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Aerodynamics

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ABSTRACT: *Aerodynamics is a branch of physics that deals with the force exerted by air or other gases in motion. Aerodynamic is by far the most significant factor affecting fuel conumption and power requirements even at normal cruising speed. For this reason there has been much interest in the aerodynamic shaping of all vehicles, including standard production cars and trucks.Although the shape of vehicle is determined by the designer, the vehicle owner sometimes unknowingly makes modification that reduce the aerodynamic effectiveness of the design. Objectives of improvement of flow past vehicle bodies: Reduction of fuel consumption. More favourable comfort characteristics (mud deposition on body, noise, ventilating and cooling of passenger compartment). Improvement of driving characteristics(stability, handling, traffic safety) Vehicle aerodynamics includes three interacting flow fields: 1)Flow past vehicle body 2)Flow past vehicle components (wheels, heat exchanger, brakes, windshield), 3)Flow in passenger compartment. The reduction of vehicle drag is a key motor for improvement of numerical and experimental tools. However, there are many other aerodynamic aspects such as crosswind stability, unsteadiness from passages of tunnels, platforms or other vehicles, ballast projection for high-speed trains, aero acoustics and soiling which require new improved approaches in flow predictions. The paper illustrates this by describing the aerodynamic design aspects of a number of different types of configuration. These differ according to their design requirements and are divided into three classes - transonic design emphasis, supersonic emphasis but with good transonic performance, and a supersonic dominant design. Taking the high velocity of the vehicle and the comparatively small free cross-sectional area of the tunnels into consideration there was a high risk of adverse aerodynamic effects for the passengers, vehicle and the tunnel structures and equipment. The aerodynamics of a car can also be developed to produce a more slippery streamlined designed shaped car, there will be a point where a car's design with a high downforce set up, will be good in the corners but will have compromised top speed. This is not a desired aerodynamic design for production cars, as it will lead to higher fuel and tyre/ tire consumption. It is always a balancing act to get the desired amount of downforce for the corners and also low drag levels for top speed, for out and out track focused cars, but production cars have their own set goals to achieve.*

Keywords: *affecting fuel ,aerodynamic shaping, dominant design ,streamlined, downforce.*

I. INTRODUCTION

The study of the movement of air and other gases. Aerodynamics includes the study of the interactions of air with moving objects, such as airplanes, and of the effects of moving air on stationary objects. The word comes from two Greek words: aerios, concerning the air, and dynamis, which means force. Aerodynamics is a branch of dynamics concerned with studying the motion of air, particularly when it interacts with a moving object. Aerodynamics is a subfield of fluid dynamics and gas dynamics, with much theory shared between them. Aerodynamics is often used synonymously with gas dynamics, with the difference being that gas dynamics applies to all gases. Understanding the motion of air (often called a flow field) around an object enables the calculation of forces and moments acting on the object.

Aerodynamic problems can be identified in a number of ways. The flow environment defines the first classification criterion. External aerodynamics is the study of flow around solid objects of various shapes. Evaluating the lift and drag on an airplane or the shock waves that form in front of the nose of a rocket are examples of external aerodynamics. Internal aerodynamics is the study of flow through passages in solid objects. For instance, internal aerodynamics encompasses the study of the airflow through a jet engine or through an air conditioning pipe.

Objectives of improvement of flow past vehicle bodies:

Reduction in fuel consumption.

More favorable comfort characteristics (mud deposition on body, noise, ventilating and cooling of passenger compartment).

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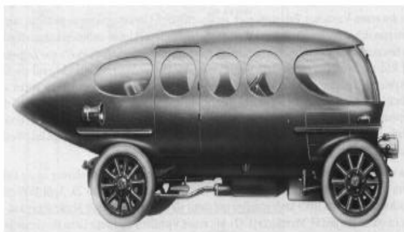
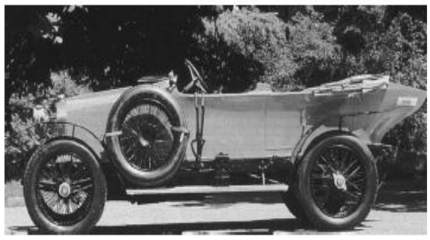
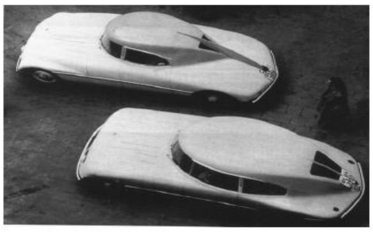
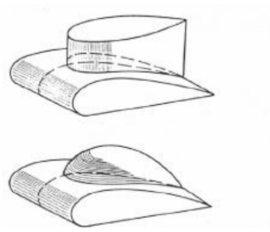
Improvement of driving characteristics (stability, handling, traffic safety)
Vehicle aerodynamics includes three interacting flow fields:
Flow past vehicle body
Flow past vehicle components (wheels, heat exchanger, brakes, windshield),
Flow in passenger compartment.
1. Influence of flow characteristics on the operation of vehicles
1.1 Approaches in vehicle aerodynamics 1. 1900-1920 Adaptation of shapes from other fields

