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Introduction to Automotive Engineering

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1 Introduction

This report investigates the 2004 Renault Clio Mk2 Phase 2 and certain areas within the automotive industry. The reason the report is based on the Renault Clio is because it is a very well-known car. It offers great style, handling and safety features. Once the research has been completed, a conclusion will be stated regarding the impacts that the areas had on the vehicle.

1.1 Renault Clio

Renault released the first Renault Clio in 1990, this was aimed to replace the Renault 5. Since the 1990 Clio, there have been several modifications to ensure that Renault meets the legal safety and emissions regulations. There have been 5 generations of the Clio. Recently Renault has released a Clio hybrid version. The Clio had a large impact on the automotive industry because of its stylish design, heritage and advanced technology.



Figure 1 Above is an image of a 2004 Renault Clio. (Renault Clio Mk2 Ph2)

1.2 Aims

- To select a vehicle between the years 1990 – 2020 and research certain areas of the automotive industry.
- Discuss how the selected areas have impacted the Renault Clio Mk2 Phase 2 design and features.

1.3 Objectives

- To research and provide an in-depth understanding of the present state of the automotive industry.
- Research into; CAD, materials, crash testing, aerodynamics, engine performance and emissions.
- Discuss how each individual field was involved in the development of the Renault Clio.

2 Research into Automotive Industry Areas

2.1 Impact of the topics

In this report the areas that will be researched will show the impacts on development and design that were involved when producing the Renault Clio Mk2 Phase 2. CAD is heavily used in the automotive industry. The software used can calculate the strength of a component. As well as simulate the components in use and under load.

Materials will determine the longevity of the vehicle as well as its ability to absorb an impact. Additionally, when choosing a material the engineer should ensure its fit for purpose and have a long-life cycle.

Structural and damage testing legislations have come into force ensuring not only the driver is safe but pedestrians as well. The design of the vehicle must recognise these legislations to ensure the car is legal and safe.

Aerodynamics is a very important area of the development of a car. Aerodynamics affects the handling of the vehicle as well as the emissions it produces. Engineers must ensure that the vehicle has a minimal drag coefficient.

Engine performance needs to be considered when developing a car, it is key that the manufacturer provides the vehicle with enough power to match its intended use.

Emissions are more pressing than ever because of the world's climate. Recently regulations have come into place to ensure manufacturers lower their emissions. This affects the type of powertrains that are used in today's vehicles.

2.2 Computer Aided Design (CAD)

CAD is used throughout the automotive and motorsport industry to design components and vehicles. The software has replaced standard engineering drawings. Additionally, CAD is able to execute tests and find the strengths and weaknesses of a designed component. CAD allows the designer to edit the drawing at any point to make fine adjustments. Furthermore, CAD is able to carry out computational fluid dynamics (CFD). This analyses the flow of liquids or gases around the vehicle.

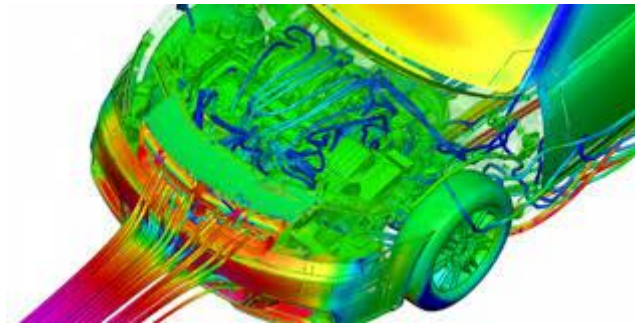


Figure 2 Above shows CFD being used to see how effective the aerodynamics are on the selected model. (McClintock, 2020)

CAD can be very complex, which means that users will have to be trained to understand all the tools within the software.

CAD is the standard, it is used to prototype and test potential components on cars. The software can calculate and predict stress points within components. As well as simulate the components in use and under load. This helps develop and produce prototypes that may later reach the final stages of design. CAD decreases costs in producing prototypes and increases chance of prototype success, additionally, it is more economical and efficient than producing engineering hand drawings because of this CAD has helped produce the Clio and many cars like it.

