Unbearable lightness?

To make cars frugal, they will have to become lighter—and more expensive

WHEN IT COMES to motor vehicles there is widespread belief—at least in America—that bigger is not only better, but safer too. The assumption is that nothing beats having lots of steel around you in a crash. And it is true, to some extent. All things being equal, the driver of a large SUV (sports-utility vehicle) is less likely to be killed than the driver of a small car in a head-on collision between the two. The downside is that SUV drivers are far more likely than car drivers to die in solitary roll-over accidents induced by the vehicle's own weight, its high centre of gravity and its truck-like suspension. Collisions with other SUVs can be deadlier still.

An excess of heavy metal imposes other penalties. American motorists are as aware as any that weight is the enemy of fuel economy. However, with pump prices low by international standards, the trade-off between safety and fuel consumption has understandably favoured the former. Adding air-bags, anti-lock brakes, stability control and side-impact beams has saved countless lives, but it has increased vehicle weights disproportionately. Cars and light trucks on American roads today are 30% heavier than they were in the mid-1980s.

Unfortunately, heavier vehicles need beefier engines to lug their extra girth around. As a result, much of the past quarter-century's improvements in engine and vehicle design—low-friction materials, turbo charging, direct injection, variable valve-timing, cylinder deactivation, stop-start ignition, dual-clutch transmissions, better aerodynamics and low rolling-resistance tires—have been mopped up by increases in vehicle weight.

It therefore comes as no surprise that the pronouncement by the White House—that cars and trucks sold in America from the 2016 model year onwards will have to achieve a fleet-wide average of 35.5mpg (6.6 litres/100km)—should have awoken fears about vehicles becoming smaller and less safe in order to meet the latest fuel-sipping standards. The new corporate-average fuel economy (CAFE) figure, originally scheduled for 2020 but brought four years forward by the Obama administration, amounts to a 34% increase over today's actual average of 26.4mpg.

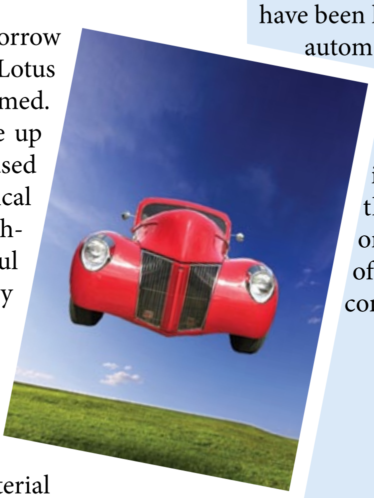
How to achieve such a whopping increase in efficiency over so short a time? The trouble is that most of the low-hanging fruit in combustion engineering have been picked already. At best, the motor industry expects only a 15-20% further improvement can be squeezed from existing petrol engines and their transmissions. A new generation of plug-in hybrids and pure electric vehicles will doubtless help achieve the required goal. But even if their sales triple over the next five years, they will still account for less than 10% of America's fleet of new cars by 2016.

Though themselves not cheap, clean diesels, with their 35% greater efficiency, would be a better bet—if only Americans could be persuaded to embrace them as Europeans have. Although no longer justified, the diesel's reputation for being slow, smelly, noisy, unreliable and difficult to start in cold weather has lingered since the 1980s, when Detroit rushed out half-baked designs in response to the oil crisis. But even if the demand for diesel cars were there, the fuel might not be—at least, not at a price Americans would be willing to pay. As it is, there is already a global shortage of diesel-making capacity. The catalytic crackers used in refineries throughout America are optimised to produce as much petrol as possible. Switching them over to the hydrocracking processes used widely in Europe and Asia for diesel production would take donkey's years.

So it comes down to this: if half the increase in efficiency demanded by the new CAFE requirements is to come from further improvements in the power-train, then the other half will have to come from reductions in a vehicle's weight. That prompts two immediate questions: how much will such a weight reduction add to prices, and will hard-won gains in vehicle safety be sacrificed in the process?

Given today's materials and know-how, automotive engineers reckon a 10% reduction in vehicle weight yields a 6% improvement in efficiency. Meanwhile, trimming the fat from a vehicle's bodywork, components and accessories costs roughly $2 a pound. Running the numbers for a typical car—say, a Toyota Camry weighing 3,260lb (1,500kg) and averaging 26mpg—suggests it would need to shed a little under a third of its weight, at a cost of roughly $2,000, to meet the 2016 standard. The Environment Protection Agency claims average prices on the forecourt will rise by only $1,300. Someone, somewhere, seems to have got their sums wrong.

In the end, the additional price for "adding lightness"—to borrow a phrase from the late Colin Chapman, the legendary founder of Lotus Cars—comes down to the materials used and how they are formed. To do the same job, HSLA (high-strength low-alloy) steels are up to 30% lighter than traditional carbon steels. They are already used in motor vehicles for components that have to withstand critical loads. Unfortunately, because of their higher strength and toughness, HSLA steels need 30% more energy to form them into useful shapes. Also, because their strength tends to be directional, they can fail under sudden loads from unexpected quarters.



