Pratibodh
A Journal for Engineering
(A free and Open Access Journal)
Homepage : https://pratibodh.org

Aerodynamic Shape of Car Body: Design and Analysis (Efficient Shape)

[1]S. P. Jadhav, [2]Ganesh Dongare, [3]Abhishek Garud, [4]Sameer adsule, [5]Chirag Bobhate
[1]Professor, [2,3,4,5] Students
Department of Mechanical Engineering,
Bharati Vidyapeeth College of Engineering, Sector 7, CBD Belapur, Navi Mumbai-400614, Maharashtra, India
[3]gad3132000@gmail.com

Abstract

The projects are aimed at improving the external fluid capacity of racing cars. The present study attempts to study and analyze the making of Aerodynamic shape of car body. It's an interesting and exhilarating program which basically reflects the principles of fluid mechanics. Race cars are designed to be air-conditioned to reduce drag or reduce vehicle resistance and to improve performance. By reducing drag on the air force, there will open the new vistas of high speed at the same time it will help in the reduction of car fuel consumption lending a hand to the development of the mechanism. Drag force helps in the slowing down the speed resulting into less fuel consumption. And this applicable even in the case of using downforce while driving around the corners. In the construction of a vehicle flowing circuits and design parameters are identified when high pressure is applied. Simultaneously, there is a fine-tuning of geometric adjustment. CFD is very useful in the automotive industry from system level to partial level analysis of fluid flow. Complete flow analysis is done using SUDDEN RESPONSIBILITIES and the results are interpreted.

Article Status

Available online : July 15, 2021

Keywords: aerodynamics, shape, car, body, drag, CFD analysis

1. Introduction

Environmental issue and growing gas cost are factors that drive car manufacturers to develop extra fuel-efficient vehicles; The massive investment aims to reduce the power required to deliver power which is a new reduced engine with new aerodynamics devices that reduce drag. In passenger cars the aerodynamic drag pressure is a great force to withstand excessive speeds. The body of the car is usually designed to reduce drag resistance. Define aerodynamic strength in a way that simplifies pulling resistance from the pressure difference between the front pressure and the base pressure behind. By reducing the difference between the pressure, the drag force will be reduced which is why the fuel will be reduced. Aerodynamics is the study of energy and movement from objects in the air. For numerous method, cars have been developed with the idea of aerodynamics, and car manufacturers have come up with a variety of innovations that make cutting that "wall" of air easier and less of a daily drive. In fact, having a car designed with the wind in mind means that it is harder to speed up and can achieve better fuel economy numbers because the engine does not have to work hard to push the car into the air wall. Engineers have developed several ways to do this. For example, additional circular designs and exterior shapes are designed to move the air in such a way that it flows around the car with the greatest possible resistance. Some luxurious cars have air-conditioned components under the car's interior. Many also include a spoiler known as the rear wings to prevent air from lifting the car's tires and making it unstable at high speeds. One of the major causes of aerodynamic suction on sedan cars is the separation of the flow near the rear end of the car. To delay the separation of the flow, bump-shaped vortexs are tested for insertion into the end of the sedan roof. Widely used on aircraft to prevent flow, the vortex generators themselves create drag, but also reduce drag by preventing the separation of the flow downstream. The overall effect of vortex generators can be calculated by including both positive and negative effects. Since this effect depends on the shape and size of the vortex generators, those on the roof of the car are adjusted. The aerodynamics of a car primarily depend on the vortices and vibrations produced around the car at different speeds. A vortex is a liquid region in which a flow rotates in a line of axis, which you can grasp or bend. Vortices are a big part of the chaotic flow. Vacial distribution, vortices (curl of flow velocity), and the concept of rotation are used to match vortices. In most parts of vortices, the flow velocity is very large near its axis and decreases in proportion to the distance from the axis. Wake turbulence is the chaos that builds up in the back of a car as it passes through the air. Lift, drag is performed with high pressure under the wing and low pressure above the wing. As high winds move around the wing to low pressure, high pressure always goes to areas with low pressure, wind circulates, or creates a direct "storm" behind the wings. The storm sinks lower and lower until it collapses. So physical condition affects aerodynamics. It is the main reason for the formation of waking and pulling in the movement of a car. And it is a major contributor to the pull,. This affects the drag of the car equilibrium. The most powerful drag in the drag drag object of any object exhibits the impact of two contributors: skin tension and drag form. The drag of a complete structure like an airplane also includes the effects

of drag disruption.

