Tuning power/economy with a limited budget

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Mixing it on your Own Dyno
by David Vizard

The average home tuner's most frequent problem, if the letter we get are anything to go by, is getting the fuel/air ratios (mixture) right after having tinkered wit hthe motor. After printing this article, we do not expect to get, ever again, a Technical Query asking what needles or jets to use on a modified motor, becuase this really should be the end of your mixture problems!

When tuning the engine, it is more than likely that the fuel/air demand of the engine is changed. Becuase of this it is neccessary to "calibrate" a carburetter so that it passes fuel into the engine in the correct quantities for the amount of air being consumed. Over its operating range, a carburetter may have to pass a volume from say two to two hundred cubic feet of air a minute! At tickover, the consumption of air is very low, but at full throttle the opposite applies.

At every point between the two extremes the air flow requirement is different, yet at all these points the carburetter is expected to mix the correct amount of fuel with the incoming air. There is little point in trying to set up the mixture at tickover becuase very few, if any, of us drive on tickover and there is absolutely no guarantee that the mixture is right throughout the range.

How do we know or how can we tell what the mixture is like anyway? Up until now, the most common method has been to "read the plugs". If you have had years of practice and are an expert plug reader (not the print on it) you can just about pull off the job of mixture setting. The trouble, however, with a plug count is that one is never too sure what the plug is saying.

For instance, a dark, very slightly sooty plug can look like a mixture that is just a shade rich, but it could be that the mixture is just right and the plug type is too hard (runs too cold) for the motor. Unless you are an expert then, reading the plug is, to say the least, just shade dodgy.

An alternative to reading a plug is to get your engine set up on a dynomometer; either the rolling road type or the engine type. When an engine is on a dyno, it can be run at various rpm and against various loads, thus simulating the conditions met on the road. While all this is going on, an electronic gas sampler can be analysing the exhaust and indicating the

fuel/air ratio.

Going from reading plugs at a dollar a time to using three grand worth of dyno might seem like going from one extreme to the other or to use a comparison, going from an abacus to an electronic computer. What is needed to use the analogy again is a slide fule ie: a method between the abacus and computer, or to come back to reality, a method of setting the mixture which is more akin to the dyno and mixture analyser than the plug reading method.

A dynomometer measures horse power, commonly called brake horse power becuase a dyno is nothing more than a brake, calibrated to read out the work absorbed and the rate of absorbtion. Here we have a clue; all cars have brakes (or should have) so what we have, in effect, is an uncalibrated dyno fitted to our car. To simulate road conditions whilst standing still, all we need do is to jack up the driving sheels of the car, put it in gear and use the throttle as if we were driving along the road.

To simulate road levels we need only apply varying pressure on the brake pedal. Such action will, of course, get the brakes hot. For our purposes we need to be able to hold full power for about fifteen seconds maximum. If your brakes cannot cope with this from the heat point of view, then you are sadly lacking in that department so see to it. It's probably better brakes you need and not more power!

Okay, so we have our dyno. The fact that it does not read out in horsepower is, for our purposes, irrelevant. What we need now is a mixture analyser. Up until a few years back this would have cost a tidy sum. These days we have a device known as a "Colortune" and within the price range that can be afforded by the enthusiast, this is the _only_ device we know of that will do the job in hand.

For those who man not know, a Colortune is a device which replaces the sparkplug in the cylinder. The top of the Colortune is made of a Borosilicate glass and this allows you to see what is going on in the mixture combustion chamber. Different mixture strengths burn at different colours.

By looking into the combustion chamber through the Colortune we can get a good indication of the mixture strength prevailing. Inspection of the flame color shows that four fairly distinct stages occur. when the flame colour is blue/white, the mixture ration is between 16 and 14:1; a blue colour indicates a mixture strength between 14 and 12,5:1; a blue/orange colour indicates 12,5 to 11:1 and orange indicates 11:1 or less.

The Colortune, then, is indicating at the colour transition points the mixture strength of the ingoing charge. Maximum power occurs when the fuel/air ratio is between about 12,5 and 13,5:1. The exact point varies from engine to engine, but most cast iron tuned production engines seem to be best around

12,8:1. The best economy is achieved on weaker mixtures than that giving maximum power, and fuel/air ratios between 14 and 16:1 seem to be the easiest on the pocket.

