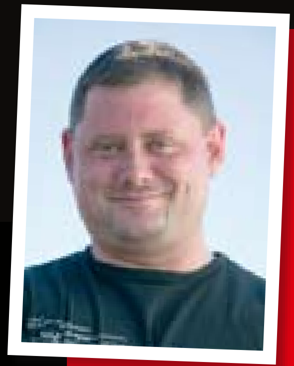
PART 3

COMPRESSION RATIO

Rounding off his series on compression ratio, Stu looks at necessary mapping changes and how engine geometry can affect it.



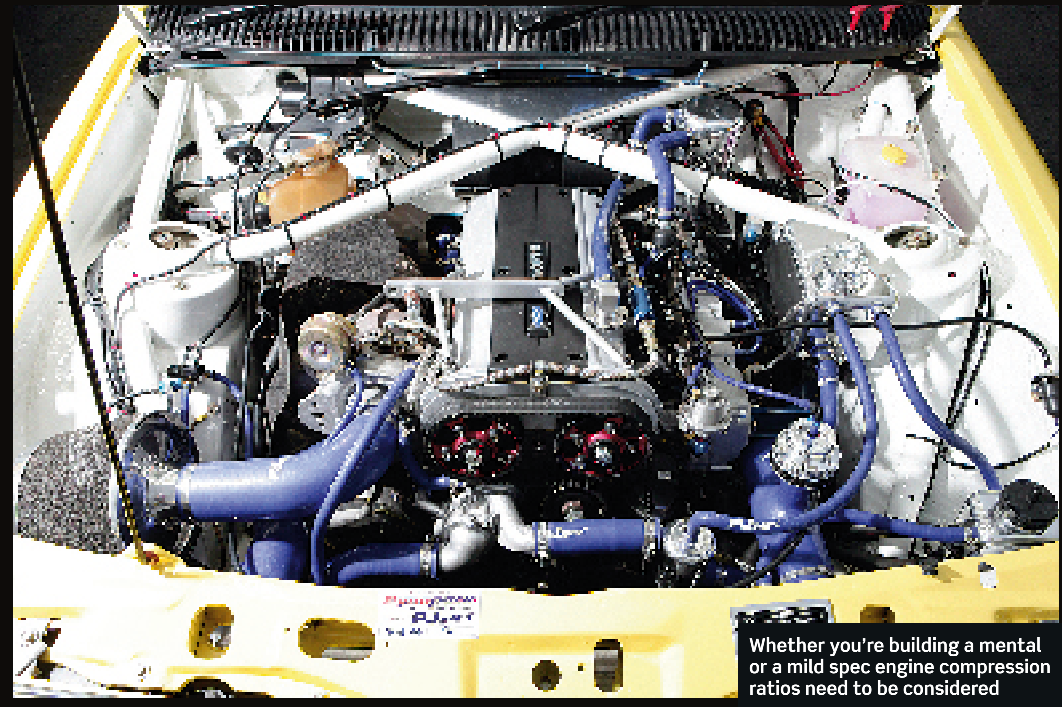
Having worked as a tuner for 17 years, Stewart 'Stu' Sanderson is one of the most-respected names in the business.

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

Then seven 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's also jointly responsible with Webmaster, Petrucci for **www.passionford.com**. Started in 2003, it's grown rapidly from a few friends contributing, to one of the biggest Ford communities on the web. His new forum, **www.fordrsforums.co.uk**, is also up and running.

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 most importantly how they can be improved.



Whether you're building a mental or a mild spec engine compression ratios need to be considered

Over the past two months we have discussed in depth an engine's compression ratio, what exactly it is and how various things affect it, including how to change it if we need to. We have also explained the difference between static and dynamic compression ratio.

This month we are going to discuss how the mapping requirements are changed when you adjust your compression ratio and also how different engine physical geometries can have a substantial effect on the amount of static compression you can run.

What actually changes when we adjust compression and what is needed to compensate for these changes? These questions must be considered and any required changes dealt with once you have adjusted the compression how you desire. So, let's look at the main items that will change and what (if any) changes may be needed to get the engine running correctly again.

CYLINDER PRESSURE

A compression ratio change will directly affect your cylinder pressure for any given volume of air.

