Steve Dawson

Chief executive of SinterCast

When it comes to increasing energy efficiency and decreasing emissions, we need to look further than just the tailpipe as a measurement

When architects design a building, they are required to quantify the energy content in all the materials. But in the automotive industry, legislation focuses on the tailpipe, with little concern for upstream energy consumption and lifecycle CO_2.

The increasing demands on fuel economy and CO_2 have prompted some OEMs to contemplate changing from cast-iron cylinder blocks to aluminium, in the quest for less weight and less CO_2. But sometimes the 'obvious' decision isn't obvious.

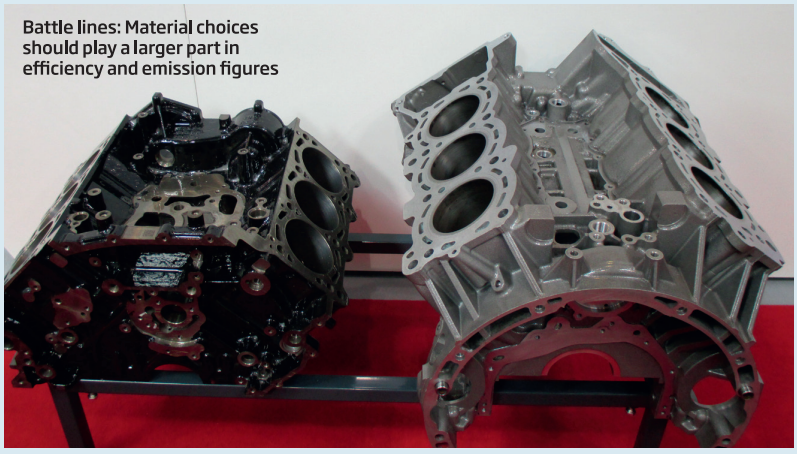
In the foundry, cast iron melts at 1,200°C. Aluminium melts at 600°C. Intuitively, cast iron should consume more energy than aluminium. However, the high electrical resistivity of iron allows the use of efficient electrical induction melting, while the melting of aluminium requires energy-intensive resistance or gas heating. The ultimate result is that the melting of cast iron requires around 10,500MJ of energy per tonne, while the melting of aluminium requires around 90,000MJ per tonne.

So the energy content of a 35kg cast-iron cylinder block is 368MJ, while the energy content of a 25kg aluminium block is 2,250MJ. To give a net benefit, the weight reduction provided by the aluminium block needs to save 1,882MJ on the road.

With an energy content of 34MJ/litre, the 1,882MJ break-even corresponds to 55 litres of petrol. And the Society of Automotive Engineers guidelines state that every 100kg saved improves fuel economy by 0.3 litres per 100km driven. This figure used to be 0.5 litres/100km, but improvements in aerodynamics and rolling resistance have diluted the weight-save bang for the buck.

Doing the maths, the payback for the 10kg weight differential between the iron and aluminium block requires 185,000km on the road. Based on data from the European Automobile Manufacturers Association that the average European passenger vehicle travels 14,000km per year, 185,000km corresponds to 13 years of driving – longer than the average vehicle life. And what if the weight difference is less than 10kg?

But we don't put cylinder blocks in cars; we put in fully assembled engines. Iron, particularly compacted graphite iron (CGI), is stronger and stiffer than aluminium. So the loadbearing walls are thinner, and iron blocks are shorter than aluminium blocks. Ultimately, all the components that span the length of the engine also become shorter and lighter, mitigating the difference in the block weight.



Battle lines: Material choices should play a larger part in efficiency and emission figures

The Audi 3-litre V6 diesel, with a CGI cylinder block, is 125mm shorter than the Mercedes 3-litre V6 diesel, based on an aluminium cylinder block. The iron engine is also 15kg lighter than the aluminium engine. Likewise, the Audi 4.2-litre V8 diesel, with a CGI cylinder block, is 120mm shorter and 4kg lighter than Mercedes' aluminium-blocked 4-litre V8. Imagine a 4.2-litre iron engine being lighter than a 4-litre aluminium engine.

And it's not just V-engines; the Volkswagen 2-litre iron diesel is 9kg lighter than the BMW N47 2-litre aluminium diesel. What is the meaning of the energy-payback calculation when the assembled light-metal engine is heavier than the iron engine?

While these examples are all diesels, Ford has chosen CGI for the 2.7-litre V6 petrol engine cylinder block of the new aluminium-bodied F-150 pick-up truck. Why is iron at the heart of the aluminium flagship? Because the CGI alternative was 40mm shorter than the aluminium option, resulting in the same assembled weight. Shorter, stronger, lighter, quieter, less expensive, better lifecycle CO_2 contribution to society.

When it comes to assembled engines, block length is often more important than block weight. The holy grail is size, not density.

Tailpipe is admittedly the easiest measurement, for both the industry and the consumer. But the lifecycle approach used by our civil engineering brothers in their buildings and bridges promotes more holistic, greener and better decisions.

It is probably a bridge too far to expect governments to change from tailpipe to well-to-wheels. But if the politicians want to be the architects of our future, they should broaden km/litre and CO_2 credits beyond good technologies such as energy-efficient air-conditioning, windows, lighting and aerodynamics, to also motivate and reward material choices that reduce the total energy content in our vehicles, and provide lifecycle contributions to society. ■