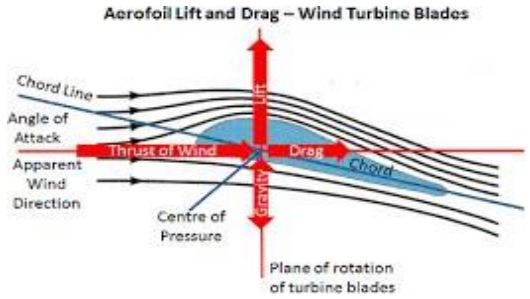

Fig 1 Aerodynamic

Aerodynamics is the take a look at of the route among shifting our bodies and surrounding fluids, under and inside them. Aerodynamics modified into first evolved through aeronautical engineers analyzing the layout of the wings of airplanes flying withinside the earth's atmosphere. Aerodynamics is used to layout many various things consisting of constructing creation, bridge creation and motorsports / automobile creation and plenty extra. Aerodynamics is a completely crucial problem in phrases of opposition involves the competition forces working in a vehicle. It involves the image wherein the automobile is shifting in a liquid environment. There are many elements together with raise, aspect power and drag which are the elements that purpose this resistance. Reducing drag at the air pressure will now no longer handiest open the doorways of excessive pace however can even lessen vehicle gasoline intake and boom development. The above elements are very essential with regards to passenger vehicles. These elements additionally decide the recognition and lay the inspiration for the advertising and marketing techniques of a specific passenger vehicle. Therefore, numerous researchers are constantly trying to enchance the layout of the motors for the motives noted above.

Aerodynamics Features - The main strength to consider in Aerodynamics is Lift, Drag and weight. Gravity and aerodynamic are the two basic forces created by the air that flows around a car. The Downforce looks down on a car made with a difference in air pressure and can increase the performance of the car by increasing the power that increases the stability of the car. As fluid flows, we can define the flow of motion. The part of the net that is perpendicular or normal to the flow direction is called the lift, and the part of the net energy in the direction of flow is called the drag. These are the definitions. Combined strength is caused by differences in pressure in the body. Aerodynamic forces operate at a level of pressure variation called the pressure center.

DRAG - aerodynamic pull is a force that opposes motor direction movement. A major contributor to traffic jams is high pressure on the front of the car, ground collisions and desirable force. In the given cases of the car, in this way one can measure the drag force. Drag can be described as a front-wheel drive, air pressure and square car speed. The gravity forces and the car speed has a kind of cubic relationship, for a small change in the speed of the car can exploit larger amount of engine power. This happens because the engine power attempts to win over the gravity force. It is the front position and the co-efficiency of of the drag that can change the amount of air and speed. It is possible to reduce the size of the car by reducing the front area of car, but it cannot all together be reduced to any length as people need to sit in the car comfortably. Hence we can definitely deduce that the easiest way to reduce the car size is to reduce the drag drag of car. The size of the drag car depends largely on the engine. Therefore, it becomes very essential to analyze the change brought in by the various manufacturers in the aerodynamic drag on the vehicle.

As discussed, dragging with the force of a car against the direction of a vehicle is why this is not a features to reduce the overall aerodynamic drag. In this way it becomes fuel efficient. The only difference in the racing car and passenger car is that racing car concentrates on the speed while the passenger car aims to reduce drag.

