

University of Wales Trinity Saint David
Wales Institute of Science and Art



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

AUDI R8 Technical Report

Oliver Wilson 2203893

Introduction to Automotive Engineering

Motorsport Engineering (BEng)

ACHA4009

Contents

Introduction	3
Impact of the topic.....	4
Topic 1- Material	4
Topic 2- Crash Structure.....	5
Topic 3- Aerodynamics.....	6
Topic 4- Emissions.....	7
Topic 5- Engine.....	8
Topic 6- Computational Simulation	9
Current state of industry.....	10
Conclusion.....	11
References	12

Introduction

This report will be looking at the AUDI R8. The launch of the first R8 was on the 30th September 2006, since then it has become a well-established member of the AUDI fleet.

From its introduction in 2006, the Audi R8 has gone through various upgrades and variations, which include the R8 Spyder and GT3 LMS. The R8 has also been the car of choice to compete in international GT racing for the past ten years, winning many titles and races.

The R8 is a favourite in many different simulator racing games, proving its performance in those games more often than not. For this reason, I will be investigating what makes this car so good, using the topics below to try and dissect the different aspects of the R8 to better understand its title winning performances.

Impact of the topic

Topic 1- Material

The Audi R8 platform is designed as a “Modular Sports-car System” or MSS for short, figure 1 shows the Body in white (BIW) for the Audi R8 Spyder, the LMS and coupe version have added roof support.

This BIW is also used as the shell for the Lamborghini Huracan. The body in white produces an aluminium body with carbon fibre being added after, to create some of the key interior features. Having a BIW reduces the amount of excess weight being put on the car as computer simulations can simulate the amount of stress expected to be put upon certain areas of the chassis, with this knowledge the manufacturer can work out where

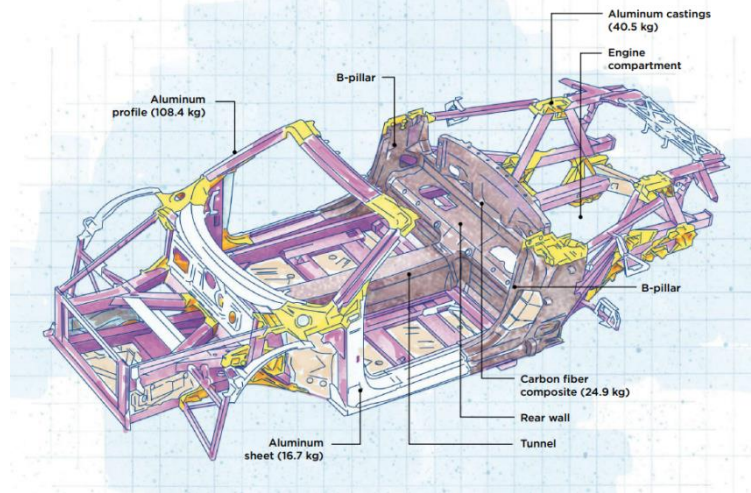


Figure 1-BIW structure (Sloan, Dec 2017)

they need extra support. For example, the B pillar of a R8 Spyder will require more support than the coupe version due to the reduced structural support over the roof. (Audi, 2022)

Aluminium is an ideal metal for use in automotive vehicles, especially in the case of a sports car due to its qualities such as non-corrosive and being highly malleable. Figure 2 shows a comparison of the 2 materials used in the BIW, the table helps with understanding why the materials are used in the specific areas chosen by the manufacturer. Carbon fibre is very rigid helping with stiffness and has a tensile strength of 1035MPa, but carbon fibre couldn't be used for the entire car as this strength is directional. The way in which carbon fibre is layered is what gives it its strength, by using it for the structure of the car it would be very weak and very expensive.

