MULTIPLE CHOICE

With piston engines still very much with us, alternative fuels, hybrids and pure EVs, the powertrain market has fragmented into a fascinating mass of different technology angles. Mahle has operations across all these areas and more, these are the options going forward

Mahle is a multinational company with just shy of 80,000 employees spread across 170 locations. It's organised into large business units, with smaller profit centres, many of which carry out extensive research programs. Here Mike Bassett, Chief Engineer for Research and Advanced Engineering from Mahle Powertrain explains where technology is now and where it is going.

IS THERE MUCH INTEREST IN ALTERNATIVE FUELS?

We're working with the oil companies to research biofuels, it's definitely something we're interested in. For example we do a lot of work in Brazil with bioethanol. We've also built a CNG engine which has a very high specific output.

However, the legislation isn't helpful here as it focuses too much on tailpipe emissions without considering the bigger CO2 picture. It's the same for EVs – the legislation takes no account of the energy used to extract the lithium and manufacture the batteries. We've been trying to get this message across for years but when you get so many parties involved it becomes quite political and complex. I hope this will change, especially as if you take bioethanol as an example it's an ideal fuel for an engine. All you need to do is ensure the rubbers and plastics are able to withstand it and you can even take advantage of its properties by raising the compression ratio, enhancing efficiency.

HOW MUCH MORE EFFICIENT CAN PISTON ENGINES GET?

Our focus at the moment is on a pre-chamber design, where we are seeing quite significant gains in fuel economy with really quite modest changes.

Part of Mahle's combustion optimisation process

We're looking at a 10-15% improvement over the next 3 or 4 years.

It's called the Mahle Jet ignition system and we have two varieties: Active, which features a second injector in the pre-chamber, and Passive, without the extra injector. What the system does is it enables us to run with higher levels of charge dilution. The latter, which is nearer to market as it's simpler, gives us 210-215 grams of carbon/KwH and it works very well with external EGR.

Looking at other engine designs, such as rotary, they are often efforts to get over the perceived downsides of piston engines – reciprocating losses due to the oscillating mass of the pistons – but when you do a kinematic analysis of the crank train any losses are ultimately recovered. I don't see any step changes in engines, especially considering the years and years of experience making the components. In 20 years engines will look very similar to how they do now.

ARE ADVANCES IN MODELLING AFFECTING ENGINE DESIGN?

Yes. The big challenges of efficiency and emissions mean that we are spending a lot more time doing detailed CFD. If you look back ten years it was quite hard to do that kind of analysis, it just took too long. Even now with a cluster of computers it can take 3 days to generate results. It's still expensive, but it does enable us to examine the 'what-ifs?' So, things that are hard to set up experimentally. We'll see more of this, especially focusing on the induction and aftertreatment systems.

From a testing perspective advances in 3D printing are helping us stay one step ahead of the analysis. It's especially good for complex shapes.

We also make extensive use of CNC machinery on the manufacturing side. For example take the pistons made in Germany for our Motorsports division – they have some incredible 5-axis machines that make the ovality and barrel-shaped profiles.

Above: Power cell unit
Below: Steel pistons for commercial vehicles

Piston production

WHAT ARE THE CURRENT MATERIAL TRENDS?

We've recently launched some bearings with a polymer coating which is designed to reduce friction. This is important as there is a movement toward thinner oils as part of a wider move to greater overall efficiency.

ARE TASTES IN TRANSMISSIONS CHANGING?

If you look at the European and Chinese markets automatics are becoming more prevalent. I see this as a continuing trend over the next ten years. On the lower end of the market torque converters will be retained with some type of lock-up function to improve efficiency, with the more expensive and complex CVTs available on the higher end models.

There are fuel economy advantages in taking the gear change away from the driver as the engine can be used in its optimal range. This is also important where hybrid drives are concerned.

We are seeing a variety of views in the market place regarding whether a plug-in or self-charging system is best, opinions differ. What is certainly true is that there is an increased interest in 48 volt systems, in particularly for larger vehicles, say over a tonne and a half in weight. I predict in Europe everything that isn't a plug-in hybrid (PHEV) will use a 48 volt system.

We've recently being doing some research on batteries and we've built a high power 25kW unit, using what we learned when we designed a 48 volt demonstrator in 2016.

WHERE ARE WE WITH REGENERATIVE TECHNOLOGY?

