



ACHA4004-2 Vehicle Structure & Aero

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Q1) The Pros and Cons of both Steel Monocoque and Generative Design Chassis/Body Structures:

The most common chassis used by vehicle manufacturers today is the Steel Monocoque. Several pressed metal pieces are spot welded together to create a strong one-piece structure perfect for mass and automated production methods. Generative design is an Artificial Intelligence (AI) software in which the requirements of a component are entered, and the software produces many different design options that could be suitable and match the entered requirements and parameters. Steel Monocoque is currently the chassis structure type that 99% of car manufacturers produce (Morrow, 2017). However, Generative Design is rapidly developing and could quickly overtake popularity with mass producers. In this report, I am going to analyse the pros and cons of both techniques and evaluate what the most common technique is likely to be in the future.

The Steel Monocoque is currently the most popular chassis structure due to its suitability for automated and mass production (Morrow, 2017). The chassis is produced by pressing several metal parts and then spot welding them together (usually using automated robotic arms) The production of the entire chassis can take a matter of minutes and as a result, the structures are extremely cost-effective to make, which is obviously a benefit to manufacturers when they are producing such high quantities. In addition, the structure of the chassis is designed to be incorporated into the body (as shown in Figure 1) – resulting in fewer parts and even further less expense to the manufacturer and even the consumer.



Figure 1

(Unknown, 2022)

The incorporation of the body into the chassis has even further benefits. The lack of necessity for joints between bodywork and panels allows the structure to be much more spacious and even have the crumple zones built into the entire structure which consequently will distribute the forces more effectively in the event of a collision than other chassis structures would.

Despite the many benefits to the Steel Monocoque Chassis, there are many drawbacks that some manufacturing companies look past to focus on the lowest cost production possible. The structure is heavy because of the excess material and as a result, the final product (the vehicle) could not be as efficient and sustainable as it could be. This is obviously a drawback from an environmental standpoint as the greater mass of the vehicle the greater force required to move it, which as a result means that more fuel will have to be used, producing more emissions. There are other chassis manufacturing methods that are lighter and as a result more sustainable. In addition to this having an environmental impact, the greater mass also affects the consumer both by making the product more expensive to run and in some circumstances making it more difficult to drive due to its heavy mass. Another con associated with Steel Monocoque chassis is the strength, pressed metal isn't as strong as other manufacturing methods, and as well as that the focus of the shell is usually space efficiency, not strength. Eventually, these two factors pose a potential risk to the consumer and any passengers on board the vehicle in the event of an accident.

However, despite this, there is a reason that almost all manufacturers use this technique as evidently the pros outweigh the cons. However, as technology advances could another technique take the place of the Steel Monocoque?

Generative design is a design technique that uses artificial intelligence (AI) to solve design problems and come up with a solution inside defined parameters. The way it works is for designers and engineers to enter the parameters that a component needs to fulfill, such as stress, forces in given directions, and structure. The AI then generates up to hundreds of different possible outcomes which can be chosen by the design team (Morrow, 2017). Once a design is selected, the part can be made by one of a few methods. Milling and 3d printing are two of the possibilities.

The AI software is beneficial because it introduces a new "creative eye" (Advantages & Disadvantages of Generative Design, 2022). The software thinks in a way that form follows function (Morrow, 2017) and as a result, the designs that the software comes up with can be organic and bizarre looking. However, this can be seen as both a benefit and a drawback. The organic and abnormal design can be seen as revolutionary but on the other hand, are we ready for such a radical difference in the way vehicles look?

AI is arguably more intelligent than the human mind, it can deal with more parameters than a human design team which consequently accelerates the design process and gets a result more quickly – evidently saving money for the manufacturing process. In addition to this, the process is excellent for weight saving. This means that the vehicle will have greater performance than alternative chassis methods as the chassis will essentially weigh less whilst still maintaining a strong structure and impact resistance. In addition, the reduction of weight will also mean fewer emissions. This is because the heavier a vehicle, the greater power needed to move it and the greater power results in more fuel being consumed in one way or another. Essentially, the reduced weight can have a positive impact on the environment – and in an era when the environment is in such a dangerous place, could this be an essential factor?



However, a product that is created also must be accepted and chosen by consumers. There is no debate that Generative Design creates abnormal and strange-looking solutions to design problems, and it raises the concerns that humans aren't ready to transport in vehicles that look so organic and have such an alien appearance. Ultimately if this method of chassis production was to be put into use on a larger scale, it would take a long time for society to adapt to this being normal and essentially this means that the likelihood is that if a manufacturer was to create a vehicle with the use of Generative Design, it wouldn't be very popular. Perhaps the solution is to make the chassis in a way that it is entirely covered by bodywork and isn't integrated into the body like that of Monocoque. However, this then increases the number of parts and design stages essentially increasing the cost. Further, in some ways the AI is too intelligent, having the potential to produce 100s of potential ideas. Consequently, this would take the design team a long time to sypher through the potential concepts.

