

ACHA4004 Vehicle tech -2

Melissa Wheeler

2104199

Many cars on the road today use steel monocoques, they are favoured due to their high strength to weight ratio and their ease of manufacture thanks to being formed from simple stamped sheet metal that is then welded together to form a strong complex shape.

The first mass production car to use a steel monocoque was the 1934 Citroën Traction Avant, to prove the strength of the monocoque compared to the traditional body on frame construction of the time Citroën produced an ad <https://www.youtube.com/watch?v=CPDJHs0aylY> where they pushed a Traction Avant off of a cliff and then drove it away.

This showed one of the major advantages of the monocoque, because the chassis surrounds the occupants, they are protected from all sides meaning side and top loads are less likely to cause the body collapse and crush those inside the vehicle.

The downsides of steel monocoques is that steel has a relatively high weight strength ratio when compared to other materials such as aluminium, or composites such as carbon fibre, both of which are also used in monocoque type constructions. The strength to weight ratio of steel is an issue as heavy cars are slower, more inefficient, and burn through tires and brakes faster making them undesirable. It is also a difficult process to scale down to low production run cars as the large stamping tools required to produce the parts are extraordinarily expensive.

Generative design consists of computer-generated forms created using advanced algorithms to generate shapes that withstand the required forces, while using the minimum amount of material. It is often used in high end sports vehicles and super cars due to its ability to create structures with incredible strength for their weight and high cost of manufacture unless specifically designed for other forms of manufacture, which reduces the complexity of the forms drastically.

A couple of examples of generative design being used in production vehicles are the brakes of a Bugatti Chiron, where the brake callipers are made out of titanium and designed using generative design. “Bugatti could therefore reduce the weight of the brake caliper by about 40% at the same time as ensuring even higher strength by using the new part.”



As seen in this image through the use of generative design Bugatti was able to remove a lot of material from the caliper without effecting its strength. (Bugatti, 14:02 21/04/2022, <https://www.bugatti.com/media/news/2018/world-premiere-brake-caliper-from-3-d-printer/>)

The Mercedes EQXX concept also makes heavy use of generative design for lightness in the name of efficiency. The rear frame, the suspension mounts, and even the mount for the front windscreen wipers were designed using generative design to ensure that they weighed no more than they needed too. This let it achieve an impressive weight for its size of only 3,858 pounds or 1,750 Kg (Mercedes, 12:15 23/04/2022, <https://media.mbusa.com/releases/release-211879a94f6a1a0ff764674cdc0a8630-vision-eqxx-taking-electric-range-and-efficiency-to-an-entirely-new-level>) This is around 300Kg less than a production car of equivalent size.

The car that makes the most of generative design is one that you can actually buy is the Czinger 21C. Almost every single metal part of the vehicle has been generatively designed, the use of this technology allowed them to reach an amazing 1:1 power to weight ratio “1250 hp @ 10,50rpm” and

a "Dry weight 1,250 kg (2,756 lbs)" (Czinger, 12:42 22/04/2022, <https://www.czinger.com/dominating-performance>) by reducing the mass of the components as much as possible without sacrificing the strength of the structure thanks to a combination of generative design and 3d printing.

Generative design has two significant issues, mass production, and load flexibility. Due to the complex nature of the shape of the parts they can only normally be produced via additive manufacturing, specifically selective laser melting/sintering. This is where a very high-powered laser is used to melt metal powder together in layers, it allows for far more complex shapes than traditional manufacturing as you do not need to worry about being able to fit a tool into tight spaces or inaccessible voids. This is a problem as it is very hard to scale up additive manufacturing when compared to traditional cast parts, making the parts incredibly expensive, limiting their use severely.

A second issue with Generative design is their inability to handle unexpected loads, the parts are designed to handle specified loads at specified hardpoints using the absolute minimum amount of material so any significant unexpected loading of minor material fatigue can lead to catastrophic failure if not designed with a significant margin of error. Unlike in traditional manufacturing where there is often a lot of excess material due to the manufacturing processes used, such as casting or forging, this means that these parts often have wide load paths and can take much more abuse due to simply having more material to abuse.

Page Break

An understanding of aerodynamics as it relates to automobiles is considered to be important in order to improve efficiency, handling, and top speed.

Aerodynamics play an important role in the efficiency of automobiles because most of a car's energy is used to push through the air, aerodynamics also effects handling through downforce and turbulence, and it effects the top speed of the car as the amount of energy required to move through the air increases exponentially with speed.

Aerodynamics is the study of how air flows around an object and it matters in relation to automotive design because cars have to be able to push through the air. Aerodynamics also relates to automotive design to help create a more comfortable car by reducing wind noise and buffeting, these can be reduced by either smoothing over surfaces that disrupt the air flow by creating oscillating areas of low pressure, or by placing a feature on the vehicle that serves to break up the airflow in a more controlled, less noticeable way.

