fasttech

BRIGHT SPARK

This month Stu takes an in-depth look at the humble spark plug.

Spark plugs, such simple things. They're cheap reliable and often either changed for no reason, or totally overlooked as a potential problem because they just spark, don't they? Well, I can assure you that spark plugs are a far more complex part than meets the eye. Read on to find out exactly how they work.

Having worked as a tuner for 17 years, Stewart 'Stu' Sanderson is one of the most-respected names in the business.

A Level 5-trained fuel-injection technician, Stu has worked for a Ford Rallye Sport dealer, a well-known fuel-injection specialist and various tuning companies.

Eight years ago he joined forces with Kenny Walker and opened up Motorsport Developments near Blackpool (01253 508400, **www.remapping.co.uk**), specialising in engine management live remapping, as well as developing a range of Evolution chips which are now sold all over the world.

He is the creator and administrator of **www.passionford.com**, which he started in 2003. It has grown rapidly from a few friends contributing, to one of the biggest Ford communities on the web.

Stu's enviable knowledge of the workings of modern-day Ford performance engines means that every month he's just the man to explain how and why things work, and importantly how they can be improved.

WHAT IS A SPARK PLUG?

For those of you new to engines, a petrol engine makes its power by burning a mixture of fuel and air inside a sealed cylinder. It converts the heat energy from this burning fuel mixture, driving the piston down the bore into rotary power to rotate the crankshaft. Before this can take place, we need to initiate the burn of the fuel mix, which requires a spark.

The device that generates this spark is known as a spark plug. This will be found in every single petrol-powered engine in the world, from single cylinder lawn mowers to V12 supercars. There will always be at least one per cylinder.

HOW DOES IT WORK?

The principle of operation is simple. A high voltage is fed to the top of the spark plug via either insulated wires called high tension leads (HT leads) in older systems, or an ignition coil for each plug, known as coil on plug.

Voltages used vary from vehicle to vehicle but expect in excess of 40,000 volts DC in some systems.

At the bottom of the plug is an air gap between the high voltage centre electrode and the earth electrode. The voltage jumps the gap and in doing so creates the spark that lights the fuel mixture. Bear in mind that the smaller in diameter the centre electrode is the less voltage will be required to jump the gap. This is relevant later on when choosing materials.

Older style ignition systems use HT leads...

... whereas the later style systems use a 'coil on plug' set-up

WHAT DOES EACH PART DO?

The spark plug is specially constructed in such a way as to enable the high voltage to pass from outside the engine to inside the combustion chamber, without losing voltage anywhere or compromising the combustion chambers seal. No mean feat when you think about it!

Most spark plug designs have the same common 10 features that allow the item to perform its task reliably. These are as follows:

INSULATOR RIBBING
1 The ribbing acts as a barrier for HT leakage that may escape from the HT lead and head for earth. The ribbing makes the earth path much further away, since the current must travel along its surface.

INSULATOR
2 This acts not only as an electrical insulator to keep the voltage in, but also as a heat suppressor to keep the heat away from the voltage supplying components such as coil and HT leads.

TERMINAL
3 These terminals vary from plug to plug. Some are threaded, some are solid, but all do the same job of connecting the plug to the high voltage source.

FLANGE RING
4 The flange ring is the part of the plug that fixes the ceramic insulator to the actual steel body of the plug.

STEEL BODY
5 This part is the metal body that usually incorporates the hexagonal fixing that allows you to fit an appropriate tool to screw it into an engine. These are normally very robust and treated with something to stop the plug rusting badly.

GAS SEAL
6 The gas seal is there to perform the incredibly important job of making sure the combustion pressure in the cylinder does not actually leak into the spark plug itself. This seal is electrically conductive as it connects the centre electrode with the electrical terminal on top of the plug.