In conclusion, both methods likely have their benefits and drawbacks. But there is a reason that 99% of manufacturers still use Steel Monocoque chassis despite the new technologies of AI. This shows that in the present, steel monocoque will remain widely used, but perhaps in the future, when society normalizes the new concept of Generative Design, we will see it dominate the design industry.

Q2) Aerodynamic importance and the effects of drag:

According to NASA, Aerodynamics is “the way air moves around things”. (What Is Aerodynamics?, 2022). Essentially, aerodynamics is the way wind flow creates forces and reacts with the surfaces and the bodies of mass moving through the air or that the air moves around. Evidently, this is an important area for designers and engineers to consider when creating anything that moves through that air and evidently is a large area of focus for the design of any type of vehicle. But what factors does aerodynamics affect; how can “aerodynamically efficiency” improve a vehicle?

According to All-Fit Automotive, the main 4 areas of performance that are improved by aerodynamics are as follows: Acceleration, Fuel Efficiency, Handling, and Speed. (5 Ways to Improve Automotive Aerodynamics - All-Fit Automotive, 2022). For each of these characteristics, I will analyse the reasoning aerodynamics affects said characteristics and how this ultimately affects the consumer.

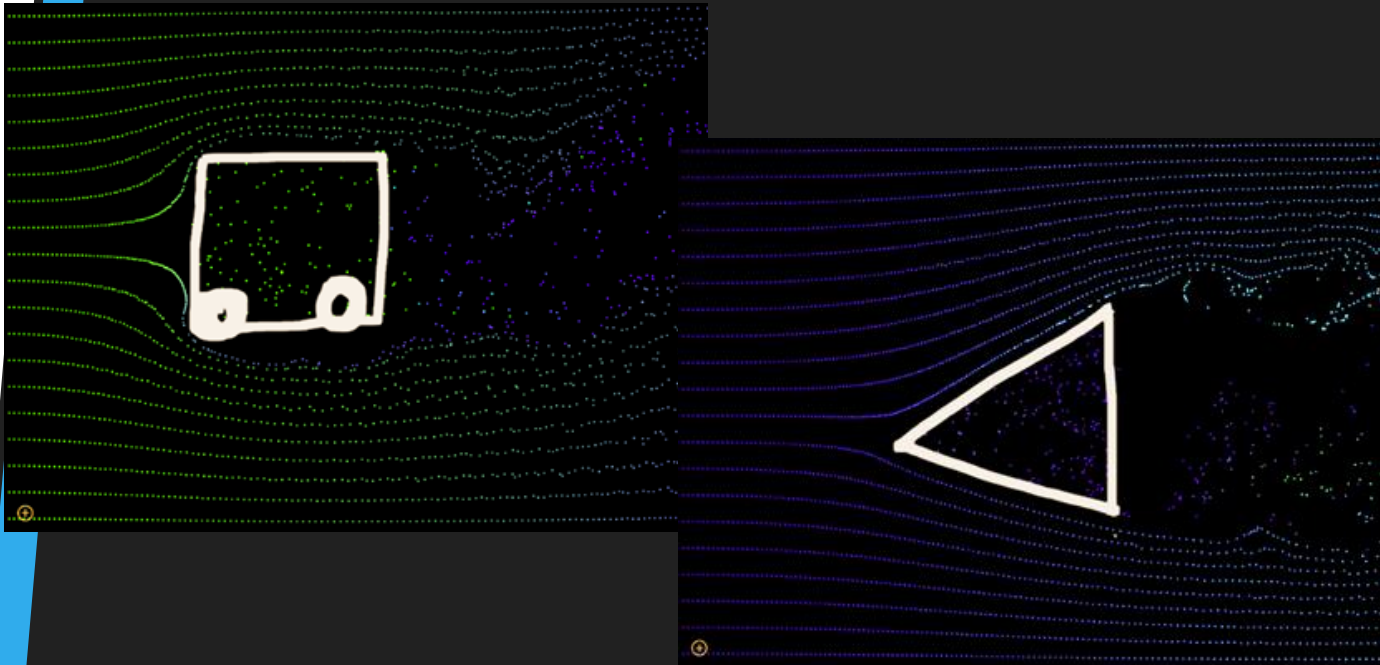
However firstly, a further understanding of the concept of aerodynamics and how the know research is applied to the design process.

When the concept of aerodynamics was introduced, it was found that the most effective aerodynamics was to essentially produce an almost wedge shape, with the assumption that this could slice through the air and as the research and technology was increased, the aerodynamics became more and more advanced and technical. This is made apparent when you compare a modern Formula 1 car to an older one. Formula One cars are arguably the paramount of engineering and aerodynamics as teams constantly push to research more efficiency to outdo their competitors.