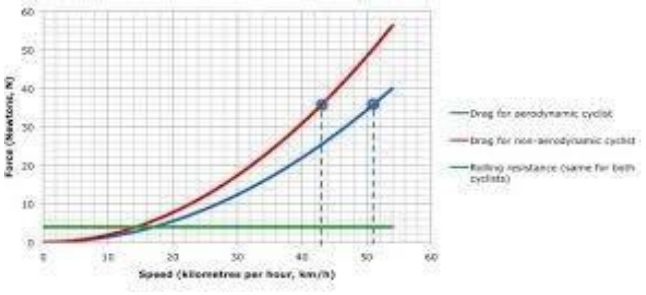

Fig 2 Graph of Speed Vs Drag

In comparison with the top surface and underbody with the wheels very little or almost no aerodynamic modernization has taken place. When it comes to the wheels and around the wheels, the vehicle aerodynamics gets complicated. Only these days have improvement targeted on the wheel region of the car.

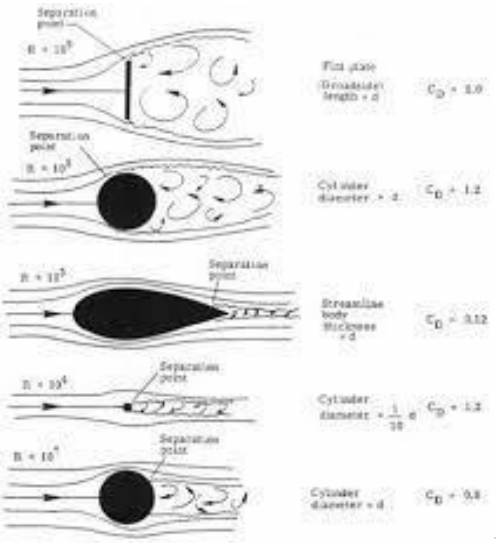

Fig 3 Aerodynamic Theory

The formula to mathematically calculate aerodynamicdrag is as followed.
$D = Cd * ½ p*v^2*A$

Where,
Cd = Coefficient of Drag
A = Frontal area
V = Relative velocity of the object with respect to fluid medium
p = Density of air

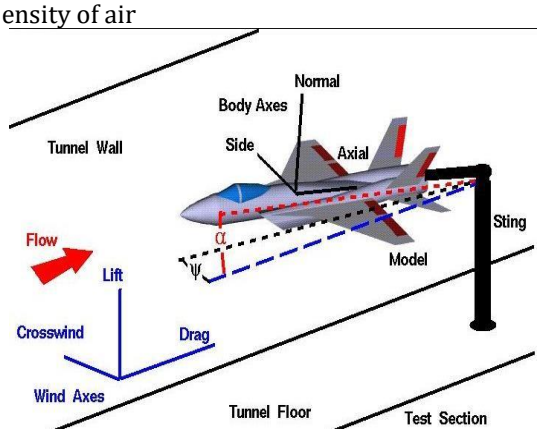

Fig 4 Concept of lift

LIFT- Lift is pressure appearing perpendicular to the movement of the car. It is crucial for plane to create fantastic raise to fly. This is undesirable in motorsports. In motorsports horrific increase it well-liked to stress the car into the floor, this pressure appearing at the car allows boom car grip which results in faster cornering pace. The formulation to mathematically calculate aerodynamic raise is just like the drag formulation despite the fact that the drag coefficient is changed with a boost coefficient and is as accompanied.

$L = CL*½*p*v^2*A$
L = lift N
C = lift coefficient
A = frontal area (vehicle) plan area (aero foil)

