

**VEHICLE
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**VEHICLE
STRUCTURE
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HOW DOES A STEEL MONOCOQUE CHASSIS COMPARE TO A GENERATIVE DESIGNED CHASSIS

When making a car, the chassis is a crucial part that contains the driver and usually is the main structure of the car, and at the design stage, the engineers have a lot of options in how to make their chassis. In this report, I am going to be comparing two different methods to see what the advantages and disadvantages are to the different types. The first is the Steel Monocoque, the most used type in the car industry with 99% of cars using one[1]. The second is Generative Design, a new technology that seems to be the future.

Steel Monocoques are the most popular method of making a car in this day and age. This is down to the fact they are very strong due to the amount of metal that goes into making them, unlike other chassis methods that can be a mixture of materials, of course, this means that the structure is extremely heavy. They are also good for crash protection as after many years of being the go-to for a production car they have been developed to be extremely efficient in dispersing energy. On top of that, they are also space-efficient which makes them perfect for large modern cars where making the most of every inch is important. However, the biggest reason for them being so popular for mass production is their low cost.

Generative Design is a relatively new concept where a CAD program on a computer can design the car for you. It doesn't have to be a car or chassis it can be anything, down to a small clip that connects two parts together, all the way up to the structure of a skyscraper, this is of course only if you have the printer to print it. To design it you simply need the software and then enter in the amount of strain the piece has to be under and add in parts like holes for screws and opening and then the software will generate it for you. In terms of car chassis', it has huge potential to become the new leader in manufacturing for the future. Because of the natural like form, it makes the structures are very strong, in fact, the strongest it can be while saving as much weight as possible. Because of it being so lightweight it makes it attractive for car design as the aim is to always make the car more efficient and faster for sports cars.

To compare the two methods, looking at manufacturing is a good way to gauge an understanding of which has more advantages. Starting with the Steel Monocoque, it is very time-consuming to

design as it takes a whole team of CAD modellers to create the full structure and make sure it can withstand the massive forces it is required to. This is costly, whereas Generative Design can be done by the computer with only a few inputs. However, it is extremely cheap to manufacture due to its easy assembly once you have the right machinery. Sheets of metal are pressed and then welded together and when this is done on a production line with robots performing the tasks the process can take very little time. This however, doesn't work for smaller runs of production as the expensive machinery doesn't pay itself off and the company may not be able to afford this in the first place.



For Generative Design the process of designing is fairly cheap and simple and requires very little from engineers or designers, the program usually gives many options for the chassis which also gives you the option to choose what you want to go with. For the making of the chassis, it can be done in a number of ways, 3D printing is a popular solution but requires a very large printer. CNC Milling is another option. The production of Generative Designs is fairly similar to the manufacturing of the Steel Monocoque as they both require little manpower if you have the right machinery, however for the time it takes to manufacture, Steel Monocoques definitely come out on top as they can be done very quickly but 3D printing or Milling takes a long time at this stage. I'm sure technologies will improve to speed this up but at the moment it's not there.

On the other hand, for one-offs or small productions, generative design works fairly well as the parts can be outsourced by companies with the right machines. This may be expensive but all low production models are, and it's certainly cheaper than the manufacturing process of the Steel Monocoque. Although the making process may be expensive when using Generative Design, the software has built-in simulation and testing for safety which mean that the model will automatically adhere to the regulations saving vast amounts of time and money[2]. Of course, if you look at this the other way it also takes away jobs, which can be good for the employer but bad for the engineers as their job becomes unnecessary.

Another way to assess the chassis is by looking at how they perform in crash tests. Starting with the Steel Monocoque, it is very efficient in a crash, it is able to distribute the load and forces in the event of a crash to other areas of the chassis like the A-pillars for example. The chassis is not very rigid which works for the crash structure. The fact that it is all made from metal helps in this strength but also hinders it, as the car is a lot heavier, which is one of the issues that generative design deals with really well. Because the software is made to make the chassis as strong as possible while using the least amount of material, it's good at making lightweight components.