Torpedo	Airship	Boot

1.2 Approaches in vehicle aerodynamics 2. 1920-1970 Adaptation of results of airplane and airship development: streamlining


JÁRAY EXPERIMENTAL CARS

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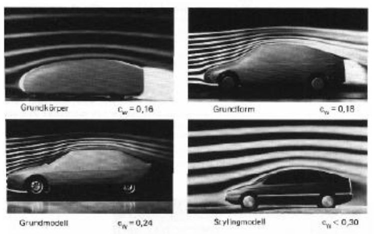
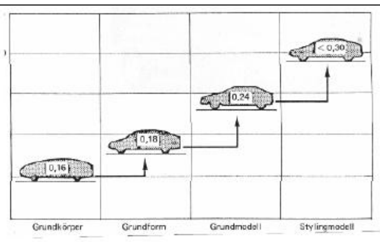
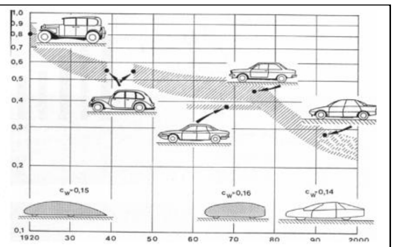
1.3 Approaches in vehicle aerodynamics 3. 1990 - Basic form optimization



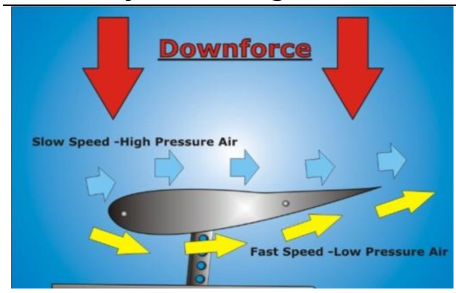


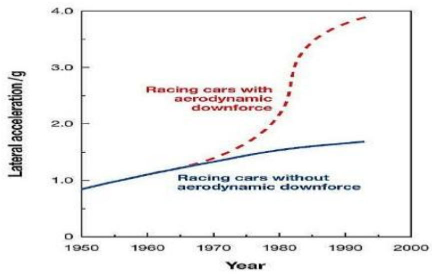


1.4 Change of drag coefficient of cars

2. Downforce

The same principles which allow aircraft to fly are similar in car aerodynamic, but the main focus is to produce downforce instead of lift. Depending on the exact requirement for the application, the set up can be modified to suit top speed (low drag) or high downforce (higher drag), while providing more grip for the corners by pushing down on the tyres. The ideal set up is normally to get the maximum amount of downforce, for the smallest amount of drag generated.





Racing cars and aerodynamics have come a long way in terms of development since basic ground effects where first applied to cars. In the early days of 1967, cars like the Lotus 49 and Lotus 79 for example, initially had huge rear wings, which were mounted on the rear suspension and even had cable operated wings to reduce the angle of attack on the straights to increase top speed, the same as DRS in F1 2011 season. Due to too many accidents with these high mounted wings, they were banned and engineers started to look at other areas of the car to create even more downforce levels. Most of the principals applied where taken from aeronautical design and modified for use in Motorsport.

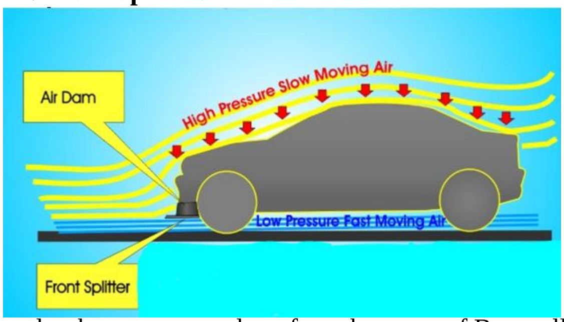
3. Coefficient of Drag

Cd (Drag coefficient or coefficient of drag) is an aerodynamic term that describes the car ability to cut through the air and the shape of the car will ultimately affect the overall top speed. The lower the Cd level, the lower the drag and more aerodynamic efficiency of a cars design (this is focused on drag reduction and not downforce).If we look at the "drag coefficient values" diagram below, we can see the impact that different shapes have on the airflow over them. The lower the CD figure the more streamlined the shape is and also its increased aerodynamic efficiency. It takes ever increasing BHP engine power to overcome air resistance, this is effectively a ration of 1:4, meaning the required powered is ex-potentially squared to the target speed. Let’s have a look at an example.. A car with a larger frontal area will require more of the engine BHP to continue to make the car accelerate and continue to gain speed. As the car continues to go faster, the required power to keep building speed increases significantly (squared).

Drag is proportionate to the square of the speed. Normally a smooth, low frontal area car will be able to produce better top speeds (if engine power is similar), this low Cd value combined with a good aerodynamics downforce aids will result in a true performance package.

