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Technical Report

Introduction to Automotive Engineering (ACHA4009)

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1 Introduction

The Porsche 911 is considered by many to be one of the most recognisable and best sports cars ever produced. With the first iteration of the 911 being released in 1963 this car has gone through continuous development throughout its 8 generations all while keeping the same concept of a 2 door, 2+2, rear engine high performance sports car. Since it first rolled off the production line in Germany over a million 911s have been sold worldwide making it the most successful selling sports car in the world with 'dozens of technological firsts and 55 years of development and improvements and it is clear this is a special car' (D, 2021). The Porsche 911 is not just a road car but has also been modified by private teams and Porsche itself for racing, rallying and various other motorsport categories. A lot has changed even if the general silhouette and concept hasn't, making this one of the prime examples of technological advancement in the automotive industry.

1.1 Aims

- Provide insight into the development and evolution of the Porsche 911.
- Show how technology has evolved and the impact that it has had on the automotive industry.

1.2 Objective

- Show that the Porsche 911 fits into the current automotive industry.

2 Impact of the topics

The Porsche 911 has undergone a lot of development since it was first released, this is due in part to technological advancements and the creation of composite materials along with the further development of the internal combustion engine and a better understanding of aerodynamics and kinematics with the help of computers.

2.1 Materials

Porsche was always innovating the automotive industry with the materials used in the 911. The first generations were produced using steel as the main material for both the chassis and bodywork however steel causes corrosion issues and so 'Porsche responded to the issue of corrosion with emphatic success. The 911 was the first series production car to be given a body which was galvanized on both sides' (Stuttcars, 2021). Porsche started implementing the likes of aluminium body parts and alloy wheels to future generations of the 911 and as technology advanced, we saw the likes of carbon fibre and other composites along with more high-end materials appearing on these sports cars. The 993 generations sported an 'all-aluminium multilink rear suspension and an all-aluminium subframe' (D, 2021). This was the start of Porsche implementing aluminium into a wide range of components on the 911. The newest generations of the 911, the 992 has taken materials to the next step with the chassis and body being constructed of various lightweight materials 'such as high-strength steel, aluminium, magnesium, and carbon fibre-reinforced polymer.' (Porsche, 2023).

2.2 Manufacturing

When the 911 was introduced, Porsche changed its production methods from manually manufacturing its cars where the body was attached to the chassis and then welded to several points and then 'filled with soft foam (which was a very tedious and time-consuming process) and then sanded' (Vinatge Everyday , 2022) to making each structural unit separate and assembling them in advance before then welding the body shell in one piece to the chassis. After this Porsche opened a second production line when sales started taking off for the 911 G-series where the production line became more automated. 'The assembly was carried out on a stationary car, but at the end of each cycle, the cars moved automatically within the same production operation' (Vinatge Everyday , 2022).



Figure 1 - Porsche production line in the 1980s showing a large human involvement.

Porsche was always innovating its manufacturing technology, the new 992 generation is assembled on a production line involving a high level of automation. Porsche's production line has evolved from everything being hand made to now having multiple robots completing each task all while working simultaneously with humans. 'The 911 body, the front end, rear end and centre of the floor pan are first joined to the chassis; to this, robots add the front wheel arches together with the shock mounts and main chassis member' (Porsche, 2019).



Figure 2 - Porsche's new production line for the 992 generation, showing automation has become a main part of production lines.

2.3 Aerodynamics

The Porsche 911 can be recognized by its very distinctive shape, this has changed very little throughout all of its generations. However, as technology and aerodynamic knowledge advances Porsche started focusing on the aerodynamics of its car, this implementing rear spoilers, diffusers and now active aero on the newest 992 generation. The 996 was the first generation to offer a GT-

series car under the name of the GT3. This iteration of the 911 came with big aerodynamic advancements as Porsche started to focus on a more track orientated sports car, 'The GT3 built on the base 996's use of large plastic underbody panels to smooth airflow underneath the car' (Andropoulos, 2018). Porsche was known for developing technology and pushing the boundaries they proved this again with the 'the 996 GT3's rear wing being developed in the wind tunnel' (Andropoulos, 2018). Aerodynamic knowledge and advancements gained momentum in the 90s, Formula 1 were pushing the boundaries, and this then trickled down into other racing series that Porsche themselves competed in and then gathered information to implement into their GT-series cars. The next generations of the 911 saw more GT3 variants, some of these cars becoming track focused cars homologated for use on the road. The 997 saw the implementation of an adjustable rear wing 'to improve downforce for track use' (Andropoulos, 2018). The next big step in the GT3 line up came under the form of the latest 992 which pushes Porsche's aerodynamics to the next level with active aero. The rear wing adjusts automatically depending on different variants measured by onboard computers along with flaps under the car and ducks in the front bumper creating more or less downforce depending on cornering speed.

2.4 CAD/Simulations

With aerodynamics becoming a big part of their cars, Porsche relies heavily on computers and various software to help design their cars before producing prototypes. This can help the save time and money, as 3D models can be created and then used to run aerodynamic simulations. Computer Fluid Dynamics (CFD) plays a big part for most automotive constructors in producing more streamline cars and making them more fuel efficient. Porsche uses CFD to improve the aerodynamics and performance of the 911, the information found using CFD can then be verified in the wind tunnel and help to improve software and calculation accuracy. In the 1980s Porsche would use bits of string attached to the car to understand the way the air flows around the body whereas this can all be done in simulations now.

