aspect of the way the air moves into the engine, but the resulting design will be a compromise of power, driveability and reliability. This gives the engine modifier room to manoeuvre. There are many options, but ultimately the ECM is king. Unmodified naturally aspirated engines will benefit little from a remap, but the power output of pressure-charged engines can be improved by up to 30%. With modifications to valve gear and manifolds, more substantial increases in power can be achieved.

So what is remapping?

The engine ECM is a computer and works in a different time frame to us! Millions of decisions can be made every second, so a decision about how much fuel to inject, or when to ignite it, even at 10,000rpm, is done with plenty of time to spare. The ECM uses a set of instructions and data look-up tables to do its job. Basic look-up tables are fuel and ignition, but there are many more for coolant temp, map, boost, etc. The look-up tables