DOWNFORCE- Downforce is a motorsports / automotive term that works on the wrong lift. This is the power that puts a car on the ground. Downforce is produced by the air flowing over the car wreaking a bad lift. In the production of the wing of an airplane, the wing of the wing is specifically designed to lift the plane off the ground. However, this is not considered suitable in the making of a racing car. By shaping the car so that the air can be pushed up and down the body, this helps in keeping the car in track as the pressure of the air forces the car down. The front position of the car directs the air over the car. The anterior fascia attaches to the very lower nose and is inflamed, broad from the inclusions. This approach as a whole lot wind as possible blows the air dam moving up and down the car, not allowing it to enter below it. The mechanism incorporates justifiably high pressure at the top and low at the bottom to maintain the equilibrium. It is with motorsport that the importance of working down increases. The motorsports are manufactured on the increase of the demand for such bikes; here starts the journey of the speed. The concept of Instant lane came into being with such increase in the demand. Another solution is to increase thespeed at the corners so that the cars can reach the fast lanes and that increases the speed completely, on all partsof the track. It is always a challenge to lock the car hard with great force. It requires to spend lot of time to push anything in a circular motion, going out with force, pressing harder and harder as the speed increases. This all happens with the installation of adhesive tyres, sturdy suspensions and increase the car's width which is making it possible for the increase of the speed at which centrifugal forces conquer grip however such as the demand for excessive speed line, cost, technology and regulations that usually restrict the potential.

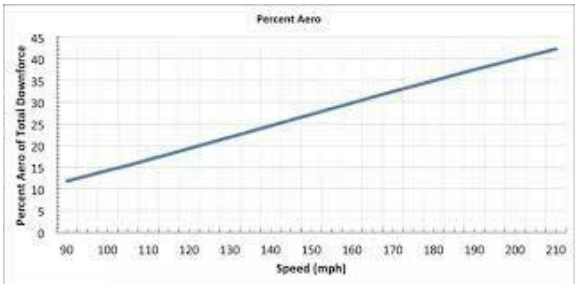

Fig 5 Graph of down force vs Speed

All other things like enter wings, aero foils, splitters incorporate the vehicle increasing the grip of the car by aerodynamic means. This is supplemented by using downforce with respect to speed. The statistics goes like for more speed more downforce is required and the more downforce invites for more grips. It is this downforce that allows F1 cars to move as fast as they can. Ironically enough, it is this downforce only that obstructs the drivers from chasing each other closely into corners.
The evolution of tyre grip is a major revolution in racing car design. This is done with the help of the use of negative lift or 'downforce'. Because the lateral adhesion of the tyres is roughly proportional to the force acting downwards with the friction between tire and road, adding aerodynamic downforce or negative lift to the weight component enhance the adhesion. The downforce allows thetires to transmit a greater thrust force without spin of wheels increasing the maximum possible acceleration. With the technological advancements the racing cars now a days can exhibit so much power and thrust without aerodynamic downforce that they could spin the wheels even at speed of 160 and more.

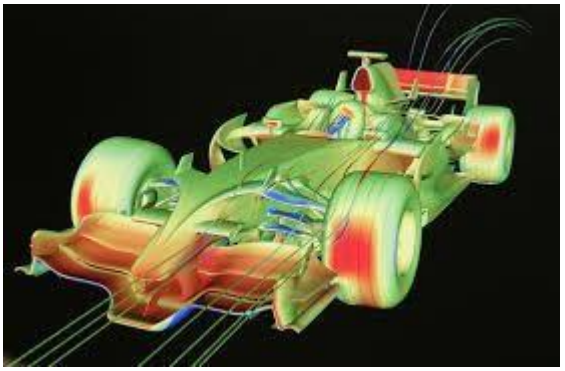

Fig 6 force Analysis of vehicle

Thus it is proved that the downforce, or improper lift, helps the car onto the tracks and stabilizes it at high speeds. It is observed that at high speeds, the F1 car can

produce 5 g's of underforce which is 5 times its weight compressing the track. This downforce should be measured between the front and the back, left and right. This balance can be easily observed between left and right with a simple measurement. The forward flow greatly affects the rear flow of the vehicle, and the rear flow also affects the

forward flow of the vehicle. The Downforce should be adjusted according to the track and speed of the vehicle. For example, staff overcrowding has led to oversteer. Too much backlash has led to a lower person.

