Manchester XPAG Tests

Part 9 - Fuel and Tuning – Carburettors

Introduction

In a previous article I suggested steps that could be taken to mitigate the problems a number of classic MG owners suffer from: *Weak Running*, where the engine stops in slow moving traffic, especially on hot days, and the *Hot Restart* problem where a hot engine cannot be restarted after stopping for 5 – 10 minutes. The Manchester XPAG tests identified a further problem with modern petrol: *Slow Combustion*. This occurs at normal road driving speeds with medium to high throttle settings. In this case modern fuel appears to burn too slowly, overheating the valves, cylinder head and exhaust system. This in turn increases under bonnet temperature, making the *Weak Running* problem worse.

In this article I will discuss how by re-tuning the carburettors, the severity of the *Slow Combustion* problem can be reduced.

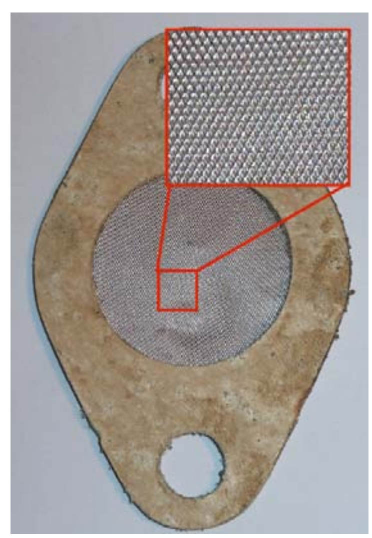
The tests appear to show the modern additives used to enhance the octane rating are possibly to blame for *Slow Combustion* and fuels that use ethanol or other chemicals as an octane enhancer perform better.

Beware! Before using ethanol blended petrol in your classic car, read the previous article.

Remember that all our cars are different and the severity of the problems experienced by owners varies immensely, even between the same models of car. The suggestions in these articles should be taken just as that, suggestions for people to try; they are not intended as solutions to be blindly adopted. While the specific details only apply to the 1 ¼" HS2 SU carburettors fitted to the XPAG engine, the general principles apply to all carburettors.

Nebulizer

In an earlier article I made reference to fitting a nebulizer. A number of people have asked about this and could it be used in a road going car? Unfortunately, the answer is no, it is not suitable for road use, read on.



The nebulizer consisted of a special nickel foil fitted between the carburettor and inlet manifold. The holes in this foil were around 8 micrometres in diameter, the same size as the droplets produced by a fuel injection system. As the inducted mixture passed through the foil, the droplets of petrol were forced to break up. The smaller droplets coupled with the increase in turbulence generated by the foil improved the mixing of the air and petrol in the inlet manifold.

Two things were special about this foil. Firstly it was very thin and secondly, it had a 70% Free Area, i.e. the holes occupied 70% of the area of the foil, or the material of the foil only reduced the overall area of the inlet by 30% about the same as the butterfly spindle does. As a result the air flowing into the engine was virtually unaffected.

A wire mesh is not a practical option for two reasons. Firstly, the holes are much bigger and meshes typically have a Free Area of only 30% - 40% restricting the air flow into the engine.

The reason a foil like this is not practical for normal driving is that unless the air and petrol entering the engine can be filtered to remove any particles greater than 8 micrometres in diameter, such a foil would soon block and choke the engine.

Ethanol Blended Petrol

Using ethanol blended petrol gives two benefits. Firstly, it is added to boost a petrol's octane rating, replacing the modern octane boosting chemicals which appear to be the cause of the *Slow Combustion* problem. Secondly, ethanol contains oxygen molecules chemically bound with the carbon and hydrogen, improving the distribution of oxygen in the inducted petrol air mix. Poor mixing of the petrol and air is the other factor causing *Slow Combustion.*

The tests at Manchester used three ethanol blended fuels, two from the UK, with approximately 5% ethanol, and E10 purchased in France. In all cases the engine ran better on these fuels.