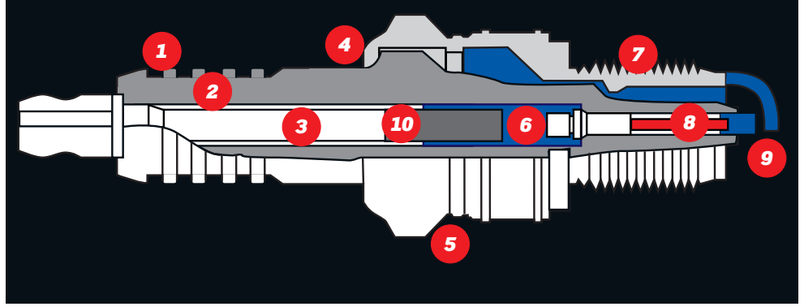
SPARK PLUG THREAD AND SEAL
7 This will vary from engine to engine as some have a gas-proof washer and some are a taper fit. The threads used will vary from engine to engine too.

CENTRE ELECTRODE
8 These vary in design from plug to plug but all are connected to the terminal at the top of the plug. They are designed to be the last point of contact for the high voltage before it makes its leap through space to the ground electrode.

GROUND ELECTRODE
9 This electrode is physically connected to number 7 so is actually a ground which is the high voltage's target. All electrical current flows to ground.

RESISTOR
10 A resistor cuts down on electrical interference. Not all designs have this, but most do.

SPARK PLUG CONSTRUCTION



DEMANDS ON A SPARK PLUG

The demands placed on a spark plug are immense, and one of the reasons a spark plug isn't as simple as its appearance or price suggests.

A spark plug has to be able to pass 40,000 volts while maintaining perfect insulation between its voltage carrying core and the outer earth chassis. It needs to be able to survive in the harsh environment that is an engine, being subject to extreme vibration, temps up to around 1000 degrees Celsius and the pressure of combustion and compression, which is in excess of 200bar on some engines.

It also needs to keep working after being subject to pretty harsh chemicals such as the fuel itself, and the various forms of carbon that will build up on it and hinder its operation. This is especially true in a worn, oil-burning engine.

A spark plug's component parts are selected to be able to work in incredibly harsh conditions

GAP AND GAP SIZE

At the business end of the spark plug there is always at least one ground electrode, and between it and the centre electrode is a gap. This gap is where the spark's going to appear and light the air and fuel mixture.

The gap is critical. The spark needs to be big enough to light the fuel, but also strong enough and have enough heat energy to do so. The deciding factors that will determine those two issues are:

1) Voltage
2) Plug gap

The gap will naturally increase as the plug ages due to electrical erosion. As the spark is created between the centre and earth electrodes it slowly erodes away the two metals, making the gap bigger. The factory quoted spark gap is given at a size that bears this in mind and allows thousands of miles of trouble-free running before the electrodes wear to the point that the gap is too large. The rate at which the metals wear depends on the materials used; simple copper cores being the ones that probably erode fastest.

The gap will usually need decreasing if you increase the engine power substantially, especially on turbocharged engines. They will start to misfire at the engine speed and load where the highest cylinder pressures are created, usually peak torque.

The higher the combustion chamber pressure, the more voltage will be required to jump the gap.

CONSTRUCTION

There are a few different types of earth electrode construction in use today so it's worth mentioning how each type differs from the normal, single square ground electrode...

DOUBLE GROUND TYPE

It's amazing the number of people I have heard insist that these plugs develop more than one spark at a time. They do not; it is physically impossible. You will only ever have one spark per ignition event.

There are many good twin ground electrode products that work perfectly well in most applications, but it is simply a basic form of multiple ground electrodes that will last longer than having just one ground electrode.

Multiple electrodes last longer because as one wears down, another will eventually become the 'nearest' to the centre electrode, ie the one that is longest will always be the one the spark chooses as its path to ground. This effectively doubles ground electrode life.

Having the ground electrode in a V-shape gives some ignition gain on some engine designs due to the spark having better exposure to the mixture's kernel, but that's another article altogether.

THREE OR MORE GROUND ELECTRODES

Multi-electrode designs are intended to increase the service life of the spark plug. The idea is that the more you have, the greater the service life.

V AND U GROOVE EARTH ELECTRODES

Single ground electrode plugs with a V or U grooves machined into the underside of them. The idea is that the mixture will form in the grooved section and give the spark more concentration on this area.