Measurement	Carbon Fiber	Aluminum	Carbon/Aluminum Comparison
Modulus of elasticity (E) GPa	70	68.9	100%
Tensile strength (σ) MPa	1035	450	230%
Density (ρ) g/cm ³	1.6	2.7	59%
Specific stiffness (E/ ρ)	43.8	25.6	171%
Specific tensile strength (σ/ρ)	647	166	389%

Figure 2-Carbon fibre/ Aluminium comparison (Research and Development Center, Algeria, 2022)

Topic 2- Crash Structure

The R8 crash structure is formed using aluminium extruding to form a shell such as the one in figure 3. By casting the shell of the car using this extruding method, the manufacturer can get precise consistent frames to use in production. From a safety perspective this also has major benefits. The designers can stress test the structure using CAD, allowing Audi to simulate how the structure will react when a collision occurs. The test results can allow the designer to deform certain sections of a car in particular directions to distribute more energy away from occupants in the cockpit. Audi have also designed the cockpit shell like what you would see in racing cars making the structure very rigid. (Audi MediaCentre, 2007)

The Audi R8 has no independent crash testing rating from Euro NCAP.

Figure 3 is colour coded to show different materials used throughout the structure of the shell helping visualise what different techniques and materials are being used to produce the platform. The structure will vary from version to version. For example, the coupe version can afford some weight saving on the B-Pillar as opposed to the Spyder variant, due to the roof being part of the support structure whereas on the Spyder the roof won't provide the same support due to its function.

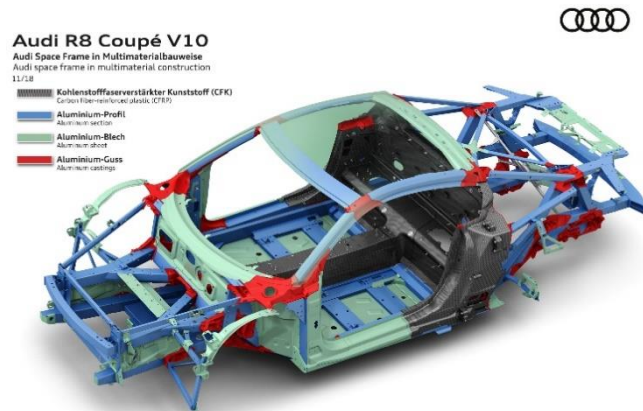


Figure 3- Audi R8 Shell (coupe) (Audi MediaCentre, 2007)

Topic 3- Aerodynamics

The aerodynamics of the Audi R8 is a critical aspect of the car, with different aerodynamic packages being used on different variations of the R8.

The intended purpose of the road cars, Quattro Coupe V10 and the GT3 LMS should be considered, as the road car variant will not require advanced aerodynamic bodywork to keep it stuck to the road. As a result, the big wings and low ride heights are not as essential and would benefit from a reduced downforce setup. The LMS R8 will need to have a greater amount of downforce that is balanced in a way that the driver can get the most out of the car and be adjusted to different setups. (Audi Media Centre, 2023)

Figure 4, shows the pressure distribution on the R8 LMS car with Red being high pressure areas where the air is hitting the car at a high velocity. The areas in Blue show the low air pressure where the air speed is lower than that around it. The low pressure under the floor that feeds the diffuser and the low pressure under the rear wing is producing the R8 downforce. The blue on the windshield is generating lift and engineers will try and reduce that area as much as possible.

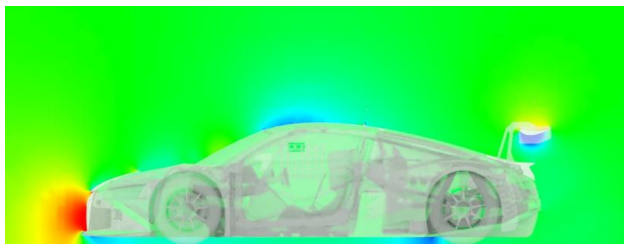


Figure 4-Audi R8 LMS Pressure distribution CFD (AirShaper, 2019)

Topic 4- Emissions

Since the launch of the R8 in 2006 the European emissions standards set by the EU have changed from Euro 4 to Euro 6 over the course of the past 17 years. The new legislation sets emission targets for vehicles currently in use for personal and commercial, with an emphasis on reducing tail pipe Co2 emissions.