One problem with ethanol is that the added oxygen results in a lean mixture, discussed in the previous article. With the exception of the E10, where it was necessary to slightly enrichen the mixture by 1 – 2 flats on the jet adjusting nuts, the carburettor settings with the 5% ethanol fuels were within limits using the standard mixture adjustment.

These results suggest the engine will run on up to 5% ethanol blended petrol without the need to adjust the carburettors.

Adding Kerosene

Adding around 5% - 10% kerosene to pump fuel again has two benefits. Firstly, it reduces the petrol's volatility below 50^{o}C helping to mitigate the effects of the *Hot Restart Problem.* Secondly, the tests at Manchester also showed it reduces the severity of the *Slow Combustion* problem. Possibly because it also dilutes the modern chemicals used to boost the octane rating.

While these benefits are not large, they are measurable and road tests show they can deliver some improvements. Again, if you are thinking of adding kerosene, the advice is to give it a try with a small amount of petrol in your tank and monitor how smoothly the engine runs. If it feels or sounds smoother, it is running better.

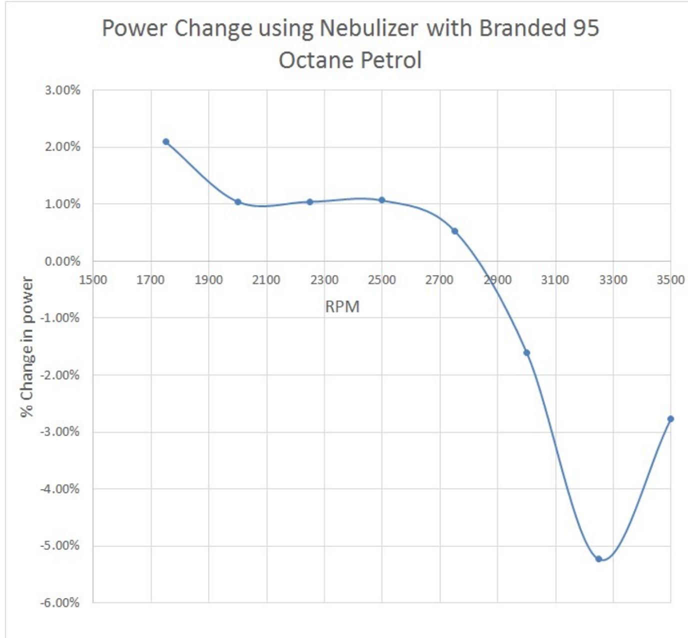
Care still needs to be taken by owners of high compression engines as kerosene reduces octane rating.

Tuning the Carburettor

When race tuning an engine, the aim is to get as much liquid petrol and air as possible into the cylinder to maximise the power output. Racing, engines are typically run on full throttle at high revs. Driving on public roads is in stark contrast, an engine will mostly run between 2,000 and 3,000 rpm on part throttle. Unfortunately, these are the conditions where the *Slow Combustion* problem is at its worst.

The steps taken to race tune an engine, such as matching the manifolds, gas flowing the cylinder head, etc., reduce the turbulence and mixing of air and fuel flowing into the cylinder, making the *Cyclic Variability* and *Slow Combustion* problem worse. Ironically, *Cyclic Variability* can also reduce power output and it is possible, that when running on modern fuel, a mildly race tuned engine produces less power at road driving speeds than an un-tuned one would.

This effect is clearly shown in the tests using the nebuliser. The nebulizer was fitted between the carburettor and inlet manifold where it improved turbulence and atomisation of the petrol, at the expense of restricting the airflow into the engine.



A comparison of the power output using the same fuel and level of tune showed the nebulizer IMPROVED the power output by 1% below 3,000 rpm. Above 3,000 rpm where *Slow Combustion* is not a problem, the restricted airflow reduced the power output.

This again points to the *Slow Combustion* problem being the result of *Cyclic Variability* caused by poor atomisation and dispersion of the petrol in the inlet manifold and cylinder. It also shows that, for road use, improving atomisation and dispersion can give a power gain even at the expense of restricting the airflow into the engine.