If you increase the compression then you will increase the cylinder pressure, whereas if you decrease the compression you will decrease the cylinder pressure. This change in cylinder pressure will have a direct effect on the fuel mixture's burn rate and will also have a direct effect on the octane required for that engine.

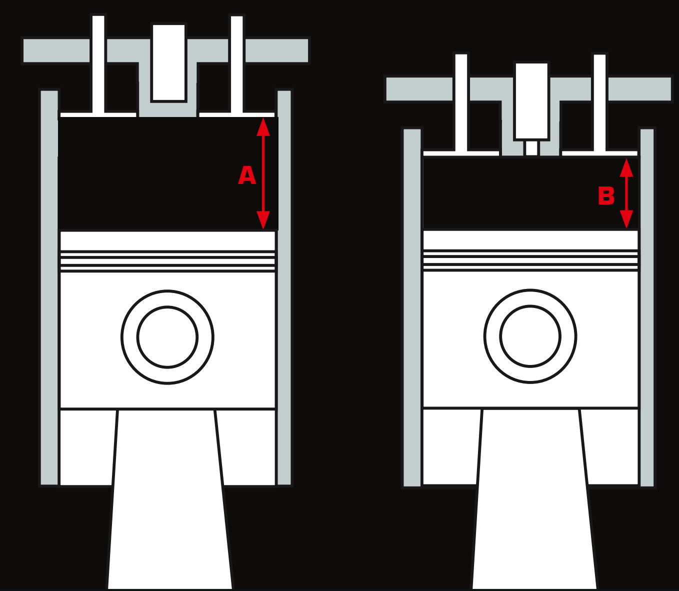
Less cylinder pressure usually means a lower octane will be required to safely work with that engine design due to the decrease in pressures and temperatures around top dead centre. This information presumes all the other engine components remain the same bar compression ratio.

PUMPING LOSSES

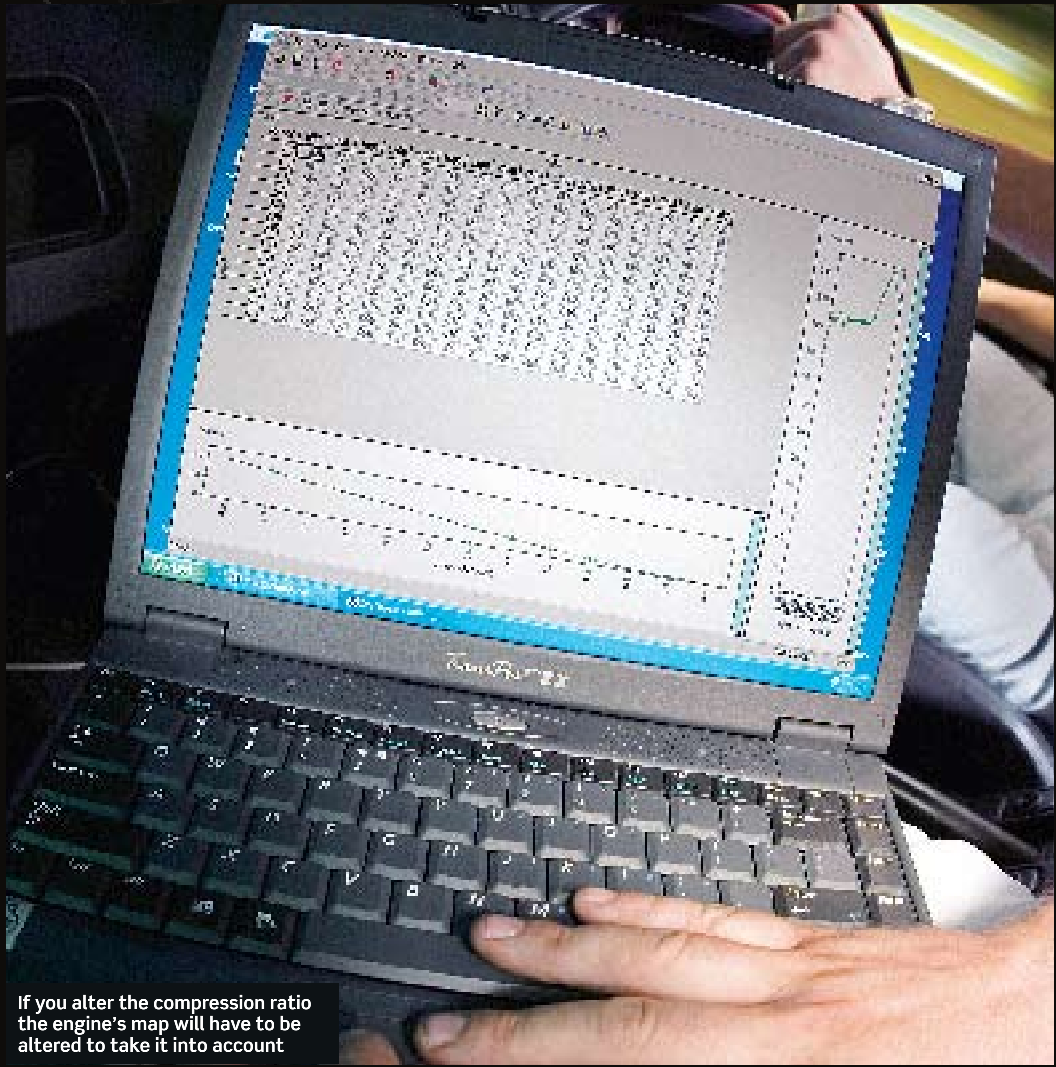
The pumping loss produced by the piston compressing any given volume of fuel and air mixture will change when you adjust the compression ratio. This will have a varied effect on the engine depending on which way you adjusted the compression. If you increased the compression, then the pumping losses will increase. If you lowered the compression then the pumping losses will decrease. See the boxout over the page for an explanation of pumping loss.

