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DESIGN DELIBERATION OF AUTOMOBILE STRUCTURES THROUGH AERODYNAMIC CONSIDERATIONS

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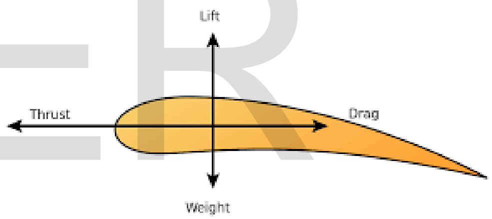
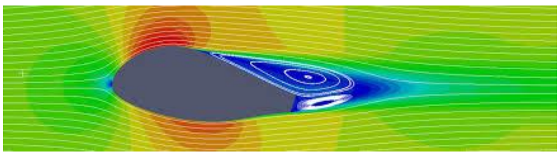
Abstract:

In the present world, technology is getting advanced day by day. As the part of technology aircrafts, automobiles are playing a key role not only in transportation but also in defence and space technology, this paper gives us a clear information about the design consideration and major parameters, about automobiles and evolution of design through the concepts of aerodynamics. This paper suggests and proves a better design of automobiles by reducing drag parameters and achieve right momentum and sprint through various effects of aerodynamics, different laws and fundamentals of aerodynamics are considered as per the requirements.
keywords: Aerodynamics, drag, automobiles, design criteria and different forces.

Introduction:

As we know for any vehicle may it be an automobile or an aircraft has its own design considerations. but the key role is played by aerodynamics, design and weight considerations, but when compared aerodynamics of a body in flight differs from the aerodynamic body which is on the surface. The basic components are shown in the below diagram , as the downforce and drag properties varies when compared to aircrafts and automobiles ,by changing some minute properties we can achieve improved sprint of a vehicle which provides maximum downforce, and with minimum aerodynamical drag and good directional stability can even be achieved at high speeds. As going further, we may also consider the unsteady aerodynamic effects on a body, such as turbulence, crosswinds, and mainly the driving stability of a vehicle at high speeds, there problems are majorly interlinked to optimal steady measurements in a wind tunnel and the actual unsteady conditions on the road.

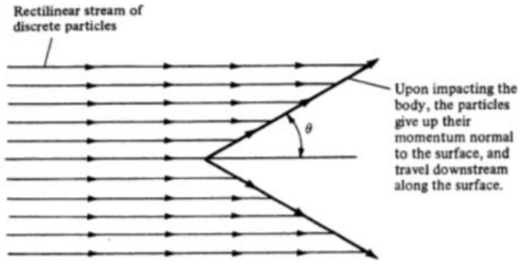




The free stream of air passes through the wing in the above pictures and the forces which act on it are mentioned. The component of net force normal to the flow direction is "lift", the force acting along the flow direction is "drag". These are mainly based on the flow direction of fluid flow and variation in pressure along a certain body, as aerodynamic forces vary with pressure difference and based on the location upon which it is acting, this is called the centre of pressure.

Discovery of Basic Module: **[1.1]**
As per "Isaac Newton's" module of fluid flow

from the year '1687'



According to newtons considerations the particles would transfer their normal momentum to the surface but their tangential momentum would be preserved , hence after collision with the surface, the particles that struck on the surface would move through it, but this was later found to be conceptually inaccurate for most fluid flows, and lead to an expression for the hydrodynamic force on the surface that the particles struck which varies as $(sin^2 \theta)$.

Design Criterion and Angular Assumptions: [1.2]

As it goes on then later " Jean LeRonda d' Alembert" and "Leonhard Euler" had carried out experiments on the design criterion and they discovered that with sin square of the angle of incidence, holds good only for angles between 50 and 90 degrees and suggested that it must be abandoned for more lesser angles[1], and according to Euler , he said that the fluid moving towards a body before reaching the latter, bends its direction and its velocity, so that when it reaches the body flows past it along the surface, and exerts no other forces on the body except the pressure corresponding to the single point of contact.[1]
Further he accounted that the shear stress distribution along the surface as well as the pressure distribution , as that leads to the expression $(sin^2 \theta)$, He said that
$sin^2 \theta$ is proportional for large incidence angles.[1]
$sin\, \theta$ is considered for smaller incidence angles. [1]
Then came the "Wright Brothers" with their glider experiment which was a failure and then the wind tunnel experiment to test different blades and their shapes, and found a efficient shape of the wing and blade which was more reliable, and then its design was used to make(ICBMs) for long distance flight and ballistics , but there were some more flaws in the design and then it was rendered by the scientists , as it causes heating problem, they rendered the design from a sharp edge to a more wider edge which was successful.

Breakthrough: **[1.3]**

The breakthrough was achieved by "H. Julian Allen" [1] at the NACA based on the outer design, on higher altitudes and the loss of kinetic and potential energy, which could be overcome, by this design differentiation.