The next sections suggest how the carburettor can be tuned to improve fuel atomisation by setting the petrol height in the jet and by ensuring the correct suction piston / spring combination are used.

Petrol height in the jet

The petrol height in the jet is controlled by the weight of the float and by the setting of the forks in the float chamber. Normally this is adjusted by inserting a rod between the lid and the inside curve of the hinged lever. When the lever is bent to the correct setting, the needle valve should be just closed when the forks meet the rod. With the HS type float chamber use a 5/16 inch rod, with the HS type with a hinged nylon float use a 1/8 in rod.

There is a problem. This time not caused by modern petrol! With an HS type of float chamber and the correct fork setting, a float weighing 28gm to 30gm is needed to achieve a fuel level of 3/16” below the jet bridge (approximately half way between 1/8” and 5/16” recommended in the factory handbook for the TC). The original brass floats weigh 24gm which gives a petrol level below the jet bridge of 3/8” (as normally specified for SU carburettors).

Modern brass floats can weigh as little as 22gm and the plastic stay-up floats 20gm. (Note: All floats made by Burlen are to the original drawing specification of 20-24 grams.) A lighter piston depresses the fuel level in the jet for the same fork settings.

While it is not immediately obvious why this is the case, the reason is simple.

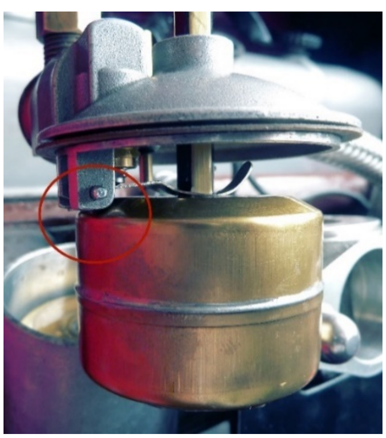
When the float is placed in petrol, it will sink to the point where the mass of the displaced petrol is equal to the mass of the float. The heavier the float, the lower it sinks. The distance between the level of the petrol and the top of the float, or to be specific the distance between the forks which sit on the top of the float and the level of the petrol, determines the petrol height in the jet. The lighter the float, the higher it floats in the petrol, the greater distance between the forks and the level of the petrol and the lower the petrol height in the jet.

A lower petrol level in the jet has a negative effect on fuel atomisation and dispersion for two reasons. Firstly, the partial vacuum in the choke has to both raise the level of the fuel to the top of the jet and provide the energy to atomise it as it is sucked out of the jet. A lower level of petrol in the jet, requires more force to raise it to the top of the jet reducing the energy that is available to break it into droplets. Secondly, the nearer the petrol is to the top of the jet, the wider the spray as it leaves the jet, better dispersing it into the air.

Although no specific tests were run at Manchester, the first set of tests run by the students in 2013 used the standard weight floats and fork settings, which would have given a petrol height in the jet about 3/8” to 1/2” below the jet bridge. The second set of tests were run with standard fork settings but using heavier floats to give a fuel height of 3/16” below the jet bridge. The latter tests showed an average increase in power output around 5% for three different fuels, however, this figure should be taken with caution as these tests were run many months apart and other factors may have influenced the measurements.

A photograph of the carburettor taken during the first set of tests shows the (artificially coloured red) petrol leaving the jet as a stream rather than a dispersed mist. Something not seen in the second set of tests.

Unfortunately, it is not possible to achieve the fuel level recommended by MG in the jet using the lighter floats. While it is possible to bend the forks **up** to **raise** the fuel level or **down** to **lower** it, care must be taken not to bend them up too far or the float will foul the chamber lid and cause flooding.



Should you adjust the forks, it worth inserting a pencil through the hole in the lid and the centre of the float to check it does not foul the pivot support (highlighted on the picture by the red circle) before the needle valve shuts off.