The Steel Monocoque is also very efficient in its space. Being made of a strong heavy metal means it needs less structure than a chassis that uses a weaker metal. This leaves more space for the passengers and more space to mount anything that needs to go in the car. Generative Design has the luxury of just entering the size needed for the passenger compartment and it will design the structure around it, a problem however with the structure is that it looks a bit peculiar but that is down to taste. If you want to cover up the bone-like structure then that will cost more weight and money, whereas for the Monocoque it can be left exposed, as it is in many cars for the pillars.



To conclude, Steel Monocoques are the perfect solution for cars at this stage, if it is going to be mass-produced it is a cost-effective safe way to do so. But once technology improves, I can see Generative Design becoming a big competitor as it does save vast costs in other areas while also being safer as it is all done by a computer.

[1] Paul morrow / 2017 / chassis strength analysis

[2] Aditi / August 10, 2020 / Advantages & Disadvantages of Generative Design / www.infurnia.com / Infurnia Technologies Pvt Ltd

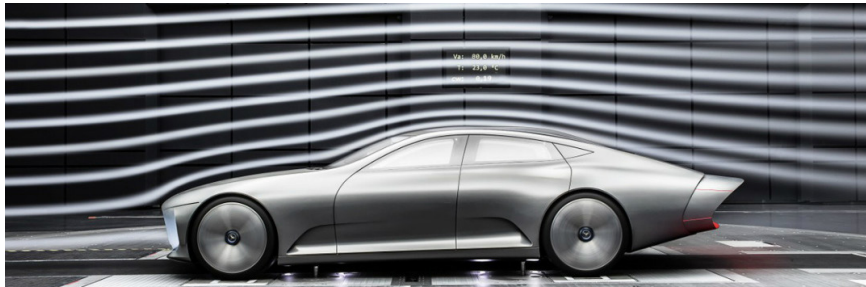
HOW DOES AERODYNAMICS AFFECT PERFORMANCE IN CARS

In the engineering and design of cars, aerodynamics is one of the most important aspects. The stability of the car is largely down to how the airflow is managed over the car and this is even more prominent at high speed. The forces that act on the car can be exaggerated or minimised due to the shape of the vehicle. Lift is a main factor that can cause instability in the car, it is measured by a coefficient or C_l , but it is usually divided into front and rear, the front being C_{lf} and rear being C_{lr} , they are usually somewhere between 0.600 - 0.000. Depending on the vehicle you are designing this number is best to be as low as possible and if the car is made for performance, then downforce is what's needed.

Downforce is used in high-performance vehicles to keep them planted to the track however it is also used in normal cars to make them more stable and safer at higher speeds. The coefficient when you use downforce will be in the minus figures so -0.100 for example[1]. Downforce can also be used in different ways for instance ground effect. This is only seen on really high-performance race cars like in formula 1 as it needs to have a super low ride height as well as very stiff suspension for it to be effective, which is not practical for cars on the road. It works by sucking in the air underneath the car and then narrowing the gap to the ground, compressing the air before it shoots it back out, this creates a lower pressure bubble sucking the car to the track. This is all achieved by very sculptural floors on these vehicles.