The Audi R8 comes with a 4.2 litre high revving FSI v8 engine (Michael Dick, 2007) as the smallest engine model available with engine sizes going up to 5.2 litre. On average the R8 produces 308g/KM of Co2 (based on 80 models) with newer models such as a 2018 R8 Spyder producing 286g/KM (Car Emissions, 2023).

When compared to the euro 6 legislation of 1.0g/KG the car is almost 3 times the limit (RAC, 2023). There's been exemptions made by the European commission, where small, manufactured supercars such as McLaren, Lotus and Lamborghini have a free pass from the emission regulations. With the R8 being part of the Audi fleet but also being classed as a supercar, it would be interesting to see if the R8 will be classed as an exemption of the rules or will have to fall in line with the zero tail pipe policy for the fleet. (Taylor, 2023)

Topic 5- Engine



Figure 5- V10 engine (Audi of America, 2007)

have free reign on developing their engines, before this exemption was made Audi had plans for a smaller V6 engine that would improve the efficiency and reduce the emission output. This wasn't met well by customers and fans of the Audi and never made it past the drawing board.

The R8 engine comes in a variation of sizes. The smallest engine size being with the 1.6 2012 gt R8, with engine sizes topping out at 5.2 Litres with most of the variants sporting a 4.2 litre V10 engine. The V10 has a 90-degree V angled engine that provides the car with a lower centre of gravity, helping with stability and handling making it the ideal candidate for a sports car that can compete at high levels. The engine uses 10 cylinders to produce 350 Nm of torque and over 500 hp to either its RWD or all wheel drive setup depending on variant. (Audi Media Center, 2023) As touched on in the previous chapter the development of more fuel efficient engines doesn't apply to supercars due to the low production, meaning in terms of engine development Audi and other manufactures still

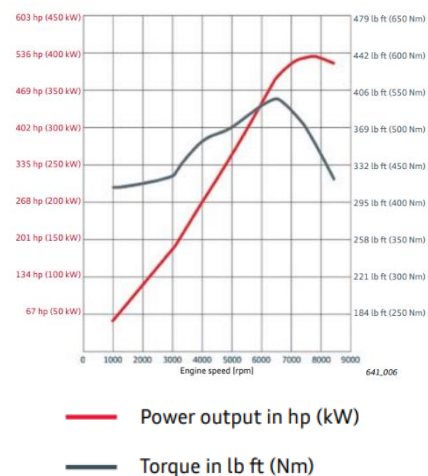


Figure 6-Torque/Horsepower (Audi of America, 2016)

Topic 6- Computational Simulation

Computational simulation has played a very important role over the past 30 years in developing the structure of the auto industry, the software includes CAD, CAE and CAM. As advancements in computer technology has increased the efficiency and power available companies can now create parts in CAD then using finite element analysis, simulate stress on a part such as load and heat, giving accurate results before manufacturing.

These methods save companies time and money by being able to rapidly prototype and design parts without having to physically make them. Audi uses these same methods to produce the Space frame for the R8, which has resulted in the structure being roughly 15% lighter and 40% more rigid than the predecessor according to Audi. This allows the R8 to be as lightweight as possible with the shell weighing in at 200kg.

CAM is used on nearly all components on the car. so engineers can test and optimise the designs efficiently without needing a physical test bed for experiments. New components will be tested when engineers have finished designing to see how accurate the simulations are and how much confidence they can have with the results before the components are mass produced for its intended purpose. (Audi Technolgy portal, 2015)

Current state of industry

The automotive industry has become under immense pressure by law makers to reduce the amount of emissions and pollution being generated by vehicles.

With ULEZ coming into place around cities and Co2 targets made by the European union which vary slightly depending on the country. The Automotive industry is under a lot of pressure to innovate and find greener alternatives to producing their fleet. Whilst the R8 may be exempt from these legislations. Audi will have to look into greener alternatives for their mass-produced cars, with the development of more efficient engines Audi would seek to implement these upgrades across its entire fleet to produce a more efficient and powerful way of propulsion.