With the HS2 or other semi-downdraft carburettors, the position of the float chamber relative to the carburettor body can affect the fuel height in the jet. Moving it towards the engine lowers the fuel level, conversely moving it away from the engine raises it. Be careful to position the float chamber with connecting arm at right angles to the carburettor body. While it is tempting to move the float chamber closer to the engine to make it easier to remove the float, this both exposes it to more heat and lowers the fuel level in the jet.

To achieve the MG recommended setting, I carefully add solder to the base of the brass floats to increase their weigh to 28gm – 30gm, using digital kitchen scales to measure their weight. As stay-up floats are solid, it may be possible to put self-tapping screws into their base to increase their weight.

It is also very important the float chambers are open to atmospheric. It is easy to think the purpose of pipes fitted to the top of the float chambers is to remove any petrol that overflows. This is not strictly true, they also act as breather pipes allowing the air pressure in the float chamber to remain at atmospheric.

It is important these pipes are not blocked and the correct stepped washer is fitted between the lid of the float chamber and the boss on the pipe.

Suction Piston weight / spring force

Early cars had a heavy brass or aluminium with a steel insert suction pistons weighing 8.5oz (240gm). Later cars had aluminium pistons weighing 4oz (110gm) and either a “red” spring which gives downward force of 4.5oz when the suction piston is closed or a “light blue” spring which gives a downwards force of 2.5oz. These springs are fitted on top of the suction piston to increase its effective closed weight to either 8.5oz or 6.5oz. If it has not worn off, springs can be identified by a coloured band on one end.

The advantage of using the “light blue” spring is that, for a given throttle setting and engine revolutions, the suction piston will float higher than would the heavier brass piston or the light piston with the “red” spring. This reduces the choking effect of the carburettor allowing more air to flow through. It is one modification favoured when race tuning engines. The disadvantage for road use is that it reduces the velocity of the air flow through the choke which in turn reduces fuel atomisation and dispersion.

Either a fixed weight piston or a light piston with the “red” spring fitted is suggested for road use.

It is understood that some remanufactured carburettors are fitted with “light blue” springs, if you have these on your car, it may be worth removing the suction chambers and checking which spring is fitted. If you do remove the suction pistons, be very careful not to bend the needles!

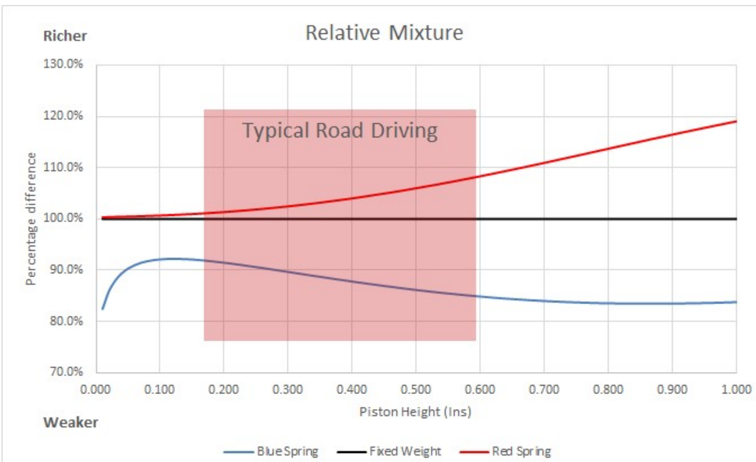
Effect of piston weight on mixture

When I was researching the effect of different springs on mixture, I found very little information on the internet; the purpose of this section is to clarify this point. NOTE: It is worth having read the article on Carburettors before continuing.

Suction piston weight affects the mixture in two opposing ways:

- The lighter the piston, the higher it floats for a given volume of air passing through the carburettor. This both reduces the choking effect of piston and **increases** the size of the annulus between the needle and jet. Making the mixture **richer**.
- However, the pressure difference between the choke and atmospheric is reduced, **decreasing** the force that is pushing the petrol out of the jet. Making the mixture **weaker**.