LIFT AND DRAG COEFFICIENTS - Lift and drag coefficient are a range of given to a version and is tormented by from vehicle form, floor friction (drag) and perspective of assault (raise).
Drag coefficient = Drag / (½*p*v^2*A)
Lift coefficient = Lift / (½*p*v^2*A)

Turbulent and the laminar boundary layers.
Boundary layer glide has another type of glow while a layer of glide passes through the floor of the car. Next you see nine hints of glide layers on top of the bus. A smooth air glide can be seen inside the front element. In this case as it is much easier for the outer layer line to be faster than the inner layers because the collision affects the inner layer that directly affects the floor. This type of glide is called Laminar glide. Too much friction is postponed.

The difference between a chaotic body flow and a separate flow
The rotating line of the glide is basically familiar because the turbulent frame is slippery. This always follows the frames of the frame and then the split glide does not match the description of the frame.

Different types of fluids in the car body
The flow is smooth
The flow of motion with a certain type of flow that at any time above the surface of the car remains constant with the same pattern. On the other hand if the flow follows a structured car body structure. In this case the flow could mean that it is attached.

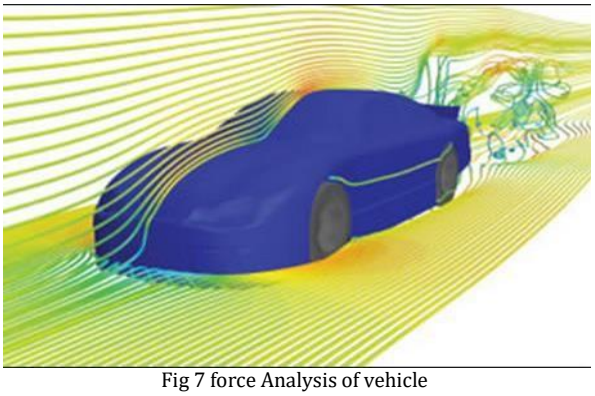

Fig 7 force Analysis of vehicle

Standing regions
This is the nature of the air that attacks the body of the car and divides it into separate flow lines in the body. The separated flow travels above and below the body. The point at which the wind blows and stays upright in the area or part where this happens is known as the stop zone.

Separation bubbles
When the air touches the surface of the car in some areas the air does not make the flow easier to decrease. Therefore, the separation bubbles formed in the space between the air flow are separated and then reattached

Reynolds Number
Boundary layer and the thickness of the layer affect the friction on the surface, flow separations etc. The flow patterns depend on the length of the body, viscosity, speed and the density which can also be name as the one quantity as knows as the Reynolds Number.
It can be expressed as follows:
This is having the same value in any system of units. If the value of density and the viscosity is constant this number is totally depends on the speed and the size of the vehicle body. So as it is studied that if the speed of the car increase the Reynolds number goes on increasing which gives the thinner boundary layers. So it is clear that this number is very important in determining the type of flow over the surface of the car.

Turbulence
It can be defined as the unsteady or the unusual manner of the flow over the car body is known as the turbulence flow. This can be termed as the swirling or the eddies turbulent motions which varies of sizes.

Three-dimensional flow
There are generally three dimensional flow patterns for the road vehicle. This pattern incorporates the circular patches, eddies and the swirling.

Vortices
In the flow regions there are few parts which often is aware of as the vortices which is mostly formed by the swirling flow structures, which mostly occurs with the whirlwinds. This project is given based on the backlight angle of the car so the vortices which formed at the back of the car are knows as the trailing vortices. These vortices also decide the lift situation of the car which either is positive or the bad. These vortices do not exist on the very long length in space. It merges in the surface or fashioned the closed loop form for example like a smoking ring.

2. Implementation

Design Procedure
It is natural with the vehicles that they develop downforce, and the vehicle can be divided in two parts: front and rear.
On rear –
Rear spoilers,wings and difuser are the main source of downforce.