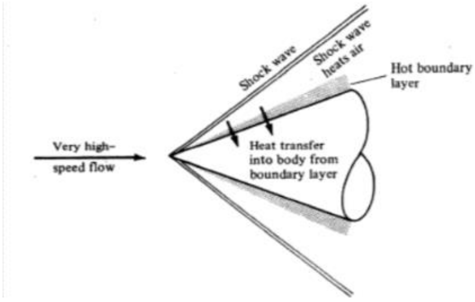


Figure (a) slender re-entry module

Energy of reentry goes into heating boath the body and the air arouunf it.

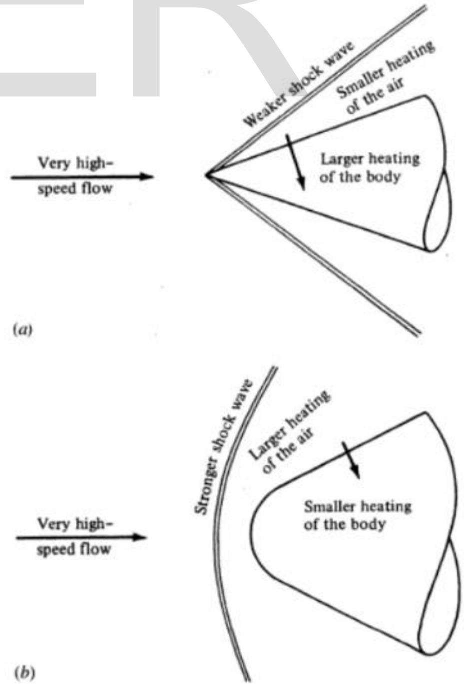


Figure (b) blunt re-entry module

As we can see the difference this discovery lead to minimize the aerodynamic heating and blunt module is more considerable then the slender module and this approach was followed.[1]

Drag: **[2]**

The simple definition for drag is the resistance offered to a body when the fluid flows over the surface, and aerodynamic drag is the combination of pressure drag and viscous drag.[4]

As we know that the pressure drag is more dominant one which is caused due to the shear force acting between two layers of fluid. And is expressed as:

Aerodynamic drag cd = drag force / $0.5\rho v^2 A$

where, ρ = is the density of air in kg/m^3,

A = is the effective area in m^2,

V = is the velocity in m/s.

to decrease the drag on a body, the source is analysed and upon given condition's the drag force maybe calculated. [4]

The co-efficient of drag upon a body is totally dependent on the shape of vehicle.

AUTOMOBILE Aerodynamics:[3]

As we know that the design for cars have been evolved from various versions of it, the evolution took place through the adaptions of aerodynamics.

Aerodynamics is mostly considered in automobiles to increase the fuel efficiency and decrease the drag force on a vehicle, in order to do this an automobile is mainly aerodynamically designed and equipped with different accessories like wings, spoilers, side skirts, diffusers and air dams.

When air is pushed opposite to a moving vehicle the drag is produced, and accordingly it exerts lift which is of two types:

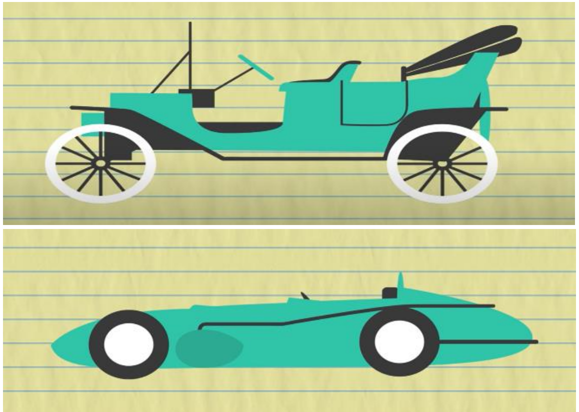
1) positive lift ,

2) negative lift, which is also known as downforce.

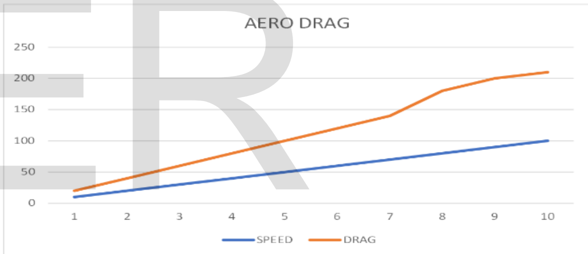
And as we know drag is $v^2 * Cd * A$ velocity square multiplied by its drag coefficient and its frontal area, the drag coefficient depends on lots of factors some of which are an objects overall shape, surface roughness and speed.

Example: a brick has a drag coefficient of (1) and a tear drop which is the most aerodynamic shape has a drag coefficient of (0.5).

