PART TWO

Up to Speed

WE FINISH OUR MASTERCLASS IN MAPPING WITH ANOTHER VISIT TO ATSPEED RACING, WHERE COLIN THORNDYKE SITS US DOWN TO EXPLAIN THE INTRICACIES OF FILE WRITING

WORDS & PICS: COLIN THORNDYKE

With the basic settings covered in the last issue of *PFC*, we are now ready to start mapping the engine.

For now, cold start is ignored, as the majority of that and any associated corrections all work from the settings on the main map, which of course won't be correct until after mapping.

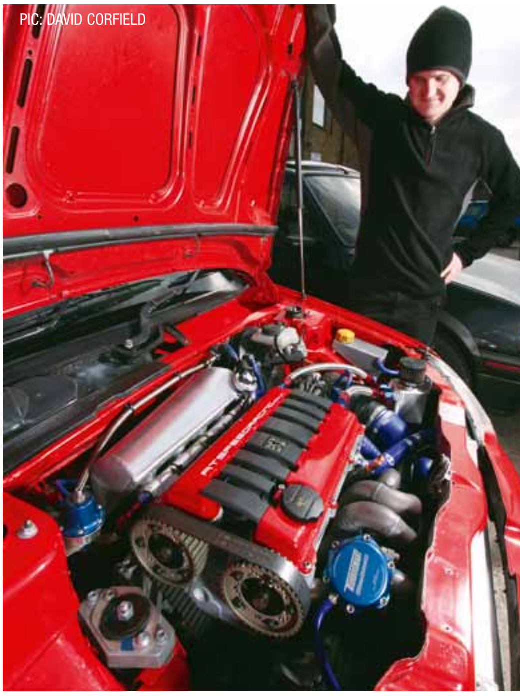
We connect a fuel pressure gauge to the feed to the fuel rail, boost pressure gauge, and an oil temperature sensor. We have a facility for coolant temperature too, but I will be monitoring this on the Omex software.

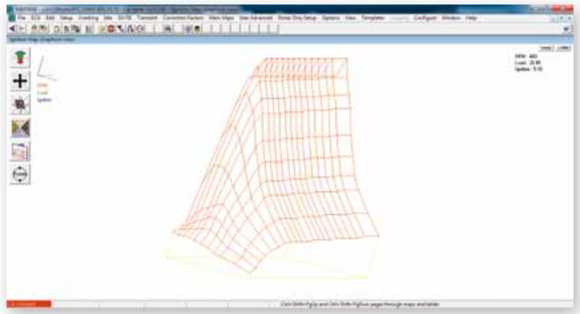
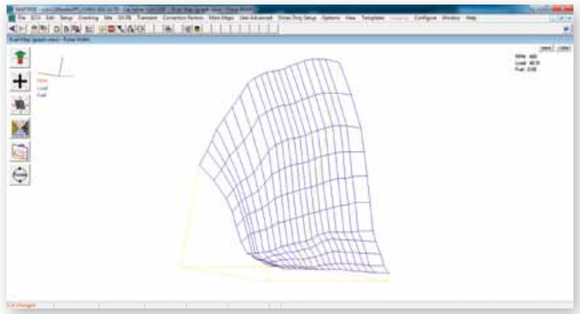
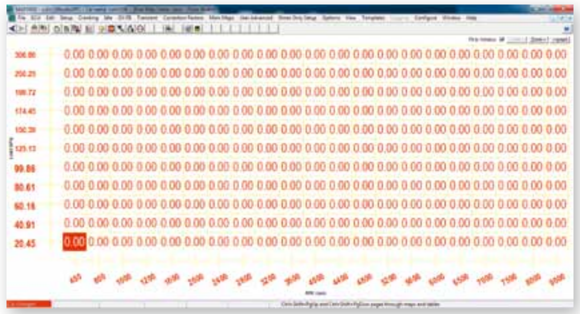
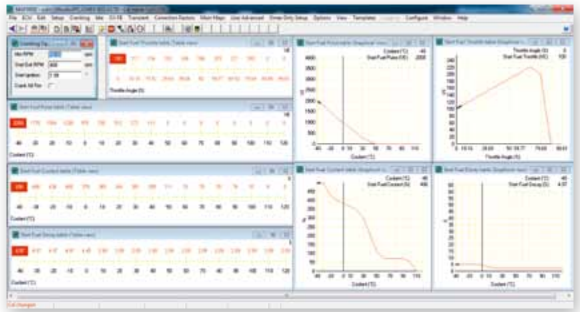
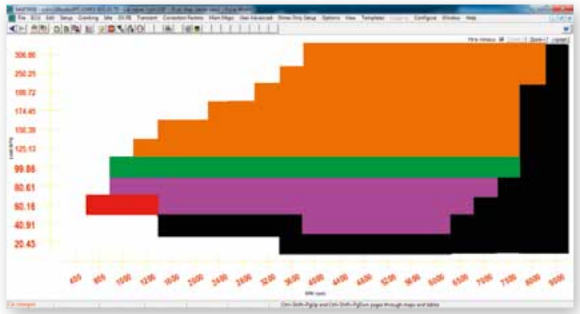
The most important tool in the dyno cell, besides the rolling road itself, is the wideband lambda gauge. This measures the Air Fuel Ratio (AFR). All of our data acquisition equipment is wired into our dyno software, so can be displayed on screen and monitored at all times.