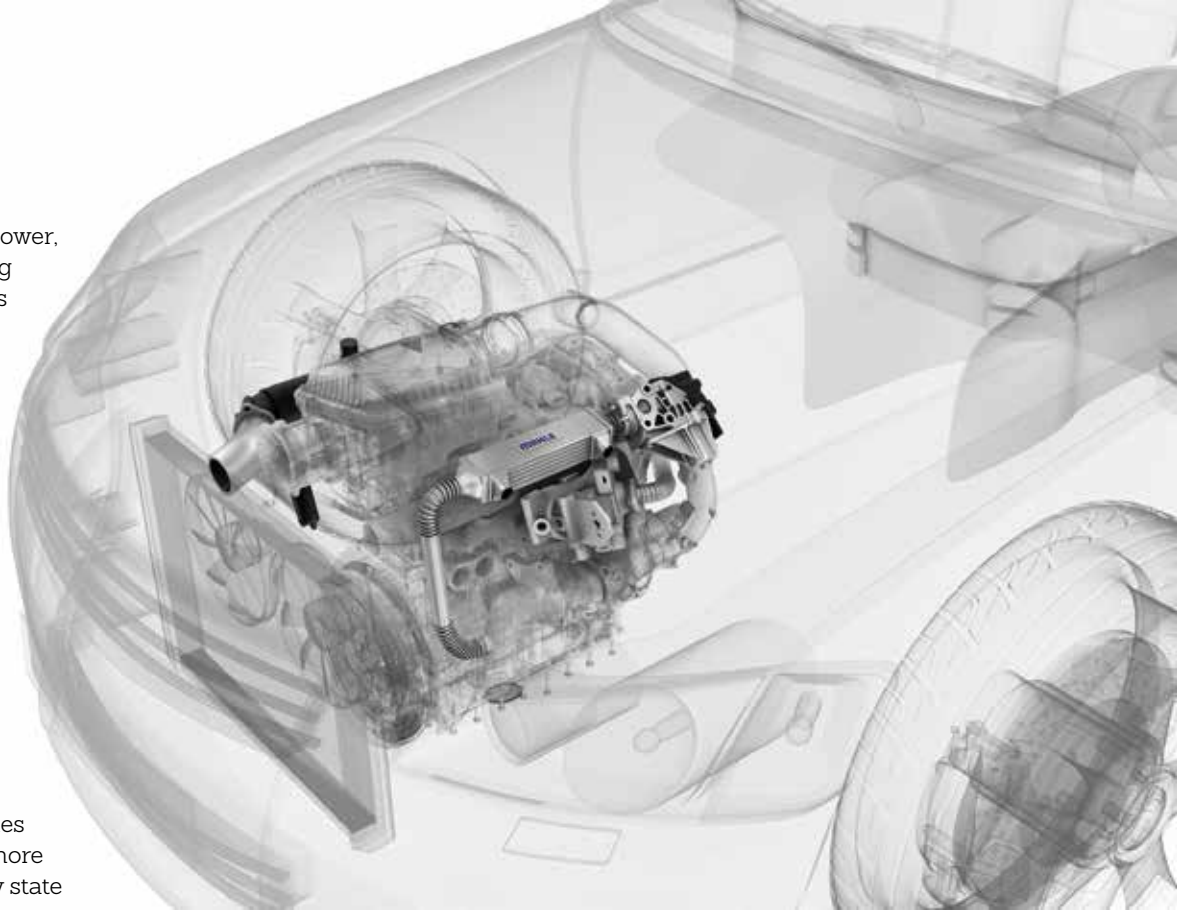
From a design perspective in all hinges on the lay out. A P4 (see end note) lay out lends itself well to maximising the regenerative energy in an efficient manner, likewise P2s are good.

With a starter/alternator arrangement they are less attractive as the engine is

still rotating and absorbing power, but still better than not having the hybrid system. It depends on how much people are willing to invest. I suspect in the future smaller starter/alternator systems will increasingly gain the ability to be disconnected from the engine.

WHAT'S THIS MEAN FOR ENGINE DESIGN?

From the engine design perspective, you end up with a unit that requires less transient capability. In other words the more the dynamic response for the vehicle comes from the hybrid system the more the engine becomes a steady state device. This is good from an efficiency standpoint.



Exhaust Gas Recirculation schematic

WHAT ABOUT THE BATTERY TECHNOLOGY?

You have to work with what you've got. I'd like to see improvements with cost, weight, size and safety.

Also the recycling is a massive issue – there's a reason why there's so much work going on in that area. For me, the so called 'second life' usage is just delaying the inevitable, and it's a nettle that has to be grasped at some point. Hopefully by the time we see large volumes of batteries that need recycling there will be a solution.

If you look at the energy density in comparison to liquid hydrocarbon fossil fuels we are a long way off too.

This is also about market acceptance, people assume they will get as far from a charge as from a tank of fuel and some education may be required here. Despite the fact the average UK car journey is only around 7 miles, there is still range anxiety. If people had reliable chargers at home that might help. The new Dyson EV is apparently going to have solid state technology so I'm very interested to see how that's going to work.

Of course this does give PHEVs an advantage as you can have quite a small battery with the IC engine to fall back on. If one does a carbon footprint analysis this does make a large difference if charged appropriately from renewables.

48 volts - the future for pure EVs?

WHERE DO FUEL CELLS FIT INTO ALL THIS?

Fuel cells are still at the research stage for most manufacturers. I know several OEMs are looking into this and we are actively involved in several programs. Many of our IC engine components are appropriate here.

The obstacle is not the technology on-board the vehicle but the hydrogen creation and fuelling infrastructure, problems EVs just don't have. Currently hydrogen production is quite carbon-intensive and until this changes this will be a barrier to further fuel cell uptake. However, it's still worth researching as greater reliance on renewables could solve this in the future. ■

P0 is alternator location, with P1 being at the flywheel, P2 is in the same place but with a clutch in between it and the engine, P3 is downstream of the gearbox, P4 is at the wheel end.