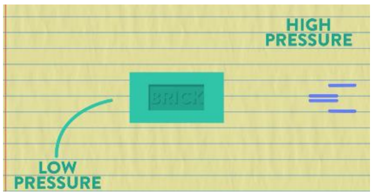
The earliest and speed record racers quickly realized streamlining their cars are going to make the vehicle move faster,

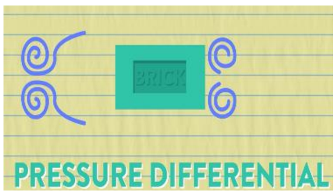


but drag increases significantly the faster we go, according to the graph mentioned below at 70 miles an hour there's four times more drag than there is at 35 miles an hour.

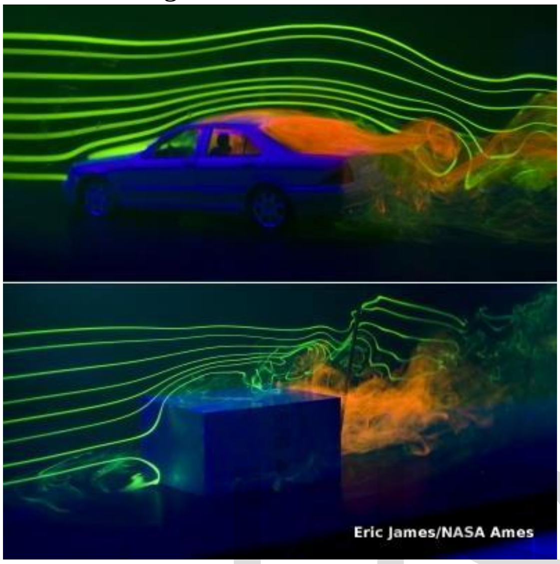


Looking at a fast moving, non-aerodynamic brick , air is going to pile up in front of it and creates an area of high pressure there , at the back a low pressure air pocket is formed and creates a pressure differential, which exerts an additional force to drag the brick backwords as shown here.

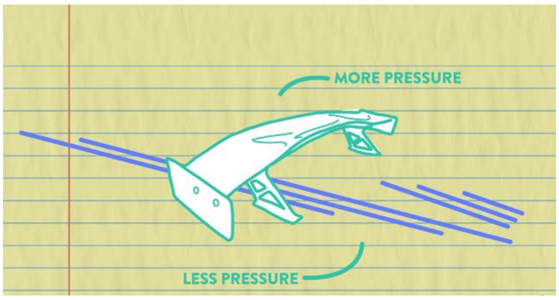




The reduction in drag force from (0.3-0.25) would increase fuel economy by about a mile a gallon, by the same reasoning an electric car can go further on a charge the more aerodynamic it is, the most modern automobile has drag coefficient in between (0.25-0.35). The race cars are mainly designed based on the frontal area where traction and grip are produced. As taking the module of brick where a pressure differential is created , and the same pressure differential is created on the top and bottom of a car as shown below which can highly lift the car , but to get the desired downforce we use the Bernoulli's principle which explains that a fast moving fluid will have lower pressure than a slower moving fluid .

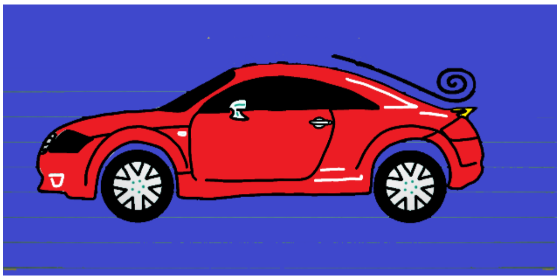


A wing mounted on a car generates down force , when air moves more quickly across the bottom of the wing, than it does across the top, so the slower moving air across the top of the wing excerts more pressure than the faster moving air underneath resulting in downforce.



In order to achieve this a wing is mainly shaped as an airfoil which follows a cooanda effect , and the direction you mount the wing determines the production of a positive or negative lift which is generated.

The spoliers which is mounted at the backs of the car interferes with air flow helping to cancel out some of the lift



, and give us a little more high speed stability and in order to add downforce to the front end spliters are used, as the air is stacked in front and creates a high presuure area before moving on top or bottom of a car, and the more air flows through the bottom than on top leads to generate more lift , so when a spliter is added it helps to create more area underneath and lets the high pressure air flow from top and low pressure from the bottom.

The downforce increases exponentially with speed so there are many more accessories and design crieterions which are used in the production of an automobile and its aerodynamics.

CONCLUSION :

This paper gives a briefing on how aerodynamics is contemplated in the production of an automobile and how diversed designes are produced and considered. The different experiments and scientific considerations were acknowleged, which leads to the breakthrough of design consideration. The different methods to calculate the forces acting on the automobiles are reviewed, and how the fluid flow effects the body and its behaviour on the vehicle gives us a clear understanding on the efffects of aerodynamics , the evolution and the history of aerodynamics has been revised and bought out the importance on how we succeded to built these magnifisent machines.

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