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Forced Induction and the
application into motorsport

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1 Introduction

Forced induction is a method of increasing the volumetric efficiency of an internal combustion engine; it does this by supplying the cylinder with air that is a higher pressure than atmospheric pressure. The two common types of forced induction are Turbocharging and Supercharging, both methods have their benefits and disadvantages. There is another form of forced induction that is Inertia Supercharging, but this method is primarily used on two stroke motorcycle engines. When a turbo is used on an internal combustion engine, there are ancillary components that must be used in order to maximise its effectiveness. One of the major components used is the charge air cooler or the intercooler 'An intercooler is a heat exchanger placed between the turbo and engine to remove heat from air exiting the turbo when operating under boost' (Bell, 1997).

1.1 Aims

The aim of this report is to inform the reader of the advantages and the disadvantages of the more common method of forced induction, the turbocharger, and the future implementation of such equipment.

1.2 Objectives

- Make the reader aware of the main advantages of using a turbo charger for an internal combustion engine over being naturally aspirated.
- To discuss the differences between the different methods of forced induction and why the turbo is becoming the more common option for motorsport teams and car manufacturers.
- To assess and evaluate the future impact of forced induction within the motorsport industry.

2 Types of forced induction and the application into motorsport

The two main types of forced induction are as follows, the belt fed supercharger and the turbo. 'A turbocharger is a supercharger driven by a turbine' (Bell, 1997). Both types of equipment essentially do the same thing albeit through different methods producing different levels of results and having different disadvantages. The Turbocharger uses the exhaust gasses from the engine and routes them through the turbine. 'A turbocharger consists of three essential parts: the turbine, the compressor, and the bearing system that supports the turbine shaft, connecting the compressor and turbine wheels together (Turbo Turbos, 2021). As the Turbocharger is powered by the spent exhaust gasses it has the capability to recover some of the thermal energy and convert it into kinetic energy, this therefore increases the engine's overall efficiency. All methods of forced induction can increase the volumetric efficiency of an engine past 100%. As volumetric efficiency is calculated as the density of the air/fuel mixture brought into the cylinder from the intake manifold at atmospheric pressure per two cycles of the piston. Forced induction has been used in previous generations of motorsport primarily due to their increase of power. The world's shifting attitude towards climate change means manufacturers are beginning to use turbocharging as a way of meeting the expected emissions targets set by the FIA and are now used as a relatively cost-effective way of increasing engine power and efficiency for the internal combustion engine.

2.1 The history of turbochargers and their importance in current and upcoming generations of motorsport

Forced induction has long been a part of the automotive and motorsport industries, first appearing in aviation, and then being introduced into F1 in the 1977 until it was eventually banned in the 1989 season. Due to the oil crisis in 1973 the United States and many other countries introduced the most stringent fuel economy standards for the time and a new 55mph speed limit introduced for the highways. During this time turbochargers were commonly used for the high-performance models from automotive manufacturers, but with the increase in fuel economy a turbocharger can provide, they were beginning to be used as a way of keeping the fuel economy within the government's mandated laws. Along with the Ban of Petroleum and diesel-powered combustion engines being banned beyond 2030, the motorsport industry has two alternatives either electric based propulsion or alternative fuels. The top echelons of the motorsport world such as Ferrari are advocating for the switch to alternative, or carbon negative fuels like hydrogen for example. Although hydrogen is the preferred option for the continuing existence of the combustion engine, it is not without its own complications. Due to hydrogen being a low-density fuel, 'This results in two problems when used in an internal combustion engine. Firstly, a very large volume is necessary to store enough hydrogen to give a vehicle an adequate driving range. Secondly, the energy density of a hydrogen-air mixture, and hence the power output, is reduced.' (Wang, 2017)

2.2 Future implementation of forced induction within motorsport

As the world becomes more consciously aware of the consequences of greenhouse gasses and pollution in the atmosphere, the Federation Internationale de l'Automobile (FIA) recently adopted their newest environmental strategies. They aim to use their substantial influence to 'use its network and influence to advocate for climate action' (Silva, 2022). This will include the use of the turbocharged 1.6L V6 engines currently used in F1 and further technological improvements such as the new Motor Generator Unit-Heat (MGU-H) 'the MGU-H is made up of magnets that spin around when it's filled with exhaust gas. Those magnets generate electrical energy, which is then sent to,

essentially a battery, ready to be used when need be.’ (Blackstock, 2022). Although this technology is no longer going to be used from the 2026 season and onwards, it adds to the confirmation that the turbo charger and forced induction are soon to be the most important technology in the internal combustion engine’s future. As the world continues to look towards electric powered vehicles, there are a number of large automotive and motorsport manufacturers who are adamant that this is not the way forward, but alternative and more sustainable fuels such as Hydrogen fuel cells. As the Hydrogen fuel uses fundamentally the same process as a traditional combustion engine. Hydrogen combustion is a promising technological improvement over the engines we have today for several reasons, such as the low energy ignition which can allow the engine to use a leaner air/fuel mixture, further improving engine economy. Some of the issues with hydrogen combustion is again due to the low energy ignition. ‘the low ignition energy means that hot gases and hot spots on the cylinder can serve as sources of ignition, creating problems of premature ignition and flashback.’ (Wang, 2017)

3 Conclusion

Through the research conducted, it has been found that the turbocharger has been used for decades, within the automotive and motorsport industry. The original reasons for the application of such technologies were to increase performance in a relatively cost-effective manner. As the first turbochargers were produced for aircraft to handle a higher altitude because of their ability to force more air in the cylinders than the volume you would allow at atmospheric pressure ‘At high elevations turbochargers compress more air into the engine cylinders making up for the lower air density allowing the engine to produce power as if it was at sea level’ (Garret Motion Inc. , 2019). This idea would then be transplanted into the smaller combustion engine’s future, with the idea of creating more power at much lower altitudes compared to aircraft. The main advantage of using a turbocharger over being naturally aspirated, is the increase in power and the recycling of the exhaust gasses to drive a turbine which in turn compresses the air entering the cylinders. Furthermore, this increases the engines overall efficiency and the increase in power, meaning the engine doesn’t have to work as hard to propel the car over the same distance as the same car with a naturally aspirated engine.

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