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ENGINE TUNE UP INFORMATION SHEET

Introduction

An ‘engine tune up’ is the process of adjustment of the ignition timing and fuel air mixture to achieve proper engine performance with regard to power and fuel economy. For cars with more than one carburettor, balancing the carburettors is also a vital part of the tune up. Balancing the carburettors means adjusting them, and the corresponding throttle linkage, to make sure the air flow through all of them is the same.

Modern fuel injected cars cannot be tuned in the conventional sense as the car’s engine ECU makes these adjustments according to a predefined ‘map’ of data stored in the ECU. Modern fuel injected cars can however be re-mapped, but this is a different process.

For the most part this document focuses on cars that require a regular tune up, that is to say classic cars with one or more carburettors, and those cars using early mechanical fuel injection systems i.e. the K-Jetronic fuel injection system.

The static tune

The first stage of the ‘tune up’ is the static tune; this is done in the workshop with the car stationary. The aim is to:

- Balance the carburettors (unless, of course, you only have one carburettor)
- Measure and adjust the ignition timing with and without vacuumed advance
- Inspect the sparkplugs to assess mixture and detect any ignition issues on a per cylinder basis
- Inspect the point, rotor arm, distributor cap, HT leads, etc
- Check needle security and adjust needle position (SU carburettors only)
- Check damper operation and refill dashpot with correct oil (SU carburettors only)
- Measure the dwell angle
- Using measurements from an exhaust gas analyser, adjust the fuel air mixture
- Adjust the idle speed
- Measure the fuel pressure (optional)
- Clean the carburettor (optional)

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Introducing the rolling road

Strictly speaking a ‘rolling road’ is more correctly known as a ‘chassis dynamometer’.
Don’t get me wrong, the rolling road is a very useful tool, for custom ECU mapping it’s practically essential, but it does have limitations and is not a magical panacea for every engine issue.
A rolling road is basically a set of rollers on which the driven wheels of the car sit. The car is then secured with big webbing straps, and some fans set up to provide air flow. A computer measures the torque applied to the rollers and the speed of rotation (RPM) and calculates the power output at the road wheels; this is usually expressed as BHP (brake horse power). The advantage of the rolling road is that the car is in a fixed position in the workshop so many sensors and items of diagnostic equipment can be connected to it.

When talking about the rolling road we must mention the elephant in the room. There are risks: both risk of injury and risk of damage to the car. No matter how good the equipment, no matter how careful the operator, sometimes things do go wrong, and if a tyre blows out or a fuel line ruptures bad things happen. Unless you use your car for motorsport, putting it on a rolling road will put it under the greatest stress it has ever experienced and if you’re doing a power run you are testing at wide open throttle, you are taking the engine to its limit!

The power run

This is done for one reason and one reason alone, to measure the peak power output of the engine. The engine is taken at wide open throttle (WOT) to the rev limit of the engine (colloquially called the red line). The peak power output is then recorded, typically with a graph showing torque and BHP plotted against RPM. Interestingly due to the mathematical relationship between the BHP and Torque in pounds-feet, the lines on the graph will always cross at 5252 RPM. In the case of metric measurements the lines for power in kilowatts and torque in Newton meters will cross at 9549 RPM.

The ‘dyno shootout’

This is where a group of like-minded individuals, perhaps from a car club, each put their cars on the dynamometer in turn to see which is the most powerful. The idea being, as the tests are done on the same dyno and hopefully the conditions remain the same during the session, it is a fair test. This doesn’t really have anything to do with engine tuning, it’s more a sort of competitive event.

ECU mapping

To be able to do any live mapping you require an ECU map that is reasonably close to start with. A base map is used to get the engine to start and then a rolling road (or other type of dyno) is used in combination with a lambda probe or gas analyser to take the engine speed and load up in steps to set the ignition timing and fuelling for each. The values for the intervening load sites are interpolated from these measurements.

Carburettor setup

Unlike fuel injection with an ECU, the level of adjustment possible is limited to the sizing of jets or the profiling of needles. This is not such an exact science as ECU mapping and a certain level of compromise and judgment must be used. For this reason ‘on road tuning’ can give superior results than setting the tune on a rolling road.

Other types of dynamometer

There are other kinds of dyno, relevant to automotive applications, these are:

- Engine dynamometer – this is more accurate than a rolling road as it does not have the transmission losses that affect the accuracy of the chassis dynamometer; however it does require the engine to be removed from the vehicle and mounted on a test stand with an external fuel supply, power connection and controls attached so that it can be run.

- Hub dynamometer – The road wheels are removed and the machine bolts directly to the wheel hubs. This eliminates inaccuracies due to wheel slip and to some extent reduces the danger of the vehicle moving unexpectedly.

The trouble with a tune up on a rolling road

The problems with using a rolling road are not related to the rolling road itself; the issues relate to the environment in which it is used.

Even using a number of very big fans the airflow over the car is just not the same as it would be say at 70 MPH on the open road. This means that the cooling is not the same as it would be if the car was driven on the road, and more to the point, the air supply to the engine is not representative of real world conditions. As the air flow from the fan is constant, issues such as vapour lock and heat soak may also go undiagnosed.

The second problem is that the way the load is applied is relatively constant, unlike the constantly varying conditions of a road.

The third issue is that the 'road' is level and thus it can tell you very little about how the car will respond when acceleration is applied. It is also the case that certain problems only manifest themselves with vibration or in response to cornering forces that may result in issues with fuel delivery if the fuel is all thrown to one side of the tank.

On road tuning

On road tuning requires two people: one to drive the car and a technician to evaluate the data. The on road tune consists of a series of test drives where data is collected and then analysed, followed by returning to the workshop to make the necessary adjustments. The vehicle is then driven again, more data is collected and the process is repeated until the tune is complete. During the test drive the car is driven normally over a route with varying road conditions, thus representing normal everyday driving.

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During these tests the technician may typically monitor the following on their own instruments, thus in no way distracting the driver from the process of driving:

- Engine speed (RPM)
- Lambda
- Exhaust gas CO (carbon monoxide) content
- Exhaust gas O_2 (oxygen) content
- Exhaust gas HC (hydrocarbon) content
- Exhaust gas CO_2 (carbon dioxide) content
- Inlet manifold vacuum
- Fuel pressure
- A portable oscilloscope may also be used to analyse the characteristics of the HT system

On modern cars that are fitted with a diagnostic EOBD port, a much wider variety of data is available and this is usually recorded for later analysis back at the workshop.

The advantages of 'on road tuning'

The main benefit of on road tuning is that it is not done in simulated conditions. It's real driving on real roads and thus air flow, cooling, vibration, and the fluctuating way power is demanded and required are all correct, something that is virtually impossible to achieve on a rolling road.

Summary

In essence the point I am trying to make is that older cars benefit from a regular tune up, and whilst a rolling road can be useful in some situations, the use of 'on road tuning' is frequently beneficial and, unless you're going racing, on road tuning is a good way to avoid overstressing your car unnecessarily.

Note: This information sheet contains general information about engine tuning. It must be borne in mind that various elements of the explanation have been simplified for easier reading and to appeal to a wider audience.