This also makes the ground electrodes a little thinner at their voltage receptor points, which is good for dropping voltage required to make the spark.

All spark plugs will only produce one spark at a time, regardless of the number of ground electrodes

MATERIALS

Various metals are used in the construction of modern spark plugs. The particular material used will affect on the price of the plug and also the plug's service life and the engine's performance, so choose wisely.

Here is a brief rundown on the various materials used:

COPPER

Copper-cored plugs are pretty much standard for today's market and are cheap and cheerful. It used to be a selling point, with manufacturers quoting 'Copper Core' for plugs with copper centre electrodes and 'Double copper' where they've used it in earth electrodes too. Now more impressive materials are around, it's rarely shouted about.

PLATINUM

The standard copper cores are normally tipped in platinum as this is a harder material and so slows down the erosion process considerably. This leads to longer plug life. As a by-product, the manufacturer can normally open up the plug gap slightly as he hasn't got to factor in as much natural wear.

IRIDIUM

Recent advances in technology enabled the use of a precious metal called iridium to be used for electrodes. Iridium is very hard yet conducts electricity incredibly well. You can not only have a better quality spark due to the extremely thin centre electrode diameter (0.4mm on Denso Iridiums, the smallest in the world at the time of writing), but also a longer lasting product too as electrical erosion is decreased massively due to the hardness of the materials used. This more efficient plug can lead to better throttle response, driveability and fuel economy.

One of the most impressive technical aspects is its melting point; it's around eight times higher than even platinum, not melting until 2450 degrees Celsius. It's ideal for high power engines as we can run a hotter, more projected plug than normal, which is good for off boost and cold running!

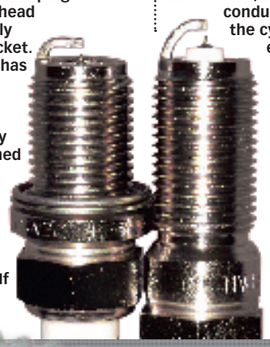
Different materials affect the spark plug's performance and service life

HEAT RANGE

One job your spark plug has to do is maintain its electrode's temperatures around the optimum range for it to burn off deposits effectively. They self clean to maintain electrical and insulation integrity and regulate heat by transferring excess heat away from the electrodes and insulation material and dumping it into the cylinder head and ultimately the water jacket.

Each type has its own heat range, from very hot, meaning they aren't designed to dissipate much heat, to very cold plugs, which are designed to dissipate lots of heat. If you get this heat range wrong, you'll end up with an engine that fouls plugs when used cold and with low power, or one that detonates or melts/drops electrodes onto pistons with catastrophic results.

Heat range is dictated by the amount of 'projection' the plug has. The projection, in basic terms, is how far the conductors extend into the cylinder past the end of the threads. A hot plug will be very projected, having its conductor's down deep in the combustion chamber. A cold plug has its conductors back near the plug thread, maybe even recessed into the threaded area.



QUANTITY V QUALITY

A two, three or four ground electrode spark plug is neither better nor worse than a single one. The only difference is service life. In fact, generally speaking, a multiple ground electrode plug is likely to be a slightly worse performer than a comparable quality single ground plug.

More, doesn't necessarily mean better

UPGRADING SPARK PLUGS

The manufacturer's chosen the correct heat range and material for the spark plugs based on engine design, service intervals and cost. Sometimes a quality iridium plug may be a small improvement over the standard plug so worth a try. The main reason we'd be forced to change the grade of plug is when engine power output's increased significantly.

If the engine creates more power, it creates more heat in the cylinder, so we'll need to change the spark plug to one that's designed to transfer this extra heat away from the electrodes. Often we can drop to the next coldest spark plug. In NGK, the range gets colder as the part numbers increase, ie a BCR6ES runs hotter than a BCR8ES, whereas Denso get colder as numbers increase.

"It needs to be able to survive in the harsh environment that is an engine."

NEXT MONTH Engine cooling: cooling systems for your engine's oil and water.