Conclusion

In conclusion, the main threat to the R8 is changing emission laws. Audi R8 has been at the forefront of luxury supercars with components such as the shell and engine being used in other supercars such as the Lamborghini Huracan. Despite the big changes to legislation and public concern, becoming more aware of co2 contribution to global warming. The R8 and other supercars alike will have a free pass to keep developing large high-performance engines. This doesn't mean that legislators will change their minds in the future and pass new laws restricting the sizes of these engines, however Audi has a vast range of engines and variations with the new A8 being completely electric and numerous hybrid systems that are becoming more common place within Audis fleet.

When and if new laws come into place Audi will be in a strong position to fit the R8 with an engine that is more economical but will likely to face a power reduction consequently. In terms of the LMS race car the engine will be used unless regulation change states otherwise and will keep developing the overall package.

References

AirShaper, 2019. *2016 AUDI R8 LMS*, s.l.: AirShaper.

Audi Media Center, 2023. *Engine*. [Online]

Available at: <https://www.audi-mediacyenter.com/en/the-audi-r8-5-dot-2-fsi-quattro-2559/engine-2602>

[Accessed 16 April 2023].

Audi Media Centre, 2023. *Aerodynamics*. [Online]

Available at: <https://www.audi-mediacyenter.com/en/the-new-audi-r8-updated-dynamics-for-the-high-performance-sports-car-11734/aerodynamics-11742>

[Accessed 19 April 2023].

Audi MediaCentre, 2007. *The Body*. [Online]

Available at: <https://www.audi-mediacyenter.com/en/the-audi-r8-2621/the-body-2676>

[Accessed 10 April 2023].

Audi of America, 2007. *The 5.2L V10 FSI Engine Design and Function*. [Online]

Available at: https://vwcampersite.files.wordpress.com/2015/01/ssp_923603_5-2ll_v10_fsi_engine.pdf

[Accessed 16 April 2023].

Audi of America, 2016. *The 2017 Audi R8 Introduction*. [Online]

Available at: <https://static.nhtsa.gov/odi/tsbs/2016/MC-10119355-9999.pdf>

[Accessed 16 April 2023].

Audi Technolgy portal, 2015. *New Audi Space Frame*. [Online]

Available at: <https://www.audi-technology-portal.de/en/body/aluminium-bodies/new-audi-space-frame-with-high-proportions-of-aluminum-and-cfrp>

[Accessed 17 April 2023].

Audi, 2022. *Audi R8 LMS GT3*. [Online]

Available at: <https://www.audi.com/en/company/audi-sport/audi-racing-models/r8-lms-gt3.html#:~:text=With%20different%20versions%2C%20the%20R8,R8%20LMS%20GT3%20evo%20II.>

[Accessed 02 march 2023].

Car Emissions, 2023. *Audi R8 MPG (Fuel Consumption)*. [Online]

Available at: <https://car-emissions.com/cars/model/AUDI/R8/page:1>

[Accessed 13 April 2023].

Michael Dick, U. H. & D. I., 2007. *Motor sport technology for the road*, s.l.: ATZ worldwide.

RAC, 2023. *Euro 1 to Euro 6 guide*. [Online]

Available at: <https://www.rac.co.uk/drive/advice/emissions/euro-emissions-standards/>

[Accessed 13 April 2023].

Research and Development Center, Algeria, 2022. *Recent Advances on Smart Lightweight Carbon Fiber/Aluminum Hybrid Composite Structures*. [Online]

Available at: <https://www-igi-global-com.ezproxy.uwtsd.ac.uk/gateway/chapter/full-text-pdf/290152>

[Accessed 06 April 2023].

Sloan, J., Dec 2017. Audi R8 seat wall: A prelude to production. *CompositesWorld; Cincinnati*, Vol. 3(Iss. 12,), pp. 52-55.

Taylor, M., 2023. *Europe's Tough 2035 CO2 Laws Give Supercar Makers A Free Pass*. [Online] Available at: <https://www.forbes.com/sites/michaeltaylor/2023/02/16/europes-tough-2035-co2-laws-give-supercar-makers-a-free-pass/?sh=34c0ee8ab79b> [Accessed 14 April 2023].