To set up the mixture in the manner about to be described you will need an accomplice. The first and essential step is to part the car in some place which is poorly lit, so that you can see the combustion colours. Jack up the driving wheels of the car until they are just clear of the ground and in the interest of safety, securly blockthe car so that it cannot move under any circumstances.

At this point, warm up the engine, the remove a spark plug and replace it with a Colortune. Set up the mixture so that you have a fuel/air ratio of about 12 to 12,5:1 (orange/blue) at normal tickover revs. If you have multiple carbs you will have to do this for each cylinder or set of cylinders having a carb.

Next, get your accomplice to put the car into gear, usually third gear is best, and increase the throttle opening but at the same time put on the brake. (Continue opening the throttle and increasing breaking pressure until your accomplice ends up with the throttle wide open and the revs pulled down by braking to 2000 rpm). You can now look ath the Colortune and at this point it will reveal what the fuel/air ratio is under the prevailing conditions.

It can then be noted, preferebly by colour rather than reference to its fuel/air ratio. After this, let the brakes cool for a few minutes, then repeat the procedure at 3000 rpm then at 4000 rpm and finally at 5000 rpm, stopping to let the brakes cool between each run.

As far as brake overheating is concerned, it should not take more than fifteen seconds to ascertain the mixture ratio at each rpm interval, so they will be well within their capacity.

Once you have an indication of the state of affairs of the fuel/air ratio up the rev range to 5000 (5000 rpm is the limit on the Colortune) the necessary corrections can be made to get it right. Not only can the full throttle conditions be catered for in this manner, but so can part throttle and transient conditions. For instance, a hesitant pickup when going from parth throttle to full throttle could indicate that the mixture is too weak during the transition from one state to the other. During the transition period and for a short while after the Colortune should show a rich mixture condition. If it doesn't, then you can bet your life that on a fixed jet type carb, the accelerator jets or pump stroke are inadequate.

On carbs like the SU and Stromberg CD variety, a lean mixture during the acceleration phase would indicate that the damping is insufficient. A thicker oil is usually required to compensate this.

A couple of cars were used as guinea pigs to test the method. Both cars were modified and therefore required different carb settings. In each case the carburation has been originally set up by the owners who had only an average working knowledge of what was required. After use of the Colortune by the mothod just described, both power and economy were better between 5-8bhp and 10-15 miles per gallon.

The reason that consumption was so much better after use of the Colortune stemmed from the fact that the mixture was originally set rich for maximum power and unfortunately becuase of the guesswork method of setting, it was too rich. The performance increase was better than the power increase alone suggesting that the mixture was right (within limits) throughout the rev range. As a side effect this led to a smoother running engine with a snappier throttle response.

To sum up, the Colortune proves to be a very useful device. It can, at a price of 4-87,5 UKP easily justify its place in the tool kit of any self-respecting enthusiast, and its intelligent use can only bring about an increase in performance.

Editor's note:

Whilst David Vizard has used this tuning method successfully with both a Mini and Austin 1100 its use on many other types of car could possibly be dangerous. Firstly therefore we recommend that the suspension characteristics and drive shaft-prop shaft geometry of the car in question be checked carefully ebfore even considering use of this method.

On rear wheel drive IRS cars which may have large wheel angularity, attempt to jack the car at points on the suspension that will allow the wheels to assume a position in angle similar to that which exists in normal use.

On a non-IRS rear wheel drive car jack under the springs on either side at the axle location point.

Make sure jacks are very secure and will not move under testing vibration, also make sure any car to be tested has alternate props underneath in case of jack failure -- ie: spare wheels and tyres which should be first tested using the full weight of the car. One advantage of the DV method is of course that during load tesing the wheels on the ground have the brakes applied.

On a Mini the best method Vizard found was to put a piece of wood on top of trolly jack lift point and jack up from the Mini sump. Once having jacked car up, jam wheels and tyres underneath car for safety. Car does rock but cannot thus fall over. Drive shafts will assume peculiar angles during testing and this can be minimised by supporting bottom suspension arms on axle stands --these can however move and you may have to take the risk of the odd shaft angles for the few moments of testing.

This method does not apear to be practical with swing axle IRS cars ie: Herald, Spitfire, Vitesse Mk 1, GT6 Mk1.