The Formula One cars above are just 40 years apart in age, and the developments and understandings in aerodynamics is apparent. The 1980s McLaren (left) is a basic wedge shape with some more boxy sections such as the rear wing and side intakes, whereas the 2022 McLaren (right) doesn't have a single straight edge. It's clear that this extent of aerodynamic developments highlights the importance of aerodynamics and demonstrates how they influence performance.

But how do aerodynamics affect performance? Firstly, let's look at Acceleration, which is the rate velocity changes with time. An object (in this instance a vehicle) can produce a greater level of acceleration when it can cut through the air more effectively. The air pushing back against the surfaces and the body results in more power having to be produced to reach a specific speed, and essentially will increase the distance to reach that speed. When you think about a 0-60mph measurement, if a square and a triangle bodied vehicles both had identical powers, identical masses, and identical wheels and axel lengths. The triangle would reach 60mph in less distance due to the reduced air resistance as it essentially slices through the air.



These wind tunnel simulations from the iPad App “Wind Tunnel Free” (published by Algorizk) highlight how the triangle performs better as the air is less disturbed as it hits the angled surface instead of the vertical surface of the square.

For the same reason, speed is another performance factor that can be massively affected by aero efficiency. With the air pushing against the body as little as possible, the body requires less energy or power to reach a higher speed. In addition, the faster a body is moving, the greater the pushing force (known as drag). With the drag minimized, the body can get to a higher and higher speed.

To summarise, effective aerodynamics essentially reduce the pushing force in the opposite direction to that in which a body is moving. The more this opposite force (drag) is reduced the less energy the body must produce to push through the air. Therefore, effective aerodynamics on a car will increase its fuel efficiency as the engine (or power unit) must push less to reach the same speed due to the opposite drag force being less.

As well as power advantages, effective aero can also improve the handling. Aerodynamicists manipulate the airflow as much as possible to create downforce (a force that pushes the vehicle into the ground to maximize friction). This is an example of where drag is utilized to the advantage of manufacturers as the force is directed in such a way it glues the car to the ground. This increase in grip results in a much more controllable vehicle that is essentially much easier to handle.

So consequently, drag can be both negative and positive (if it is manipulated effectively). But what factors affect drag and wind resistance. According to NASA, the 3 main factors are the object, the motion, and the air. (force?, 2022) The object's geometry, cross-sectional area, and size is an important factors. As mentioned previously, the object should slice through the air and any shape and geometry that doesn't have that tendency will essentially generate drag. The motion of the object and how the velocity of the air will interact with the object is another important factor. The object should be designed in such a way that the air is inclined to flow naturally with minimal disruption. These are factors that can somewhat be controlled, but the final factor is out of the designer and engineer's control. The air's mass of flow, viscosity, and compressibility are all factors that if not assessed will contribute to the drag. Although they cannot be altered, they can be evaluated and researched to optimize the object to prevent drag as much as possible in the environment that which it is intended to be used.

To conclude, aerodynamics is an enormous factor to consider and the constant war against drag is something that designers and engineers will constantly have to fight. But as the technology and research evolve, aerodynamic efficiency becomes greater and greater every day.

References

- All-Fit Automotive. 2022. *5 Ways to Improve Automotive Aerodynamics - All-Fit Automotive*. [online] Available at: <<https://allfitautomotive.com/blog/5-ways-to-improve-automotive-aerodynamics>> [Accessed 25 April 2022].
- Cdn-1.motorsport.com. 2008. [online] Available at: <https://cdn-1.motorsport.com/static/img/amp/4900000/4980000/4982000/4982700/4982738/s6_1010149/1010149.jpg> [Accessed 25 April 2022].
- Cdn-1.motorsport.com. 2022. [online] Available at: <<https://cdn-1.motorsport.com/images/amp/63vAPEEY/s1000/daniel-ricciardo-mclaren-mcl36.jpg>> [Accessed 25 April 2022].
- force?, W., 2022. *What factors effect the magnitude of the drag force?* | Socratic. [online] Socratic.org. Available at: <<https://socratic.org/questions/57375f9d11ef6b16c723b00a#:~:text=Explanation%3A,viscosity%2C%20mass%2C%20and%20compressibility.>> [Accessed 25 April 2022].
- Infurnia.com. 2022. *Advantages & Disadvantages of Generative Design*. [online] Available at: <<https://www.infurnia.com/blog/generative-design-pros-cons>> [Accessed 25 April 2022].
- Morrow, P., 2017. Chassis Strength Analysis.
- NASA. 2022. *What Is Aerodynamics?*. [online] Available at: <<https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-aerodynamics-k4.html>> [Accessed 25 April 2022].