Spoiler -
A spoiler is a simple type of plate found in the supply of a car frame to touch or damage the glide throughout the vehicle, increasing the glide-controlled separation in the operating area. This is completed due to the quick fact, the easy airflow will increase the good ascent, so by interrupting this ski the climb is reduced or perhaps completely erased.
Diffusers-
Diffusers are high-performance gadgets that are visible to

increase power performance inside the rear of the race car. Bernoulli equation is the standard equation that we use for diffusers. It has enough internal space very similar to a challenging tube. In reality, what we actually experience is that thepressure and speed of double liquid are entirely different, so that the diffusers can help decrease the pressure of the glide under the car by increasing its speed.

On Front -

The main supply of ground operators for front riders (known as looters, dam or breakers), beards (known as additional addition plates), vortex wind turbines, front diffuser.

Splitter

Splitters help in reducing the distance between the bottom and theback of the car's upper air barrier. T h e front of the chase car isvery similar to the ground that ultimately maintainsa balanced pressure on the top of the car, as opposed to the flow beneath it. Unbalanced pressure goes down the drain,and it helps to create low energy or awesome upgrades. Spoiler design and mechanism –

At a speed of more than 180 km/hr, the car switches to handling mode. To increase low power and reduce wind resistance, the front of the car is lowered by 90 mm and the rear by 102 mm. at the same time, the front diffuser is open. The rear wing and lateral deflection are fully extended to support turning power.

At a speed of more than 375km / hr, the car is driven in high-speed mode. The steering wheel has limits, and the car drops even more. The front distributor closes again, and the damage to the rear wing is removed

. How active aerodynamic system works –

There are two in the nose of the car. When it exits, the system opens both and directs the air under the car to reduce drag and speed. On using the brakes the flip flops, block the airflow under the car and guide it to the two edges in the valley. This increases gravity and performance, thereby increasing the ability to control and tighten the brakes. The rear wing is the best part of the whole program. There is a central hole in the back of the engine port. That's not cooling any stuff. Instead, it directs the wind to the surface and to the wing itself. The air can then be released through the lead border of the wing. At high speeds, the ark remains open and air from the leadingedge is forced under the wing thus increasing the pressure under the wing. This is the opposite of how the unit needs to work. It strengthens the wing so much that it produces very little energy. The immovable rear wing is ideal for high speeds. Hit the brakes, and the wind closes and allows the wing to return to normal operation. However, this wing has one trick at the top of the sleeve. This air is divided into two edges, and at the corners, the car can leave one part open and the other closed which allows the wing to move the car to a real corner.

3. Testing

Computational Fluid Dynamics –

Computational fluid dynamics (CFD) is a branch of a liquid machine that uses numerical analysis and algorithms to solve and analyze problems involving water flow. Computers are used to perform the calculations needed to mimic fluid and gas interactions with areas defined by boundary conditions. The initial confirmation of the software test is done using the air tunnel with the final confirmation that comes with full testing, the basic basis for almost all CFD problems is Navier - Stokes's statistics, simulation is started and the calculations are resolved as stable or transitional. Finally, the postprocessor is used for analysis and evaluation of an existing solution.