With the engine running at a fast idle, fuel is changed in the fuel map roughly to the desired AFR, and if adjustable, fuel pressure set to the desired amount. We can now check for any coolant, oil or fuel leaks. Once we're satisfied, the car is strapped down to the rolling road, and extraction and cooling fans set up, plus any required Information entered into the dyne software. This also gives a chance for the engine to run up to operating temperature.

IDLE

Our first step now is to set the correct idle. My car (The red 106 turbo many of you will have seen) has no idle valve, or lambda controls, and relies purely on the Omex for controlling tick over. My target is 1000rpm, and to do this idle controls are temporarily switched off. The throttle screw is then adjusted until an idle speed of 1100RPM is obtained. Then the fuel value in the main map is altered until my desired AFR Is achieved. Then using the Omex virtual "pot box" ignition Is added to bring the engine's RPM into the centre of the 1200rpm cell with TPS remaining at 0. I then adjust this cell to my AFR target - the procedure is then reversed and fuelling set for 800rpm. ▸▸


PIC: DAVID CORFIELD


The new minimum TPS value is now entered Into the ECU and Idle controls switched back on.

IDLE IS SWITCHED ON IN THE FOLLOWING CONDITIONS:
Idle ON below throttle % AND below a particular RPM. In this case 1.17% and 1900rpm. Whilst in the idle condition, the Omex uses "spark scatter" to add and remove ignition timing to maintain idle speed. I deliberately mechanically set my idle 100rpm high, so I am supplying the engine with more than adequate air, the Omex can now electronically slow it down to my target, and because I have set the fuel correct either side of my target idle speed, whilst obtaining a fully closed throttle flap, I have a rock steady idle. We can also increase the idle speed (by around 300rpm) until a certain coolant temperature, this fast idle vs. temperature can aid with cold start.

The engine is now ready for mapping. The fuel map is commonly referred to as the "VE table" (volumetric efficiency), where an engine is basically a pump, and at different engine speeds and loads it consumes different volumes of air. The main maps should therefore reflect this air consumption by adding more fuel when the engine is consuming more air and adding Ignition timing when it isn't.

IGNITION BASICS

Most NA (normally aspirated, or non-turbo) engines usually run around 30 degrees ignition at WOT (wide open throttle) but this varies from engine to engine due to many reasons, the common ones being fuel, compression, bore size, head/piston design, camshaft, induction type to name just a few. The ignition timing is measured in degrees before top dead centre BTDC.

A normal combustion process is the burning of air and fuel mixture charge in the combustion chamber. It should burn in a steady, even 3D fashion across the chamber. Originating at the spark plug and progressing across the chamber, the flame front should progress in an orderly fashion. The burn moves all the way across the chamber and cools against the walls and the piston crown.

The objective of tuning the ignition is to achieve the maximum amount of torque from the engine. At the point of maximum torque the timing is backed off until just before torque begins to fall. This means the engine is now set at minimum advance for maximum efficiency. If we run too little ignition timing, torque is lost; if we run too much, detonation can occur. Engines producing not much power can sometimes run with a small amount of detonation, but if detonation occurs in engines making a lot of power per volume the results can be destructive. Turbocharged engines, due to their very nature, are very susceptible to detonation. High intake temperatures and high intake pressures are all key ingredients. This Is why ignition timing on a turbocharged engine must be reduced when on boost.

