Tech Basics: Crash, Boom, Bang

How to plug into more power!

by Godfrey Towns

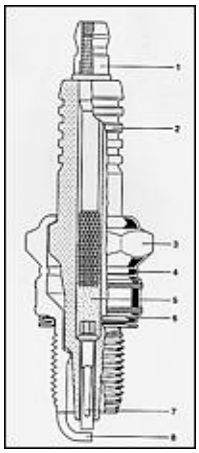
Every engine has them. Without them working perfectly the engine will be down on power. The factory picks 'em, but on a modified engine they might no longer be the right ones. What are we talking about - fuel injectors, pistons, or even bearings? Nope - the humble spark plugs!

What they need to do

The spark that occurs between the plug electrodes sets fire to the air/fuel mixture that's been squashed into the combustion chamber. But that simple statement ignores the fact that it does this many times each second with very high voltage electricity, and in conditions of extreme heat and pressure. For the plug to last more than a few minutes it needs to be very carefully designed.

Plug Structure

Starting at the top there's the high voltage connector that the lead pushes onto. This transfers the electricity down through the ceramic insulator to the electrode. Talking about the insulator, the reason that it is so long (and has raised bands on it) is that high voltage electricity will leak out along any path that takes its fancy. If the insulator were any shorter, the spark would be able to jump off the plug before it got to the electrode inside the cylinder.

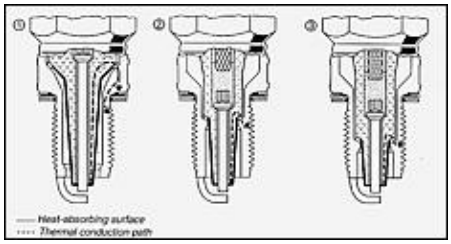


The centre piece of conductive metal stops short before it gets to the electrode, with the gap between it and the electrode filled with conductive glass material. Then it's on to the ceramic nose of the plug containing the electrode itself. The electrode can be made from nickel-alloy with a copper core, platinum or other metals. The spark jumps from the centre electrode to the ground electrode (or sometimes the other way), with - as the name suggests - the ground electrode earthed to the engine's block. In this Bosch diagram, (1) connector, (2) ceramic insulator, (3) shell, (4) heat shrinkage zone, (5) conductive glass seal, (6) captive outer gasket, (7) centre electrode, (8) ground electrode.

Heat Range

The plug nose needs to reach a temp of 400 degrees Celsius as quickly as possible. If this temp isn't reached, the plug fouls with unburnt fuel and carbon. The problem with this happening is that it creates another path for the electricity to take, preventing the spark occurring. The result is a miss. However, if the plug gets too hot (above 850 degrees) its life will be severely reduced, and its glowing end can also set fire to the mixture early (pre-ignition) or cause detonation.

If all engines worked in the same way there'd be no problem. A universal heat range plug could be designed and that'd be that. But obviously this isn't the case. Engines vary in the temperature and length of combustion. An engine getting 100hp per litre will have quite a different temp conditions from one producing only 50hp per litre!



Because of this, plugs are designed with different heat ranges. A 'cold' plug gets rid of heat quickly, and so is better suited to a hi-po engine. A 'hot' plug stays hotter, and so works best in an engine producing less power. The way in which the manufacturers of the plugs are able to change the heat range of a plug is by changing the length of the plug nose. As this Bosch diagram shows, a long nose plug tends to retain heat, because the path that the heat can take to get away from the combustion is longer. A colder plug (eg plug #3) will have a shorter path between the electrode and the threaded portion of the plug, and so the heat escapes more readily.

Picking a Plug

So enough of the background - how do you get the right plug for your engine?

The plug that you pick needs to have the right thread diameter, hex size, seat type and reach for your engine. A VL six cylinder Commodore, for example, has a standard plug labelled BCPR6ES-11. Translated, that means that it has a thread diameter of 14mm, a 16mm hexagon, a projected insulator nose, a heat range of 6, a copper cored electrode and an 1.1mm plug gap. Whew!

Of these only the heat range ('6'), the plug gap ('1.1mm'), and the nose type ('projected insulator nose') are able to be changed when you select another type of plug. However, note that not all plug manufacturers use this coding system; Champion, for example, use a totally different approach! Plug manufacturers do produce cross-referencing charts, however.

While there are at least 18 different designs available at the firing end of the plug (Surface Gap through to Delta Ground Electrode!), making a radical change in this area of the plug is not a good idea on normal road cars. The projection of the plug into the combustion chamber, for example, should not be lengthened - or else the piston may hit it! Selecting 'U' shaped or platinum electrode plugs with the standard projection is of course fine. However, as a starting point for experimentation, keeping the electrode design standard or near-standard has advantages because you at least know where you're coming from.

It's heat range that is the big one! Finding a plug that prevents fouling and does not cause pre-ignition or detonation by staying too hot while still developing max grunt will mean that you've found the ideal heat range plug for your engine. Then you can go on to look at different electrode designs.

The required heat range of the plugs in your engine depends on:

- the air/fuel ratios being used;
- spark advance;
- compression ratio;
- fuel type;
- use of nitrous;
- supercharging or turbocharging;
- height above sea level, and
- (in competition) the nature of the track.

What an amazing list! Obviously its therefore impossible for us to tell you what heat range to use - experimentation is the only way.

The best place to start is with a plug one heat range colder than standard. Has the engine got more power - without poor running due to the plugs fouling up? Can you advance the timing without getting detonation? Are the plugs as clean as a whistle when pulled after driving? If the answer is 'yes' to all these, try one heat range colder again. Eventually you'll get to the stage where the plugs start to foul, and you can then work backwards to pick which plugs work best for you.

If you're prepared to blip the throttle occasionally to clear the plugs and you drive the car fairly hard you may find that two heat ranges colder plugs on a hi-po engine are fine. The advanced timing that you should be able to run without detonation or pre-ignition (giving more power) will be a very worthwhile trade-off for a slightly grumbly idle.

Reading Plugs

Even workshops equipped with mega-dollar exhaust gas analysis equipment and air/fuel ratio metres still read plugs. This guide from Champion gives you an idea of what to look for.

Conclusion

While plugs are often not given a second thought, if your engine is in a hotter tune than standard you may well be able to get better performance by running non-standard plugs. The minor expenditure makes it worth trying!

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