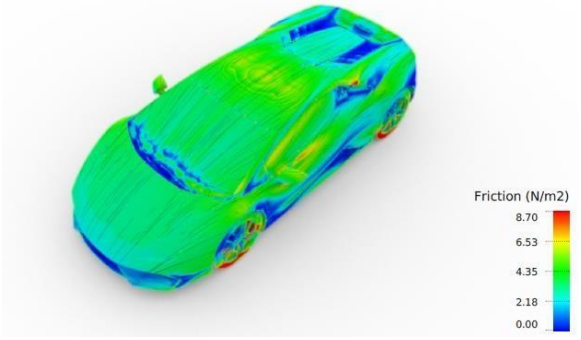

Fig 8 friction Analysis of vehicle

Wind Tunnel Testing –

Air tunnel is a tool used in aerodynamic research to study the effects of wind moving past solid objects. The air tunnel consists of a tubular tube with an underlying test inserted inside. The spirit is made to pass through something through a powerful fan system or other means. The test material, commonly referred to as the air tunnel model, is fitted with devices that measure aerodynamic strength, pressure distribution, or other aerodynamic-related features. The pressure across the model area can be measured if the model incorporates pressure pumps. This may be helpful in conditions under pressure, but this only results in normal physical force. The rear angles of the attacking wing over time are shown, the angular rotation speed of the wing is the same in both readings, resulting in the wing reaching an angle of 20 ° by 0.1 s and it takes another 0.15 s to rotate around 50 °. The features of the lifting partner and the coefficient of gravity are almost similar up to 0.35 s, which is the time when the revolving wing at 20 ° stops making movements and the flow conditions of the case stop changing, and in one case, the wing stops rotating by

0.50 s. In both cases, it takes about 0.5 s after the wing stops moving so that the flow can fully align. It must be noticed that, the total value of the lift coefficient and the suction coefficient are higher than the flow in the case of volatile conditions. It clearly indicates the faster movement of aerodynamic equipment.

At the same time we can deduce that the additional aerodynamic forces can be produced, albeit only for a very short time. It is very clear in this process that the flowneeds a bit adjustment when the wing is set to 20 °, and after rotation to 50 ° a reversible position is created behind it and the flow characteristics change significantly. Simultaneously, we must remember that a pollutant under the wing directs its direct flow making it possible for the air to "stick" to it at high temperatures up to 20 °.

4. Conclusion

Based on the car model, 2D and 3D simulations are performed in both automotive geometry to visualize air flow and pressure distribution. The analysis of the CFDs mentioned is achieved by identifying sensitive areas in Geometry that have led to the formation of bad breath. It led to the acquisition of the found 2D model and led to the modification of the existing 2D model according to the redesigned side of the car, the existing 3D car model was redesigned. The rearrangement is done by increasing the angle between the hood and the front window of the car, and adding the rear wing. In addition, 3D analysis of air flow around the geometry of the reconstructed vehicle has been achieved. With the results of 2D and 3D results, it is concluded that the stated changes in the geometry of the redesigned car lead to better airflow around the car, and produce more low power using the rear wing. The amount of exhaustion results in better vehicle stability and increased tensile strength. The dual element wing is used because even more power can be achieved with lower spped in order to increase gravity. In this way acceleration and power reduction is possible when the car is in straight line.

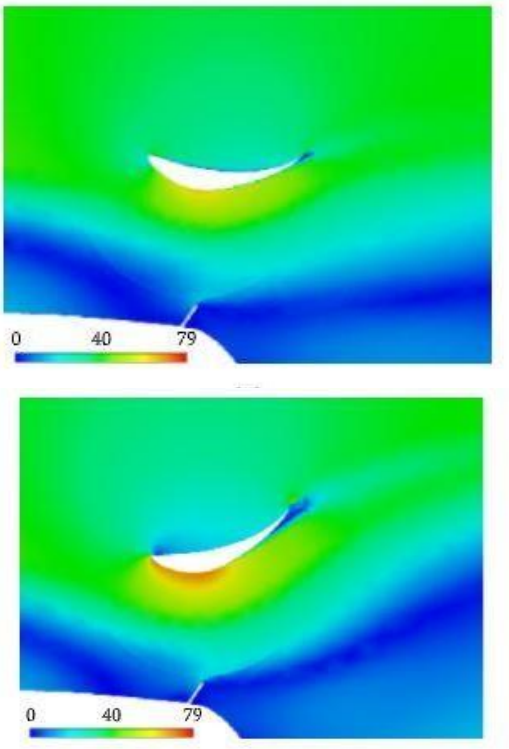

Fig 9 friction Analysis of wings

The wings of the add-ins are effective aerodynamic, because they create more energy and thus have less impact on increasing drag. It has also been found that in the event of a rebuilt geometry of vehicles there are fewer disturbances in the back of the vehicle and the turbulent area is cleaner.