Better aerodynamics can improve efficiency and downforce, but not all at once as to improve handling by increasing downforce you have to make the airflow over the vehicle less efficient, this also serves to reduce the top speed of the vehicle.

Downforce is generated by slowing the air flowing over the top of a vehicle, like an inverse aerofoil creating a region of higher pressure, this is the opposite of efficient air flow as efficient airflow requires as little disruption to the air moving past the vehicle as possible.

These areas are the most important as they are the ones that the customer and driver will notice the most and can affect both the safety and desirability of the vehicle. As poor aerodynamics can lead to a vehicle that becomes un-steerable at high speeds due to front end lift taking weight off of the front tires reducing their contact patch, and traction with the road, and while a car may be safe, if poor

aerodynamics cause severe enough wind noise the driver may find it either incredibly annoying or even distracting.

Drag coefficient, written as CD is a measure of how efficiency a car can cut through the air, you multiply together CD and frontal area to get the total drag of a vehicle.

The average drag coefficient of a vehicle is around 0.24, however some modern electric vehicles are hitting even lower CD s “Not only is Lucid Air simply stunning, it’s also among the most aerodynamic cars in the world — with a 0.21 coefficient of drag.” (Lucid Motors, 11:15 23/04/2022 <https://www.lucidmotors.com/air/design>), Mercedes-Benz even has a road worthy concept car, the EQXX, with an impressive CD of 0.17, because of its incredibly low air resistance it is able to travel over 1000km on a single charge. Around double the range of a normal electric vehicle using a battery of the same capacity.

It achieved such a low coefficient of drag by having a very low smooth teardrop profile, and also removing as many radiators as possible, this was done by having the battery cooled by a metal plate slung under the vehicle.

Another vehicle where aerodynamics where a priority is the Aptera, this vehicle when put into production next year will be the most aerodynamic thing on the market with a CD of 0.13, to achieve such an incredibly low CD it has a radical design.



(Aptera, 11:40 23/04/2022, <https://aptera.us/reserve/>)

To get such a low CD they had to make some compromises, such as only having 3 wheels, and 2 seats. “Aptera’s undercarriage swoops like a dolphin’s belly. This reduces drag, or the force of air flowing against the motion of the vehicle. Aptera is curved at the nose, wide along the sides and tapered toward the trunk — like a small, speedy aircraft.” (Aptera, 11:40 23/04/2022, <https://aptera.us/vehicle/>) The small pointy front end of the vehicle helps it cut cleanly through the air, while the curved underside provides a smooth unrestricted path for air to flow around the vehicle, instead of forcing it either forcing it through a restrictive radiator, or up and around the sides like in a traditional car. Another way they have reduced aerodynamic drag is by covering all the wheels. Spinning wheels create a lot of turbulence, especially if they have many spokes as these stir up the air, this is why more efficient wheels either have large flat spokes, or no spokes at all, as this lets the air more easily slip past without getting caught up in the wheels.

Bibliography

- Aptera. 2022. *Reserve Aptera*. [online] Available at: <<https://aptera.us/reserve/>> [Accessed 23 April 2022].
- Aptera. 2022. *Vehicle | Aptera*. [online] Available at: <<https://aptera.us/vehicle/>> [Accessed 23 April 2022].
- Bugatti. 2022. *Bugatti - World premiere: brake caliper from 3-D printer*. [online] Available at: <<https://www.bugatti.com/media/news/2018/world-premiere-brake-caliper-from-3-d-printer>> [Accessed 23 April 2022].
- Czinger, K., 2022. *Czinger*. [online] Czinger.com. Available at: <<https://www.czinger.com/dominating-performance>> [Accessed 23 April 2022].
- Doll, S., 2022. *How much does a Tesla weigh? Comparing each model*. [online] Electrek. Available at: <<https://electrek.co/2021/08/02/how-much-does-a-tesla-weigh-comparing-each-model/#h-model-s>> [Accessed 23 April 2022].
- Lucidmotors.com. 2022. *Lucid Air | Design*. [online] Available at: <<https://www.lucidmotors.com/air/design>> [Accessed 23 April 2022].
- Mercedes-Benz. 2022. *VISION EQXX – taking electric range and efficiency to an entirely new level*. [online] Available at: <<https://media.mbusa.com/releases/release-211879a94f6a1a0ff764674cdc0a8630-vision-eqxx-taking-electric-range-and-efficiency-to-an-entirely-new-level>> [Accessed 23 April 2022].
- Youtube.com. 2022. *1930`s Crashtest Citroen Traction Avant , push it down a cliff and drive away.*. [online] Available at: <<https://www.youtube.com/watch?v=CPDJHs0aylY>> [Accessed 23 April 2022].