2.3 Materials

It is very important when producing a vehicle to choose the correct materials and the manufacturing processes used for each material. Currently, cars typically consist mainly of aluminum and plastic, these are cheap materials that require very little surface coatings to protect.

When selecting materials it is important to consider; tensile strength (UTS), strain, stress and young's modulus. Tensile strength refers to the amount of stress that can be applied to the material without fracturing. On the other hand, Strain is related to the length of the material divided by the original length. Stress is linked to external forces being divided by the cross-section of the original material.

Aluminum is lightweight and strong (good strength-to-weight ratio). It is an abundant, easily recyclable material making it a cheap material compared to steel. The chassis of the car is aluminum which is bonded using a strong adhesive.

The body of the Clio consists mostly of plastic. The body work is manufactured using a plastic injection moulding process. It involves placing plastic pellets into a hopper with a lead screw that forces the material through a series of nozzles into the mould. The lead screw chamber heats the plastic pellets to make the plastic molten. A large number of plastic components on the Clio are manufactured using this process.

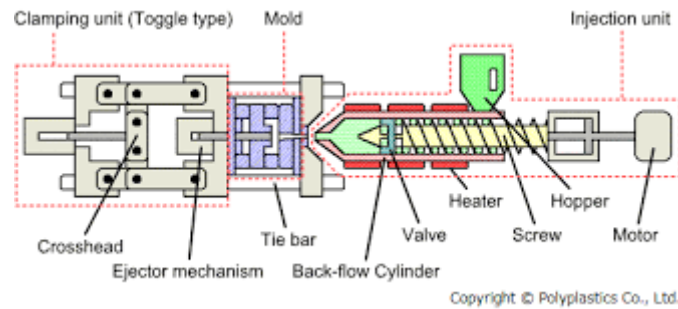


Figure 3 above is a diagram of an injection moulding machine. (Injection Moulding Machine Diagram)

2.4 Structural and Damage testing

Over years regulations have been put in place to ensure the safety of the drivers and pedestrians.

The Renault Clio model has completed the test by European New Car Assessment Programme (EURO NCAP). This is an organisation that carries out a series of tests to prove a vehicle is safe to be used on the road. The Renault Clio received a 4-star safety rating. (EURO NCAP, 2000)

2.4.1 Front Impact Test

There are a series of scenarios that are carried out to ensure that the car is safe to be used on the road. One of these is a front impact test. When carrying out the test the front airbags deployed offering protection for the occupant's chests and heads.



Figure 4 Above is an image of the Renault Clio carrying out a front impact test at NCAP. (NCAP)

In Figure 4 you can see that there are several datum points placed over the car. These datum points are yellow and black. Several cameras are placed around the surrounding area to capture the test and be analysed.

Aluminum has a good strength-to-weight ratio however it is considered soft. The automotive industry uses aluminium to absorb impacts. Typically today crash structures consist of aluminium. Renault have used the same system on the Clio.

2.4.2 Side Impact Test

Another test that is carried out is a side impact test. The occupant's head and chest were protected, this was completed when the curtain and side airbags deployed. The Clio offers airbags in the seats as well to provide more protection, this would have increased the score allowing for full marks in this test.

Overall, the Renault Clio completed the test with EURO NCAP and passed with a safety rating of 4 stars. (EURO NCAP , 2000) This shows that the Renault Clio is safe to drive and in an event of a crash provides the necessary protection for all occupants inside the car. Due to the nature of the Clio's shape, it provides good protection from an adult occupant's head in an event of a collision.

2.5 Aerodynamics

Aerodynamics plays a large role in the performance of a vehicle. The Renault Clio is known for its smooth curves and body line. This design reduces drag and therefore increases fuel efficiency. Drag coefficient is used to determine the resistance of a vehicle moving through fluid. All fluids will resist the object passing through it with the force which acts opposite to the motion of the vehicle. The drag produced by the car is the surrounding air, this air pushes against the car when the car is moving. The effects of drag are felt at higher speeds so this means that the drag coefficient must be reduced as much as possible. If the vehicle has a high drag coefficient it affects the control of the car and decreases fuel efficiency. (Patrascu, What Is the Car Drag Coefficient , 2018)

Calculating the drag coefficient involves the vehicle's speed, density of air and the surface of the car. When designing a car, it is important not to completely eradicate drag as this can produce too much lift which consequently produces bad handling qualities. (Patrascu, What Is the Car Drag Coefficient , 2018)

$$C_d = \frac{D}{\rho V^2 A / 2}$$

Coefficient C_d contains all the complex dependencies and is usually determined experimentally.