FUELLING

With the fuelling the values In the ECU are changed to achieve the desired AFR (air fuel ratio). Lambda 1 is an AFR of 14.7, which is a complete burn. However engines cannot run this mixture all the time. It is great for fuel economy – some will even run with the AFR In the 15s at very light throttle, some manufacturers cut the injectors entirely on deceleration for fuel economy, but as it is quite a lean mixture (14.7 parts air to 1 part fuel) it is quite a warm burn. Engines do not like this when under full load, as the cylinder temperatures rise, and it costs power. It can also damage pistons, and in extreme cases melt them. Most engines make maximum power around 12.5 – 13.5 AFR. Some prefer being a bit richer, some leaner. Turbo cars generally run richer, and it's not uncommon to see them running the AFR In the very low 12s,

even down In the 11s – which is a much cooler burn which can aid with cooler combustion temperatures greatly, so due to their nature, will happily make power with this mixture. The amount of fuel injected is also an ignition retarder. More fuel takes longer to burn.

MAPPING PROCEDURE

The engine is driven through various RPM and load sites, and the fuel and ignition maps are altered to suit.

On light throttle off boost driving, because the engine's compression ratio is low and air volume being consumed is minimal, we are able to run a lot of ignition advance, and a very lean mixture, tuned In this way, under normal driving, there's no reason why a big car cant be economical. Generally these loads are mapped with the AFR being in the 14s, with the ignition timing well into the 40s dependant on the engine. The injector duty is minimal, meaning we are not using much fuel here. Unfortunately with this engine due to the camshafts it doesn't like driving at low rpms and light throttle, so we had to set the mixture a little richer here, in the mid 13s, but the rule is simple: give the engine what it wants, not what you think it wants. If the engine's happier and more efficient, torque increases, and the car drives smoother.

Another condition that is mapped is the transient, or acceleration fuelling. This map adds in a % of extra fuel based on engine load, RPM, and rate, in which the throttle was applied, to aid with correct mixture when the throttle is opened. When the throttle is snapped open, there is a rapid and sudden extra consumption of air, so additional fuel must be added to correct for this. Correct mixture here depends on the particular RPM you are working on, but generally an AFR somewhere around 12-13 Is ideal. Too rich will cause the engine to stutter; too lean will make the engine sluggish. At low rpms the engine requires more fuel, for longer duration, and at high engine speeds the extra fuel required is minimal, the Omex has excellent transient fuelling options which often only requires minor adjustment. It can also add an additional fuel based on coolant temperature.

I like to pay particular attention to the speeds and loads you would experience out on the road under normal driving. I see far too many cars that have been mapped, where the mapper has not paid attention to any kind of fuel economy from the car, but concentrates far too much on the top row and maximum power. That is the easy part; it's the light throttle cruise conditions that take the time to get right. Having a nice power printout isn't going to keep the customer happy for long when they have to drive home in a car that drives jerky and uses lots of fuel under normal driving.

Once I have these "real world" driving load and rpm sites mapped as lean as possible, without sacrificing drivability its time to move on to some higher loads. Wide throttle off boost is a critical part of the map as far as turbo spool and responsiveness are concerned, so it is important to spend a lot of time making sure the ignition timing is correct here, and getting the mixture rich enough so the engine makes maximum torque, but lean enough so the cylinder stays crisp and clean for better turbo and throttle response – this will help the engine boost sooner and perform better. A mixture around the mid 13s and ignition around 30degrees appears to be working here. The engine is still in its of-cam, off-boost state, so it will happily run this ignition timing. I like to look over the 3D graph view of the maps throughout tuning, this way I can iron out any noticeable dips or missed sites, which can be filled in.

BOOST MAPS

Now for some boost mapping! I like to start with the wastegate duty set to minimum, and gradually increase it. This way fuelling and ignition are correct for any boost pressure I am likely to run, whether on the streets, track or drag strip. I Initially set the boost at gated pressure (7 psi in this case). As this is on boost, I now begin to start taking spark out of the car, and start increasing fuel, but as the car still needs to pass through this boost level in order to spool up for higher boost later, time still has to be spent making it right. For this testing I run the car on the dyno in an inertia test, from 3000rpm to maximum safe rpm. After the run the dyno software automatically stops the car and opens up a graph showing the test results. I can see the mixture is too lean below 4000rpm, and too rich above 6000rpm, so I can adjust the map at these RPM and redo another test.

I repeat this until I cannot make any more improvements. Once happy with the map at this boost pressure I am ready to start putting some more boost into it, so for this I increase wastegate duty until I am running in the centre of the next load column, and repeat the above steps, again optimising ignition timing and fuelling for maximum power and torque. This is repeated until the engine is mapped for its maximum boost pressure and maximum power/torque levels. ■