The graph shows the relative effects on mixture between the fixed weight piston, a lighter piston with the blue spring and a lighter piston with the red spring for the 1 ¼” SU Carburettor.



Both the blue and red springs change the mixture profile with increasing revs / load in the same way as changing the needle would. However, fitting a blue spring also makes the baseline mixture weaker.

Over the normal range of piston heights used for driving on the road, the *ES* needle can be used in all three cases. Carburettors fitted with a blue spring can be made richer by screwing out the jet adjusting nut which will move the whole blue curve upwards. Similarly for those fitted with red springs, screwing the jet adjusting nut in, will weaken the mixture.

One problem with the blue spring is that when using the *ES* needle, the mixture becomes **weaker** as the engine revs and load increase. A more conservative approach is for the mixture to become **richer** as the extra petrol helps keep the valves cooler helping to prevent damage to the engine. Using a red spring produces a more conservative mixture curve than with the blue spring.

1250cc MG TF 1 ½”carburettors

At this point it is worth mentioning that all original MG TFs were fitted with 1½” carburettors with “light blue springs” rather than the 1¼” carburettors that were fitted to earlier T Types. The findings from Manchester support the comments of the critics, who at the time, said the bigger carburettors were not needed. Unfortunately, the engineers were overruled by the marketing department.

With these bigger carburettors, as the suction piston rises, the aperture is more like a slit than the taller, squarer opening would be in the 1¼” carburettors for the same throttle setting. With the 1½” carburettors, it is probably better to keep the blue springs to produce a squarer aperture and better mixing.

Conclusion

This article has discussed the *Slow Combustion* problem which appears to be due to high levels of *Cyclic Variability* caused by poor atomisation and mixing of the petrol in the carburettor. It appear as though one possible cause is the chemicals added to petrol to boost its octane rating. It also suggests that steps to race tune an engine could make matters worse for road use.

The Manchester tests showed that with the exception of the specialist Sunoco Optima 98 petrol, the best performing, commercially available fuels are ones that used ethanol to boost the octane rating. This is not surprising as ethanol contains chemically bound oxygen, improving the oxygen / carbon / hydrogen mixing in the cylinder. Unfortunately, the dangers of any water in the fuel system when using ethanol blended fuels is very clear.

As *Cyclic Variability* causes an engine to run slightly rough, owners should choose the fuel on which the engine runs most smoothly; particularly on full throttle below 3,000 rpm. An indication of lower levels of cyclic variability.

Although Sunoco Optima 98 is around twice the price of pump fuel, its low volatility below 50^{o}C, improved running characteristics, guarantee it does not contain ethanol and long storage lifetime make it a fuel of choice for low mileage vehicles.

Sunoco Optima can be ordered direct from the Anglo American Oil Company via their web shop (www.aaoil.co.uk) or by telephone on 01929 551557. Be aware, the law limits the amount of petrol that can be stored in a garage, or anywhere within six metres of a dwelling to 30 litres.

If you live in the UK remember, you can legally add kerosene to petrol for cars produced before 1956, but you will need to apply to HM Customs and Excise for a Concession. Write to:

Mr John Loughney, Excise, Stamps and Money Businesses
HM Revenue & Customs
3rd Floor West
Ralli Quays
3 Stanley Street
Salford
M60 9LA

Requesting a “General Licence to mix hydrocarbon oils under Regulation 43 of the Hydrocarbon Oil Regulations 1973 (SI 1973/1311)” giving your name, address, model and dates of production of the model of your vehicle.

Finally the article discusses how the SU Carburettors can be tuned to improve fuel atomisation and dispersion by adjusting the petrol height in the jet and by choice of suction piston spring.

Ultimately, reducing the degree of the *Slow Combustion* problem will lower exhaust temperatures, helping to protect the engine from burned valves and damage to the cylinder head. Lower exhaust temperatures will also help keep the under bonnet area cooler reducing the severity of the *Weak Running* problem.