Actually the wings on both sides increase the gravitational force at high speeds, it may be necessary to find a reducing solution that will reduce enough to work at high speeds, but at some point it does not affect the increase of gravity.

Computational analysis of aerodynamic back spoiler was successfully performed using Computational Fluid Dynamics (CFD) techniques using CFD software, ANSYS Fluent. The analysis revealed the aerodynamic performance of this specified rear spoiler when installed in a car to be used at high speed. The results obtained are consistent with the findings in this area. From the relevant literature, it is well-known that the use of rear-mounted wings can be a deterrent to the drag on the car, and there is the advantage of the desired maximum force (negative lift) on the car. This is especially true of race cars. The high percentage variation however, however, does not correspond to established findings. It is mainly due to the lack of sufficiently integrated solutions which is a result of time and the Central Processing Unit using a variety of solutions. But the indicators of the results are indicators of the effect of the background damage on the car. In general, the analysis showed that the rear spoiler is suitable for high-speed cars like race cars, because only then will its high-powered generating power be fully utilized. It is well-known that having an under force produces the following benefits:

- Increases the volume of tires to generate power in the corner;
- Stops the car at high speed;

Improves braking performance;

- Provides better traction.

Getting more power than a little drag can be very important in passenger cars because safe driving is always a priority. Also, with an efficient and efficient machine like this, the weight of the car can be easily reduced without consequences and this will compensate for the increased drag in terms of fuel consumption.

Future Scope

Future work would consist trying to optimize the current additional components this would consist lower the angle of the outer diffuser channel to reduce the flow separation with these channels. Another area that would be included in future work would be modification the wheel arches to allow air to flow more freely out of them which would reduce the pressure within them, the manner this can be done is by designing vents to release and redirect the air flow easily across the vehicle. One extra advice would to try and put off the flow separation happening around the bottom of the wind screen and down the rear window this could be done by decreasing the angle of the windscreen, and for the rear window it needs to have a less of a recess and to be made more flush with the bodywork.

It may be judged that aerodynamic drag is the maximum essential issue that is answerable for Fuel intake, strength loss and pinnacle pace in a car. It is likewise concluded that the outside layout capabilities of a car account maximum in lowering the outcomes of drag in a car. The researchers here have accompanied the equal concept of amendment of outside layout capabilities. Addition of vortex turbines, rear display, rear fairing, fenders, etc. are a number of the treatments accompanied. Some of them labored on various the rear taper perspective, rear underbody perspective, etc. All the above changes have basically been finished Race vehicles: a few in passengers' vehicles and excessive load motors too. However, none has attempted the front and rear spoilers in a "passenger car" to lessen drag impact. Hence, there may be a scope of labor on this path as well. These additions may be proved fruitful in immoderate give up passenger motors wherein price isn't always a totally huge issue for the buyers.

References

[1] R.H. Heald, "Aerodynamic characteristics of automobile models," Part of Bureau of Standards Journal of Research, Vol 11, August 1933.

[2] Shobhit Senger and S.D. Rahul Bhardwaj, "Aerodynamic design of F1 and normal cars and their effect on performance," International Review of Applied Engineering Research. ISSN 2248-9967 Vol. 4, Number 4 (2014), pp. 363-370.

[3] Taherkhani AR, deBoer GN, Gaskell PH2, Gilkeson CA, Hewson RW, Keech A, Thompson HM and Toropov VV, "Aerodynamic drag reduction of emergency reaction motor," Advanced Automobile Engineering Vol. 4 Issue 2 - 1000122 ISSN: 2167-7670 AAE, 2015.

[4] Jeff Howell, Martin Passmore and Simon Tuplin, "Aerodynamic drag reduction on a simple car like form with rear upper body Taper," SAE International 04/08/2013.

[5] Francesco Mariani, Claudio Pogianni, Francesco Risi and Lorenzo Scappaticci, "Formula SAE Racing Car: Experimental and Numerical Analysis of the External Aerodynamics," 69th Conference of Italian Thermal Machines Engineering Association, ATI 2014.