Automotive Legislation Increases CO_2

Tailpipe legislation has backfired, causing an increase in carbon dioxide (CO_2) greenhouse gas emissions.

Today, automotive legislation focusses only on tailpipe emissions, ignoring the energy consumed and the CO_2 discharged during vehicle manufacture. This solitary focus on tailpipe CO_2 compels automakers to increase their use of low-density materials, like aluminium and plastics, instead of cast iron or steel. While the use of aluminium does trim weight, reducing fuel consumption and on-road CO_2 emissions, the initial production of aluminium emits significantly more CO_2 than cast iron and steel. It rarely pays back.

Researchers at the Sustainable Manufacturing Systems Centre at Cranfield University in the UK conducted a landmark cradle-to-grave study to establish the total energy and CO_2 impact of passenger vehicle engine production. The study collected production data and interviewed more than 100 manufacturers and industry experts, addressing every step of the process, from the mining of raw materials through to engine production, on-road use, and end-of-life recycling. Researchers compared aluminium and cast iron passenger vehicle engines with the same driving performance, for both diesel and petrol power units.

Despite the lighter weight of an aluminium cylinder block, the production phase dominates the life total cycle energy efficiency. Depending on the manufacturing technique, the production of an aluminium cylinder block consumes 1.8 to 3.7 times more energy than the production of cast iron.

The nearly twofold increase in energy consumption occurs when the aluminium components are produced by high pressure die casting, in re-usable metal moulds. The almost fourfold increase results when the aluminium is produced by sand casting; where the components are produced in expendable sand moulds. The sand casting technique is similar to the production of cast iron, but aluminium consumes five times more chemically-bonded sand than the moulds used to produce cast iron. The energy required to produce the resins used to bond the heavier chemically-bonded sand moulds was the main reason for the higher energy consumption with sand casting.

The aluminium industry notes that the highest energy consumption occurs during the production of virgin aluminium from ore and that cylinder block production primarily uses recycled aluminium. But the Cranfield study took this into account, adopting the best-case scenario for aluminium – infinite recycling.

In order to provide a net benefit to society, the higher energy consumed in the manufacturing phase must be recovered during the on-the-road use phase, through reduced fuel consumption. Using the fuel saving ratio adopted by the US Environmental Protection Agency (4.6% fuel saving for each 5 to 10% of weight saved), the breakeven distance for petrol engines ranged from 185,000 km for die casting to 395,000 km for sand casting. For the diesel engine, the breakeven distance ranged from 270,000 to 560,000 km. Of the six different scenarios investigated, only the die casting of petrol engines provided energy breakeven for aluminium before the global average vehicle lifetime of 210,000 km. For most production conditions, the use of aluminium results in a net energy penalty to society.

According to the World Aluminium Organisation, China accounts for about 55% of the global primary aluminium production, and more than 90% of the primary aluminium production in China is produced using coal-derived electricity. The Gulf States are second with nearly 10%, and all of the aluminium produced in the Gulf States is produced using electricity derived from natural gas. Overall, more than 70% of the global aluminium production is based on fossil fuels. The net result: the production of each kilogram of aluminium generates more than 10 kg of CO_2.

Even with the favourable assumption of infinite recycling, the production of an aluminium cylinder block releases up to 2.25 times more CO_2 than a cast iron cylinder block. This corresponds to CO_2 breakeven distances ranging from 105,000 km to 470,000 km. As with the life cycle energy balance, only the high pressure die casting of aluminium petrol engines was able to provide a CO_2 breakeven within the life of the vehicle.

Scratch the surface and a new reality appears. Legislation compels engineers to use low-density materials, forcing them to swim in dirty water. It's time for legislators to dive beneath the surface and establish holistic life cycle policies that actually reduce CO_2 emissions.