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An overview of aerodynamic features on motorcycles and its development

Academic Skills ACHA4005

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10/2022

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1.Introduction

The purpose of this report is to consider how aerodynamics has changed through history of performance motorcycles, how this affected the power, handling and comfort for the rider. Also looking into the developments that have been made. The technologies and calculations that have been used to improve the aerodynamic features.

1.1Aim

The aim of this report is to show the importance of aerodynamics in racing settings. The developments made and the advantages and disadvantages of these aerodynamic features, how it affects the overall performance.

History of aerodynamics

In the History of motorcycle aerodynamics, the developments typically lagged other automotive sectors, such as F1, by a great many years. In 1968 The Lotus 49B was the first F1 car brought out with wings in aid of performance. It took nearly 50 years for the motorcycle world to adopt the same features in the mainstream. There are a variety of reasons as to why this is the case such as the rider being such a large proportion of the vehicle, leading to a dynamic and seldom repeatable scenario in terms of airflow. When a motorcycle transitions from acceleration to braking the pitch of the motorcycle can change by typically around the 10-15 degree area for a performance motorcycle. This directly affects the wing angle of attack. Furthermore, a motorcycle will lean in excess of 65 degrees (MotoGP, 2013) which changes how the additional downforce affects the motorcycle. For this reason, early development in motorcycle dynamics was focused on streamlining of motorcycle and to make motorcycle's fairing's cover as much as the rider as possible. Another factor was making it narrow and low to the ground to reduce the frontal area. These types of fairing's developed in the 1950s this was known as dustbin fairing. This type of fairings proved to be problematic as issues like brake cooling, front end lift and crosswinds made the motorcycles dangerous and difficult to corner. These types of fairings were banned in 1957 by the FIM. (FIM, 2022) The performance, safety and comfort can all be drastically changed by the modification of the motorcycle's aerodynamic features. The idea of fairings being more open yet sleek is concept that had remained through the development of motorcycle aerodynamics. Other features that have been developed over time

Aerodynamics feature and how they compare to modern performance motorcycles

In the early development of aerodynamics an idea developed by Rodger Freeth "Aerofoil Viko TZ750A" from 1977 (V Sedlakwas, 2012) to attach wings on the front and rear of the motorcycle this was thought to generate more downforce and to increase cornering performance this was not the case and more problematic. The main problem of these wings was the size, thus being the main reason for the wings being banned as the risk of entanglement during racing was high.

Even though it did not work in the late 70's this concept is similar to a modern Aerodynamic feature that Ducati introduced in the pre-season MotoGP testing in 2015. The main effect of these front winglets is to generate more downforce and to keep the front end of the motorcycle down the way the winglets work is by directing the air from horizontal to an upwards direction. The winglets essentially will increase traction therefore the motorcycle can gain more speed. The wings are

important as they add a safety feature and stability for the rider. The way the wings Ducati's new streetfighter v4 has wings on the front of the motorcycle. Ducati claims these wings 'ensure maximum stability at high speeds and when braking, they help prevent the tendency to wheelie during acceleration. In performance racing applications these winglets will have advantages, compared to production road motorcycles will have very little affect. The disadvantage of these appendages is that it increases drag Ducati released the data of these wings for the streetfighter v4 the effect of them is 27.9kg of downforce at 74.9 m/s of this 27.9kg generated 19.9 kg is on the front wheel and 7.9kg is on the rear wheel (Ducati ,2022). Ducati also mention the effect the aerodynamic features have on water and oil cooling. In terms of heat loss, the wings increase the speed of passage to the radiators increasing the heat loss by +2% (water) and +10% (oil).



Time trials bicycle have for a long time used rear wheel covers and deep section rims to aid in reducing aerodynamic drag, increasing average speed during a race or time trial with a given power output from the athlete. Compared to a spoked rear wheel a 80% cladded wheel will have gain a reduction in drag coefficient of 5.2% at 10m/s in a non-isolated CFD study (B.B. Arora, S. Bhattacharjee V. Kashyap 2019). In isolation this could be much higher. Importantly however frame members, such as forks, brake and in some cases, mudguards can also have significant effects such as a 12.9%reduction (F.Malizia, T.van Druenen B. Blocken, 2021) in overall drag when rotating. Along with TT bicycles, wheel covers have recently been used in the Moto3 championship to aid the turbulent flow. these devices are found on the rear wheel of the motorcycle, similar to TT Bikes. Whilst it is very hard to say how much benefit these give in this example, the fact they are used must in turn validate the opinion they have a benefit. Similar features are also present on the Ducati GP22, with the lower half of the rear wheel covered by a small fairing.

Computational Fluid Dynamics (CFD).

Aerodynamics is a key point in the design process of performance motorcycles, as this has a direct effect on the performance of the motorcycle and the comfort or the rider. The way aerodynamics can be tested and designed in modern ways is with Computational Fluid Dynamics (CFD). CFD is a powerful tool used by engineers and aerodynamicists in order to predict the behaviour of fluids (Air) around a body, such as a vehicle.

The ability to test without the need of a physical object and wind tunnel time can speed up design time, reduce costs and provide a better design as multiple iterations can be run before the design is

finalised. CFD has been utilised by engineers since the early 1980's when packages such as Poenices were released commercially. Since then, the development in computer technology has made CFD widely accessible and increasingly more accurate.

Good CFD simulations can be very close to actuality, providing good practice methods have been followed. Factors such as Element size and density, geometry definition requirements and domain must be taken into account.

The process starts at the cad model, for new vehicles this is fairly simple to import as they are already designed with CAD however in some cases this process must be reversed from physical object to model. It must also be noted that in the case of motorcycle aerodynamics the rider must be a part of this model due to the affect they would have on the airflow around the bike. With the geometry created typically a meshing pre-processing software such as ICEM or other similar programs would be used.

The purpose of an FE (finite element) mesher is to break down a geometry into a mesh consisting of a finite number of elements which can be input to a fluid dynamics software, e.g., Fluent.

the reason meshes are used is to limit the number of calculations required, each simulation being made up of many thousand differential equations (Benjamin, S.F. and Hickman, C.,2014)

There are also various approaches to meshing that can be used, such as octree and Delaunay methods as well as other factors that influence decisions in the mesh, such as boundary layers.

CFD also allows an engineer to simulate the effects of the rider in regards aerodynamics. A famous example of the rider being incorporated would be the Suzuki Hayabusa which used CFD modelling to reduce the total drag of the motorcycle specifically with the rider in a tuck position.

Studies have also been carried out with side mounted wings, where the rider's movement to one side of the bike blocks the airflow downstream of the wing, decreasing the effectiveness of the wing on that side which would give the benefit of a gain in downforce in the corner without the unwanted horizontal force component that comes with fixed wings. (V Sedlakwas ,2012)

Conclusion

Motorcycle Aerodynamics has historically been relatively undeveloped, however in recent years large steps have been made to bring it to the same level of other sectors in the automotive industry and through the use of CFD manufacturers have begun to bring it into the mainstream, as apposed to racing specific applications. The future of Aerodynamics is an exciting area, with many advancements still to be made regardless of whether a shift to electric power trains will be made or not.

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