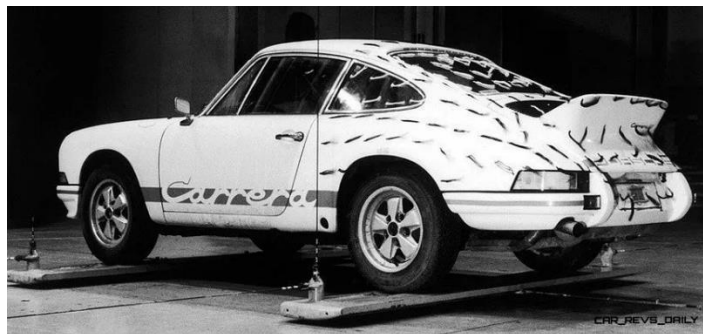


Figure 3 - Mid 1970s 911 in the wind tunnel

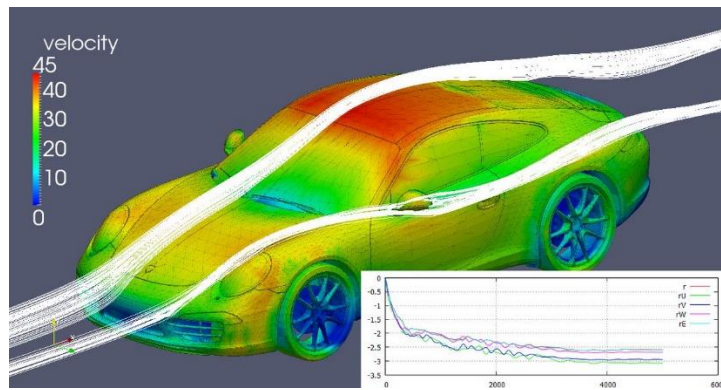


Figure 4 - CFD image of a 991 Porsche 911

2.5 Emissions

Emissions have become a big hurdle for manufacturers in the last few decades, as regulations get tighter cars must produce less CO₂ emissions. With Porsche having a bigger production of cars than other super car manufacturers they must produce less emissions than the likes of Ferrari or Lamborghini due to them producing less cars. 'An application for a derogation from the specific emissions target calculated in accordance with Annex I may be made by a manufacturer of fewer than 10 000 new passenger cars' (European Parliament and council, 2019). These restrictions have a big impact on sports cars as they chase performance all while being restricted on engine pollution. Porsche and other manufacturers find ways around these restrictions, one way they do this is to programme the car to produce lower emissions when it recognizes a driving pattern that matches the European Emissions test cycle. However, with these restrictions getting tighter Porsche must find other ways of bringing emissions down all while trying to increase performance with every new iteration of the 911.

2.6 Alternative fuels

To tackle these emissions restraints, Porsche is focusing on developing alternative fuels. They are starting to produce and test hydrogen powered engines, so far these tests have been very positive and are creating hope for the future of the internal combustion engine. They have developed a hydrogen powered internal combustion engine that 'matches the power and performance of a gasoline-fuelled 4.4L V-8 but reduces fuel consumption and has emissions close to ambient air.' (Kiley, 2023). This is becoming big news in understanding the future of internal combustion engines and shows once again that Porsche are market leaders in innovating their cars and changing the automotive industry. Porsche are not only working on hydrogen fuelled cars but are also looking into 'the production of a synthetic fuel that replaces gasoline' (Kiley, 2023). The potential in E-fuels is very big, there are more than 1 billion cars with an internal combustion engine on this planet and

Porsche's plan is to create a near CO2 neutral fuel that can be used in these vehicles. This could have a huge bearing on the future of the automotive industry and determine what happens with the development of electric cars and other green options for vehicles in the next decades.

3 Current state of the industry

The automotive industry is currently going through its biggest uncertainty ever, it is under huge pressure from an ecological point of view. The internal combustion engine is truly in the firing line as it has been proven that the emissions produced by this engine are causing various environmental issues. 'Given that transportation contributes to over one-third of global carbon dioxide emissions, switching from traditional fossil-fuelled vehicles to electric ones has become a key emissions reduction strategy' (Moore, 2022). The newest trend to hit the car market is Electric Vehicles, these cars have seen a huge increase in production and development in the last decade. EVs are thought to be the future, no emissions whilst driving but it needs to be considered that these vehicles require more electricity to be produced and need more precious materials to be mined to create the batteries. This has now become a big question in the industry on whether EVs are as green as they were initially thought to be. An all-electric future is starting to show that it might not be the most sustainable option. Porsches push to develop hydrogen engines and E-fuels could be a big decider on the future of cars as we know it.

Amongst all this, the Automotive industry supports a big number of industries around it, like metal works plants, component manufacturers and glass manufacturers. These industries account 'for 3% of the world's total GDP' (Moore, 2022). With the industry moving towards electric vehicles this could cause disruption in the market when it comes to the other industries working alongside car manufacturers.

This is all proof that the future of the automotive industry is still undecided, whether it is E-fuels, hydrogen, or electric there's still a long way to go on reducing the emissions of our vehicles.

4 Conclusion

The Porsche 911 has become a proven sports car throughout its generations, it has undergone a lot of development through technological advancements and has become a very established performance car within the industry. From developing the materials used to create the 911 or how it is made within the factories and tackling various hurdles including reducing the emission produced by the car. Porsche has had a big impact on what direction the automotive industry has taken on developing the car as we know it today. Whether it is the use of computer simulation, or the creation of automated production lines Porsche has developed production methods used by all car manufacturers today. The Porsche 911 is certainly not your average commuter car, it is certainly not in the average consumers price range however it allows Porsche to experiment and develop on this platform as the company is not seeking to keep costs down with this model. The future of the automotive industry is uncertain but Porsche's efforts to keep the internal combustion engine alive are proving to be very successful. This car has had a big impact on the industry and will hopefully help to decide the future of the car as we know it now.

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