BURN SPEED

The way the mixture burns is the main thing that changes when we adjust the compression ratio, and is more often than not the very reason we change it. If we increase the compression ratio, then broadly speaking our burn speed will increase. If we decrease the compression then burn speed will decrease.



THE CYLINDER PRESSURE IS AFFECTED BY THE COMPRESSION RATIO. WITH THE PISTONS AT TDC THE DIAGRAM ON THE LEFT (A) WILL HAVE A LOWER CYLINDER PRESSURE THAN THE ONE ON THE RIGHT (B)



If you alter the compression ratio the engine's map will have to be altered to take it into account

MAPPING

The maps that control the engine are found within the engine management computer and these will certainly need adjustments if you have altered the compression ratio. The fuel mixture will likely have changed due to increased or decreased cylinder size, but this change is usually minimal and will require very little adjustment to get it perfect again. What is normally the most important change is the amount of spark advance required at any given throttle angle or plenum pressure.

When you lower the compression on an engine, you lower the cylinder pressure on both the compression and the power strokes. This cylinder pressure has a strong relationship with the air/fuel mixture's actual burn speed because, generally, the higher the cylinder pressure the faster the air/fuel mixture will burn. Consequently, when you lower the engine's compression, you will slow down the burn of the fuel too, this means that in order to keep the same peak cylinder pressure at the correct crank angle as you had before you will need to initiate the combustion sooner to compensate for the fact that it is burning more slowly. Bear in mind that too little advance will not only lose you power, it will also dramatically increase your exhaust gas temperatures too.

The same is true in reverse. If you increase the compression then you will increase the burn speed. This is more dangerous as unless you retard the timing in the ECU, you will often suffer from deadly engine-destroying detonation as the peak cylinder pressure from combustion can occur too soon in the cycle, and blow holes in pistons and melt cylinder heads and valve heads in no time at all.

It is worth noting that the increased spark advance you can run due to lowered compression will not normally give you any more power than before you lowered the compression. It is not the advance itself that provides the power. The extra power comes from your ability to run extra boost and add more fuel. Spark advance will only add more power if you were actually running too retarded in the first place. Simply compensating for a drop in compression ratio will not add power.

As a final note about mapping, please remember that if you have adjusted your compression to be able to run more or less boost, and higher or lower octane fuels, then these modifications will require further mapping to bring everything together.

> "The engine's geometry will has a massive bearing on how an engine will actually run."