Choice of reference area A affects the value of C_d .

Figure 5 above shows the formula for drag coefficient. (Benson, 2021)

A general production car has the drag coefficient of 0.2-0.3. The Clio's drag coefficient is 0.35 as you can see this is considered an above average drag coefficient. The Clio has good aerodynamic design that allows it to have good fuel economy whilst having a 5-star safety rating. (Patrascu, What Is the Car Drag Coefficient , 2018)

2.6 Engine and performance

Renault fitted a variety of engines, including the 1.2 litre, 1.4 litre, 1.6 litre and 2.0-litre engines.

Renault offered 16-valve engines paired with 5 speed manuals or a four-speed automatic transmission. When the 3rd generation (2004) Clio's were released, they provided great fuel economy as the 1.2-liter engine provided 45 miles per gallon (mpg).



Figure 6 Above is a section view of the 1.2 Litre 16 valve Renault engine. (Renault, 2014)

The 1.2 litre 16 valve petrol engine was produced between the years 1998-2006 (9 years) It was used in the 2nd and 3rd generations of the Clio hatchback. The Renault D4F engine was a four-spark ignition, 4 stroke petrol engine with indirect injection. It was naturally aspirated with four valves per cylinder. With these features, the engine produced 75hp with 105 Newton Metres (Nm) of torque. (Zal, Renault Clio 1.2 Specification , 2010)

2.7 Emissions

New regulations have come into force for manufacturers which requires them to provide an average fleet emission value. This value needs to be met otherwise manufacturers are in breach of the emission regulations. This is why all manufactures produce petrol, diesel, hybrid and full electric cars. By producing the electric cars which don't produce any emissions this will lower the emissions average for the manufactures. This is similar with hybrids. Renault provides multiple generations of Clio's with various types of drivetrains.

Model	Engine	Fuel Type	CO2 Output	Fuel Consumption (Miles per gallon)
2004 Renault Clio	1.2L DF4	Petrol	171.0 g/km	45 mpg
2006 Renault Clio	1.5L dCi	Diesel	122 g/km	61.4 mpg
Renault Clio E-Tech Hybrid	1.6L	Petrol	98 g/km	65.69 mpg

Table 1 The table above contains emissions data on different generations of Clio.

(Renault Clio 2004 (Fuel Consumption), 2023) (Renault Clio 2006 (Fuel Consumption), 2023) (Renault Clio V Ph1 E-Tech, n.d.)

As you can see by the data provided in the table above, Renault has decreased their carbon outputs by producing more economical engines and introducing new technologies such as e-tech. the 2004 Clio today is still considered an economical car due to it miles per gallon score. The Clio is considered to have good power for a hatchback and rivals its competitors with power and economy.

3 Current state of the industry

The automotive industry is a very large industry which plays a vital part in the global economy.

Automotive manufacturers are responsible for producing, developing, designing and sales of vehicles. Since the start to the present, the automotive industry has grown and evolved, this is because of the technology and increased clientele however regulations do limit the manufacturers, but this ensures that the vehicles on the road are safe.

The future is not internal combustion, manufacturers need to invest and increase the research and development that is going into sustainable fuels. Synthetic fuel is a field that is ever-growing and can help humanity's effort to attain the vehicles that are in use today.

4 Conclusion

Overall, the report demonstrated that research was conducted in all 6 areas of the automotive industry. The impact was stated at the end of each area. The Renault Clio is considered an economical car to today's standard however the CO₂ output is large compared to the latest hatchbacks. CAD has allowed Renault to test and develop prototypes to ensure that it is a safe car. The materials used in producing the car were resourceful. If the car was to get damaged, parts are easy to source and cheap due to the materials used. It offers a good drag coefficient that allows for good handling in all driving conditions. The engine fitted provides good power for a lightweight car with good torque and allows for the Clio to carry out its intended use.

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