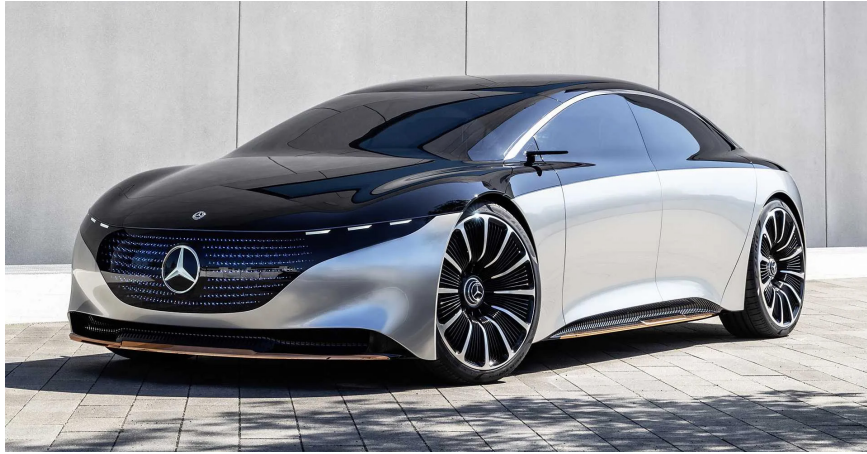


Another way engineers create downforce for road cars is by using spoilers. When cars start to build up speed, they start to generate lift which as I've mentioned leads to instability, by adding a wing to the back of the car, you can counter this with downforce pushing the rear of the car into the road. An example of this is the Audi TT 1998, the car was released to the public with its sleek form, but problems quickly started to show with the car at high speed. Audi recalled 40,000 models to fit them with small lip spoilers and to adjust the suspension to make the car more willing to understeer rather than oversteer. This is a great example of how minor changes can make big differences[2]. Lots of more sports-oriented cars use active aero spoilers nowadays, this is where the wing can deploy at a certain speed and retract when then the car is slowing down. This is done to not take away from the aesthetic that the designers have tried to create, but it can also be done to act as an air brake. When the car is travelling at high speed and starts to apply the brakes the wing can tilt to a much steeper angle creating drag and helping slow the car down.



Wind tunnels are a great tool for engineers developing a vehicle as it is a way for them to gauge an understanding of the forces and wind resistance that will be on the car when it's out on the roads. There are two types of wind tunnels, closed and open. Closed is a massive cylinder in one big loop circling the air around and open is a large cylinder in a straight line that intakes air and then defuses it out the other end. The forces that act on the car are, roll which is where the car rocks side to side, usually due to cornering. Yaw where the car turns, this can be helped by a boat-tail backend. Pitch, this is where the car rocks back to front usually caused by braking or accelerating[3]. Finally, drag which is really what they are testing in the wind tunnels as it is caused by wind resistance. When designing a car, you want as little wind resistance as possible as the worse it is the less efficient is on fuel and of course top speed.

Drag or wind resistance is caused by the frontal area of the vehicle and can be displayed as the drag coefficient or C_d , aerodynamic drag is usually anywhere between 0.600 – 0.200[4]. You want this number to be as low as possible because that means the car is slippery through the air. The way to make the car as flowing as possible is through the body shape so smoothing off areas of the car and taking off any parts that stick out. A great example of this is the new electric cars that are now hitting the market. All of them are going for the absolute lowest C_d value they can to get the most mileage out of their electric motors. Lots of them have cameras for wing mirrors and flat undertrays to reduce turbulent air around the vehicle creating more unnecessary drag. Some cars are even going to the extent of having wheel covers to make the car just glide through the air.



As fuel has become a major problem for us and electric seems to be the way forward I think aerodynamics are only going to become more important, and I'm sure it won't be long until there are many more ways to make cars more efficient, like the smooth, grill-less frontends of electric cars.

[1] Paul Morrow / Automotive Aerodynamics / <https://moodle.uwtsd.ac.uk/course/view.php?id=8730> / slide 073

[2] Paul Morrow / Automotive Aerodynamics / <https://moodle.uwtsd.ac.uk/course/view.php?id=8730> / page 39

[3] Prof.Boffin / Jul 3, 2021 / Roll Pitch and Yaw | Auto Aspects | Basic Vehicle Dynamics terms #4 / <https://www.youtube.com/watch?v=1GEQwWGUEBI>

[4] Paul Morrow / Automotive Aerodynamics / <https://moodle.uwtsd.ac.uk/course/view.php?id=8730> / slide 073