BRAKE SPECIFIC FUEL CONSUMPTION

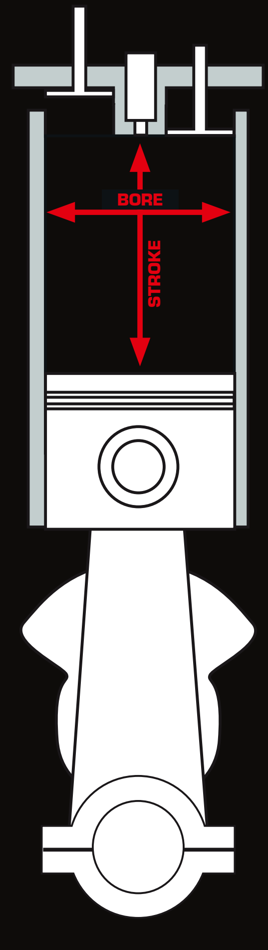
The engine's brake specific fuel consumption will change in relation to compression too. Generally speaking it will decrease as you lower compression and increase as you raise the compression. This means that in general, a low compression car will be worse on fuel than its higher compression counterpart for any given power output if all things remain equal. This can have a large bearing on race cars, especially at such levels as Formula 1 where an extra fuel stop can lose you the race. (See the boxout for an explanation of brake specific fuel consumption.

ENGINE GEOMETRY EFFECTS

One of the most misunderstood things about compression ratio is the fact that the engine's geometry has a massive bearing on how an engine will actually run. It affects such dynamics as how much fuel will be consumed and even how much spark advance will be required to correctly burn a specific amount of fuel. As an example, a Mitsubishi Lancer will run 400bhp very safely at 8.8:1 static compression ratio where as a Cosworth YB will struggle at that compression if used hard. One of the main reasons for this is simply engine geometry.

The Mitsubishi Lancer engine finds its two litres of capacity by running a bore of 85mm with a stroke of 88mm. The YB finds its two litres by running a bore of 90.82mm with a stroke of 76.95mm. Exactly why this affects things so much is a very complex subject that we'll look at in more depth at a later date, during a feature about engine geometry.

It's worth mentioning here so that readers with aspirations of building their own engines don't fall into the trap of building an engine to a certain compression ratio just because you read in a magazine, that other manufacturers' engines run that compression ratio. There are a lot of things to take into consideration before you choose your compression ratio and the engine geometry is one of the biggest.



THE YB HAS A BORE OF 90.82MM AND A STROKE OF 76.95MM

VARIABLE COMPRESSION RATIO

Ultimately, the best results would come from an engine that ran high compression for idling, even higher compression still for off boost economical cruising and low compression for flat-out high boost acceleration. Believe it or not, that technology is upon us.

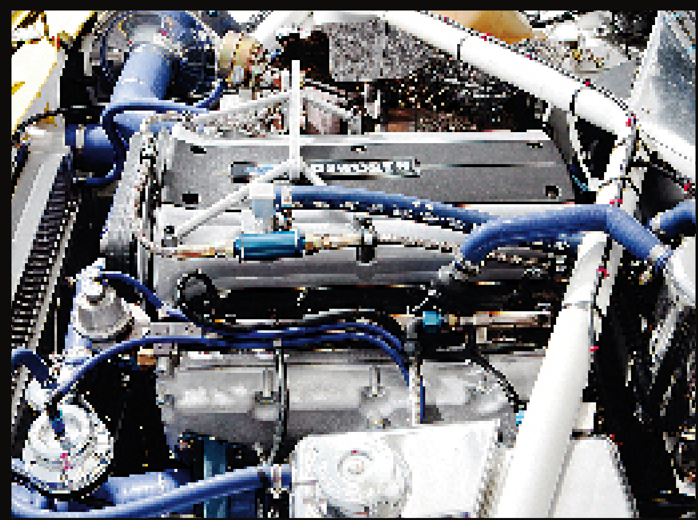
Manufacturers have almost perfected this system and have various different designs up and running. Saab for example has found a way to pivot the cylinder head electronically, thus adjusting the un-swept area inside the cylinder, whereas Nissan has achieved its variable compression ratio using a special set of cranks and pistons that can be adjusted in relation to one another.