But designers and engineers have a fine balancing act to combine good downforce for the corners and minimum drag for the straights. So you can see that just bolting on that fancy or cool looking spoiler or huge rear wing, could have huge affects on the overall performance of your car. That is why Motorsport is so expensive and teams end up spending huge sums of money for a competitive aerodynamic package, within the confines of their regulations and given goals.

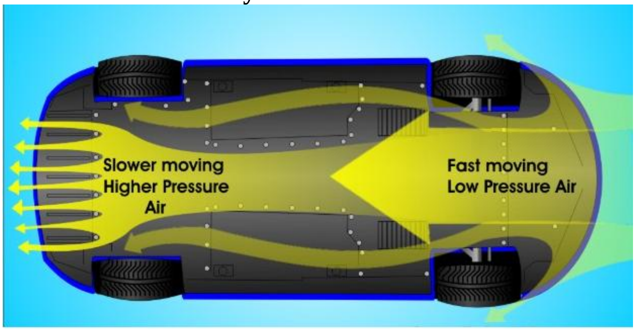
4. Front Splitter/Air Dam



The main aim of a front splitter and air dam is to aid in the optimization of the flow of air to the rest of the car and reduce drag, while creating negative lift (downforce). The main balance is to achieve minimum drag and maximum downforce, aiding the front tyres to get more grip and reduce understeer tendencies. The front splitter is attached to the bottom of the air dam, it serves to increase the amount of downforce at the front of the car. High pressure over the splitter caused by the air dam, and low pressure by the airflow under the car creates downforce by ways of Bernoulli's effect. (high pressure is drawn to low pressure areas).

This helps to minimize the affects of understeer and gives the front end more turn in response on entering corners at speed. Like most racing applications, adjustable angle of attacks maybe possible to adjust for different applications and tracks.In a standard stock car or in modifications for specialist race series, cars will undergo dynamic development to help increase these downforce levels. Normally lowering the car to a certain ride height level as well as a lower frontal area will help to increase the desired downforce requirements. Also it is generally known that a increase in front downforce while entering the turn in for a corner will help to combat understeer. This can help to balance a car more and having more grip to maximise steering inputs to hit the apex. letting you come on the power more quickly, producing better lap times.

5. Chassis/Under Body



While largely hidden from view, chassis and underbody aerodynamics are the secret weapons in an arsenal of aerodynamic features for generating downforce on racing cars. The bodies are designed to slice through the air and minimize wind resistance or drag. In every day driving this will help keep your fuel/gas bills down as well as provide a better top speed. If you can imagine all the nooks and crannys normally expose on a cars under body, by creating a smooth boxed in under tray, drag can be greatly reduced. Maximisation of a cars aerodynamic potential can be achieved with these along with the other aerodynamic devices already discussed.

Detailed pieces of bodywork can be engineered to allow a smooth air flow to reach the downforce-creating elements (wings or spoilers, and underbody tunnels). In recent times more and more work has been undertaken on the underside of the body, similar in shape to an inverted wing (first used by Colin Chapman's Ground Effects racecars). The main principal works by the front of the car (splitter/ airdam) creating low pressure fast moving airflow to the underbody of the car. Then the rear of the car's diffuser creates a expansion area, made to slow down the faster moving air, as a result creating additional downforce and vacuum effect (a giant venturis, high pressure air presses down on low pressure air). The Diffuser also aids in smoothing out the airflow at the back of the car, reducing drag and improving aerodynamic efficiency.

7. Streamlined Design Cars

The aerodynamics of a car can also be developed to produce a more slippery streamlined designed shaped car, there will be a point where a car's design with a high downforce set up, will be good in the corners but will have compromised top speed. This is not a desired aerodynamic design for production cars, as it will lead to higher fuel and tyre/ tire consumption. It is always a balancing act to get the desired amount of downforce for the corners and also low drag levels for top speed, for out and out track focused cars, but production cars have their own set goals to achieve.Some production car do have active car aerodynamics, where a wing pops up at a given speed, or in some cases appears under heavy braking acting as a air brake to stabilise rear traction and reduce high speed lift. This is mostly seen in Ultra cars likes the Bugatti Veyron

This set up of the wing dropping down into the body work essentially follows the rule of a streamlined body design, as huge wings and spoilers will create drag which is the biggest killer in terms of top speed and aerodynamic efficiency. Also the majority of the required downforce levels are generated through underbody diffuser design, which produces low drag levels.If we also look at the world speed record cars, they essentially look more like a rocket, or aeroplane with its wings cut off, then traditional cars designs. The design is predominately engineered to cut through the air, minimal drag levels. Although not practical in everyday production cars, we can see the relevance of a slippery design in achieving a streamlined design for maximum top speed.

II. CONCLUSION:

Optimization of vehicle bodies results in
• considerable reduction of fuel consumption
• improvement of comfort characteristics and
• more favourable driving characteristics of ground vehicles.In optimisation besides wind tunnel investigations numerical simulation of flow field has become more and more important.

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