One of the ways that Chapman added lightness to his cars, the use of composite materials such as carbon fibre and glass-reinforced plastic, is not that practical either. Lotuses are turned out in small numbers, but composites require too much manual work for volume production. So the only sensible material for reducing a conventional car's weight while maintaining its strength is aluminium.

At present, aluminium accounts for 9% of a typical vehicle's content—mostly in the form of castings and forgings for engine blocks, transmission cases, wheels and suspension parts. For the aluminium content to increase much further means using

MARKETING INSIGHT

Alcoa is Ramping Up to Meet Demand

DES MOINES, Iowa (Associated Press). Alcoa Inc. announced in September 2011 that it will invest $300 million to expand and add 150 jobs to its Davenport, Iowa plant.

Alcoa Vice President and General Manager John Fox said demand for aluminum products produced by Alcoa is growing with the new automotive guidelines.

"It allows for a smaller power train, better mileage and less CO_2 output," Fox said. "It means our business is growing quite well."

"All the major manufacturers continue to express interest in moving to aluminum, with that movement that means we can bring more people to work," Fox said.

The expansion will also help retain 200 jobs Fox said would otherwise have been lost. He said with the automakers required to increase mileage by 2016, the company needed to move forward with the project immediately. Fox added that equipment has been ordered and the expansion of the plant is expected to be completed by the end of 2013.

sheets and extrusions of the stuff for body panels and subframes. That will require further advances in laser welding and other bonding techniques to make production costs competitive.

The handful of aluminium-bodied cars in production have mostly been low-volume luxury models, such as the Honda NSX, the Audi A8 and the Jaguar XJ. Their body weights have typically been 10% to 15% lower than those of their steel equivalents. However, if all the parts made of iron and steel in cars today were replaced with aluminium, the vehicle would weigh 45% less. And it would be stronger, too. Pound for pound, aluminium is up to two-and-a-half times stronger than conventional steel—and can absorb twice the energy in a crash.

In short, making vehicles lighter does not mean they have to be smaller or less safe. If anything, cars with a high aluminium content have tended to be bigger and stronger than their steel-bodied predecessors. Replacing steel with aluminium allows additional interior space to be offered, along with larger crumple zones at the front and rear for even better crash protection, all without paying a heavy penalty in fuel consumption.

But there is a snag: cost. Aluminium is three to four times more expensive than steel. On the plus side, aluminium cars do not rust, and therefore last longer than conventional cars. And, at the end of their lives, they have a much higher scrap value. Add in the fuel saving, and the lifetime cost of an aluminium car—from raw material and manufacturing to daily use and final disposal—can be comparable to that of a conventional car. And the higher petrol prices go, of course, the sooner an aluminium car becomes as cheap overall as a conventional one.

The stumbling block in this analysis is that the person who walks into a showroom to buy a brand new aluminium car is unlikely to capture all those lifetime benefits. Nor is the manufacturer—at least, not immediately. So expect the initial sticker prices to be at least $2,000 higher for enlightened compact cars, and $4,500-6,000 more for trimmer luxury cars and SUVs. The only consolation will be not having to fill up the tank quite so often.

Metal Improvement Company Responds to CAFE Requirements

Engineers at General Motors are credited with developing shot peening as a production process in the 1930s. Shot peening was initially applied to valve springs, then to gears and connecting rods, then to many other steel automotive components. Metal Improvement Company believes that the automotive industry, like aerospace, will further evolve and begin to incorporate higher-strength steels and aluminum to reduce weight and subsequently improve fuel efficiencies. These metal alloys, however, tend to be more brittle and vulnerable to fatigue cracking and stress corrosion-related failures than conventional steel, and shot peening will be called upon to provide protection.

An automobile has hundreds of components embedded into many sub-systems. Most of these components have already been continually optimized for decades, thus making it hard to find obvious and easily obtainable solutions to the pending Corporate Average Fuel Economy (CAFE) requirements. An indirect benefit of these improvements, which isn't recognized in the CAFE requirements, is the ability of new vehicles to last 150,000-300,000 miles, thereby reducing the need to replace vehicles as frequently as in the past. Car owners that keep their vehicles longer present a significant reduction in energy usage due to reduced new vehicle production.

"Throughout the vehicle, it's the many incremental savings, like those achieved with shot peening, that will gradually move our current vehicle fleet towards the new CAFE requirements."

—Jim Harrison
Marketing Manager
Metal Improvement Company

While today's vehicles last longer, they have gotten significantly heavier. Compact cars sold in the U.S. today on average weigh 549 pounds more than those sold in the States a decade ago according to an edmunds.com analysis. The weight gain is a major challenge in meeting CAFE requirements.

Shot peening fits into the solution through its ability to incrementally improve the power density of metal components. For example, if replacing a steel component with an aluminum component yields a 30% weight savings, additional weight savings are possible with shot peening, depending on the failure mode and application. Throughout the vehicle, it's the many incremental savings, like those achieved with shot peening, that will gradually move our current vehicle fleet towards the new CAFE requirements.

Metal Improvement Company is already working closely with its automotive customers to develop shot peening specification callouts that enable the use of these materials to their best advantage.