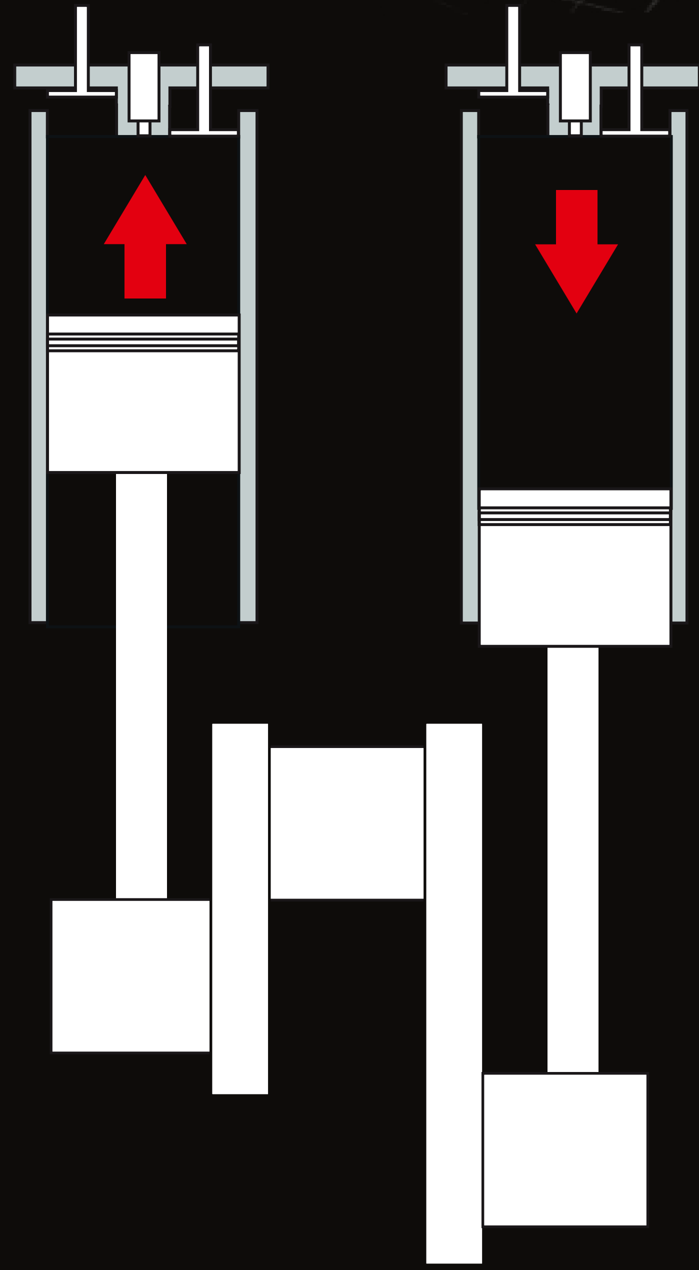
The future is bright for variable compression and when used well in conjunction with well matched turbos and decent variable valve timing systems we can reasonably expect to see some spectacularly flexible engine designs over the next couple of years or so. I for one can't wait to start modifying them and seeing what gains we can yield with lots more boost. Watch this space...

That pretty much puts the lid on the subject of compression ratios and I hope that this aspect of engine theory has been clarified a little for you. There's no denying it's a very complex subject and I suggest you at least consider reading all three parts again in a day or two just to see if anything you didn't quite get the first time around clicks into place. It's an incredibly tricky subject that I've tried to de-complicate for general consumption, but if you're still unsure, I'm sure if you read it piece by piece it will start to make sense.

PUMPING LOSS

When the engine's cylinder is sealed and the mixture compressed by the piston, the energy required to do this is taken from the power stroke of another cylinder. This lost energy is termed as a pumping loss. To help you imagine a pumping loss, imagine operating a bicycle pump and then blocking the outlet completely. This is what happens in your engine once both the inlet and exhaust valves are closed and the piston continues its compression stroke. The piston continues its journey up to TDC and anything in the cylinder above it is highly compressed into the relatively tiny combustion chamber at the top.





AS THE PISTON HEADS UP THE CYLINDER THE AMOUNT OF ENERGY REQUIRED TO COMPRESS THE FUEL/AIR MIXTURE DIRECTLY AFFECTS THE (DOWNWARD) POWER STROKE OF ANOTHER CYLINDER

BRAKE SPECIFIC FUEL CONSUMPTION

BSFC is a measure of an engine's efficiency. The figures relate to the amount of energy an engine can produce with a given amount of fuel and are the result of measuring the rate of fuel consumption divided by the rate of power production.

NEXT MONTH

The inner workings of the Bosch KE Jetronic fuel injection systems as fitted to Escort RSTs.