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AERODYNAMICS

The evolution in f1

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Introduction

The following assignment will aim to discuss key developments within motorsport aerodynamics. This will have a particular focus on formula one and will address some of the pivotal developments, characters behind those developments and how they impacted on motorsport. Beginning with motorsport in the 1894 and concluding with the most recent developments it aims to include areas such as ground effect and ride height, characters including Colin Chapman, Gordon Murray, and Adrian Newey and how they directly impacted the development of motorsport aerodynamics. As well mentioning how these developments affected racing both in their own period, and since their inception, both directly, and indirectly, and covering how some of the innovations worked.

Motorsport first began with a 50 mile race from Paris to Rouen, the purpose of the race was to test reliability (Mercedes benz, 2022), and was won with an average speed of 10mph, during this time the cars were very basic, with very little thought given to aerodynamics, this remained the case until the 1920s with the tropfenwagen (teardrop car), being very much the start of what we now know as modern aerodynamics (Don Sherman, 2020). 1950 saw the beginning of the formula 1 world championship, and with it, varying aerodynamic designs, with many cars having open wheels, and only the Mercedes covering the wheels (Peter Higham, 2020). During this time cars were still very high, and blocky, with the turn of the 1960s it was discovered that inverse wings could allow cars to stick to the road better, by creating negative lift, or downforce, allowing the cars to slide less, and subsequently take corners faster. This came at the expense of increased drag as cars would have to move more air at the same speed.

In the 1970s the lead designer of Lotus, Colin Chapman pioneered the early iterations of ground effect introducing the lotus 78 (Doug Nye, 2020). Ground effect is important as it creates downforce by exploiting the venturi effect increasing under vehicle pressure, thus creating suction between the floor and the road, however unlike modern cars, the lotus 78 used sliding “skirts” to seal off the under floor from the rest of the air flow, maximising the air effect. As others discovered this affects both the ground effect had on corner speed and straight-line speed, as the cars could be run with much less wing angle to get the same amount of downforce, thus reducing drag (Matt Somerfield, 2017). The trend of ground effect evolved for 5 years, until the FIA mandated flat floors in 1982, with teams having to find ways to regain this loss in downforce.

The next major development, came from John Barnard in 1989, who replaced the conventional H-pattern manual gearbox with the paddle shift gearbox on Ferrari cars, this change eliminated the space required for a gear lever, allowing the cockpit to be made narrower, allowing for less drag and increase airflow to the rear of the car, increasing the efficiency of the rear wing and the diffuser (Coilin Higgins, 2022). This allowed the car to be able to be less draggy, due to reduced cockpit width. This allowed for a smaller nose as the car no longer required 3 pedals, as the clutch would be mounted on the steering wheel, the narrower nose allowed for better airflow to the underfloor, increasing the efficiency of devices such as the coke bottle region, as well as the “tea tray”, increasing the downforce.

In 1990 the Tyrrell 019, designed by Harvey Postlethwaite and Jean-Claude Migeot, took the effect of clearing the airflow to the front of the car to the next level by raising the nose

allowing direct access of the air to the car parts without being affected by the front wing allowing the tea tray to work harder, also increasing overall downforce benefitting more at low speed. The slight disadvantage of this being the weight being slightly higher, as the drivers' legs were higher than some of its rivals due to the space required for the clean air flow to reach the front of the "tea tray" which was longer due to the regulations at the time. The raised nose was not the only thing that assisted the Tyrrell as it had a form of active suspension, allowing the drivers to alter the nose by 2mm from "normal" allowing for more airflow to the underfloor, or more grip depending on corner demand.

The next development in aerodynamics was kept under the skin of the vehicle, with the FW14B of 1992 designed by Adrian Newey taking the idea of active suspension further than the Tyrrell, by changing each of the wheels in response to where the vehicle was on the circuit, this provided a consistent ride height to the vehicle (Craig Scarborough, 2021), as well as providing a more stable aero platform allowing drivers to have more confidence in the car allowing it to be driven harder. Active suspension allowed the cars stiffness to be controlled both the way the car moved over hills, crests and curb handling with a soft suspension on one combined with solid on the other for one corner which became opposing to suit the cornering needs (Craig Scarborough, 2021).

After the banning of active suspension, the need for a level aero platform was understood, as in 2005 Renault pioneered the tuned mass damper, which consisted of a 5-10 kg weight suspended in a spring, mounted in the nose cone of the car to dampen out the tyre bouncing frequency, a counter weight would move in the opposing direction to the body of the car, allowing the drivers to push harder into corners reportedly giving them more confidence in the car (Edd Straw, 2021), and that it would stick when the car got into the mid corner, this was refined in 2006 when a similar system was fitted in the rear of the car, meaning that the bouncing was evened out throughout the vehicle.

During the 2010 season the Adrian Newey designed RB6 featured a lower than usual exhaust exit done in order to increase the pressure of the gasses flowing over the diffuser increasing the pressure by drawing airflow from underneath, increasing downforce at the rear of the vehicle (Matt Somerfield, 2020). This allowed for the sealing of the diffuser from the airflow of the rotating tire, meaning that the airflow coming off the rear wheels has a lesser effect on the rear diffuser, making the diffuser more effective. However, in order to get the most out of the blown diffuser, exhaust gasses needed to be expelled at high pressure from the engine, mid corner, requiring the engine to be at full throttle, despite cornering, requiring clever engine mapping to ensure that gasses were being expelled from the engine, without the torque so that drivers could control the vehicle, but not at a detriment of the downforce produced by the exhaust gasses flowing over the diffuser (Matt Somerfield, 2020).

Another innovation from the 2010 was the F-Duct, a rudimentary system that required covering a hole in the monocoque, diverting the airflow from a duct above the driver's knee, which lead into the cockpit. However, by covering the hole in the cockpit, this airflow would be diverted over the rear wing, stalling the rear wing, and cutting downforce, with the effect of reducing the drag over the rear wing, increasing the top speed (racecar engineering, 2022). Unfortunately, this was banned after one season as some teams modified their cars after the homologation period, using their hands requiring drivers to drive with one hand off the

steering wheel. This in addition to fears from the teams that more elaborate solutions would be developed, meant that it was unanimously voted to be banned for the 2011 season.

Another trend of recent years is the rake of f1 cars, this is where the rear of the car is much higher than the front of the car, done so that there is an area of low pressure under the floor, which increases the further along the car, thus increasing downforce as the car is sucked downwards (jake boxall-legge, 2021). This is maximised by sealing the underfloor airflow away from the outer airflow, frequently achieved with air vortices meaning that the air flow itself is used to prevent the low-pressure air from spilling out. While high rake cars are more stable into corners, they do come at the cost of a lower top speed due to increased drag due to the higher amounts of downforce (Jake boxall-legge, 2021).

Conclusion

In conclusion, aerodynamics in motorsport has not only evolved from just making cars faster in a straight line by reducing drag, in both terms of reducing the frontal area of the car, and the angles at which components such as the nose of the car sit, but also to adding wings and air flow “conditioners” to aid the vehicles cornering ability, thus meaning that the car can be faster around a corner, as well as on straights, with the extra caveat that a car may reduce stress on its tires by sliding less around a corner, something which is important in motorsport and on road going vehicles.

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