Automotive Weight and Drag Reduction

HIGHLIGHTS

■ **TECHNOLOGY STATUS –** Weight and drag reduction are widely recognised as cost effective ways of reducing automotive energy consumption, however they have not always been given as high priority as other vehicle characteristics. The introduction of CO_2 emissions legislation for passenger cars in Europe has started to reverse this trend with several recent models being lighter than their predecessors and manufacturers increasingly striving to achieve low aerodynamic drag coefficients. However improvements in drag coefficients of passenger cars over the years have largely been offset by increasing frontal areas. Europe has also introduced legislation to mandate the reduction of rolling resistance through the use of low rolling resistance tyres for all vehicle types and tyre pressure monitoring systems on passenger cars. Typically over half of the energy used by large goods vehicles is to overcome rolling resistance and a further third is aerodynamic drag on higher speed roads so they too can benefit from these technologies.

■ **PERFORMANCE AND COSTS –** While more expensive materials such as magnesium and carbon fibre can be used to reduce weight, many reductions can be achieved through optimising design without increased cost. It is also important to realise the secondary weight reduction in components such as the powertrain, braking system and suspension system which can be achieved as a result of an overall reduction in vehicle weight. Fitment of low rolling resistance tyres and tyre pressure monitoring systems to passenger cars can each offer 2-3% reductions in CO_2. Aerodynamic drag reduction can be achieved through detailed wind tunnel design work and does not necessarily require an increase in vehicle production costs. For heavy goods vehicles, low rolling resistance tyres could reduce CO_2 by 5% at no additional cost. Tyre pressure monitoring systems could achieve 7-8% CO_2 reductions but systems cost around €11,500. However they can be removed and refitted to successive vehicles. There is also strong potential for drag reduction of long haul large goods vehicles, with CO_2 savings of 0.1-6.5% and costs of €290-1950.

■ **POTENTIAL AND BARRIERS –** There is potential for further weight and drag reduction in passenger cars and it is not unreasonable to expect that average passenger car weights could be reduced by as much as 40%. Primary barriers include concerns regarding the safety of very light vehicles particularly when in collision with heavier traditional designs, although there is no fundamental reason why very light vehicles cannot also be very safe. Public acceptance of ultra-low drag styling and the different 'feel' of lightweight vehicles may also need to be overcome. Drag and weight reduction for vans and heavy duty vehicles also have strong potential for energy and cost savings yet the technologies are not yet widely applied.

TECHNOLOGY STATUS – Weight and drag reduction are two important ways of reducing automotive energy consumption. The introduction of CO_2 emissions legislation for European passenger cars and rising oil prices has seen an increasing focus on improving efficiency through weight and drag reduction. For commercial and heavy duty vehicle operators, fuel costs are a major consideration and CO_2 emissions legislation in Europe is being extended to include light vans. This brief covers, passenger cars, light trucks and vans and heavy duty vehicles (heavy trucks, buses and coaches).

■ **Weight Reduction:** There are two commonly used ways of expressing vehicle weight. **Kerb weight** refers to the total weight of a vehicle with standard equipment, all the consumables required for operation (typically oil, lubricants and coolants) and a full tank of fuel, but no passengers or cargo. Many European manufacturers also include 75kg to represent the driver as specified by European Directive 95/48/EC [1].

Gross vehicle weight (GVW, sometimes described as Maximum Authorised Mass, MAM) is the maximum allowable weight of a vehicle including passengers and cargo. Heavy duty vehicles can be defined as those with a GVW greater than 3.5 tonnes.

In order for a vehicle to accelerate, it must overcome inertial forces. The 'inertial power' required is linearly proportional to vehicle weight, so for a given speed and acceleration rate, if vehicle weight is halved, the inertial power required will be halved.

Importantly, for almost all vehicles it is the required aceleration rate rather than the top speed that governs the required engine power. Thus reducing vehicle weight will reduce the engine power requirement and in turn the likely fuel consumption.

Over the years passenger car weights have increased as vehicles in a given segment have got larger, and have had additional safety and comfort features added. For example each successive new version of the Volkswagen Golf hatchback has increased in weight until in 2003 the Mk5 version weighed 67% more than the 1974 original. Recently this trend has started to change and the Mk6 version introduced in 2009 is lighter than the Mk5, despite being physically larger.

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