CFD Analysis on the Aerodynamic Effects of Spoiler at Different Angle on Car Body

Akhilesh Singh Tomar, Anuj Prajapati, Anuj Sharma, Shubham Shrivastava

Abstract: ***This paper investigates the effect of rear spoiler and the angular effect of spoiler on the aerodynamics of the vehicle. We had analyzed the vehicle for various spoiler angles for coefficient of drag. In this project we had done computational fluid dynamics analysis on a car which we had designed on SOLIDWORKS2016x 64 Edition. After which we had done CFD analysis on the designed model usingANSYS 15.0and the module used for the analysis was FLUID FLOW (FLUENT). The aerodynamics of vehicle was analyzed at constant velocity for various spoiler angles with respect to ground. The comparison between the vehicle with spoiler and without spoiler is also done. The computational results with spoiler are compared with the experimental data. The results of the CFD analysis are somewhere very close to exact but are approximate as we had done 1000 iterations. In the analysis we the used spoiler at various angle i.e. 0, 10, 20 and 30 degree. In the analysis we got the results for coefficient of drag and drag force.***

Keywords: Drag Force, Spoiler, Drag coefficient, CFD, Ansys 15

Abbreviations used:

A – Area (m^2)
P – Density of air (Kg/m^3)
C_d- Coefficient of Drag
F_d- Drag force (N)
P- Pressure (kPa)
V- Velocity (m/s)
L- Length (mm)
µ- Viscosity (Kg/m-s)

I. INTRODUCTION

Aerodynamics of vehicle plays a vital role in the modern world. As aerodynamics study can help in achieving the maximum output as much as possible. “Aerodynamics is the study of flow of surrounding fluid over a moving element (here car body)”.[1]Due to better aerodynamics the cornering speed and stability of the vehicle increases.
Vehicle aerodynamics makes it more fuel efficient and safer vehicle. Nowadays aerodynamics is widely used for the racing cars to enhance their efficiency in terms of velocity.

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Various forces on the vehicle:

1) Motor force
2) Drag Force
3) Weight of vehicle
4) Normal force

Among these forces we had analyzed the effect of spoiler angle for drag force.
Drag force is the resisting force experienced by the body in the direction of flow of surrounding fluid or in the direction opposite to the motion of the body.Drag coefficient is different for different shapes. It is lowest for streamlined shape and highest for cuboidal shape bodies.Drag force is given as:

$$F_d = (C_d x V^2 x A x \rho)/2$$

There are various factors which affects drag force which are as follows:

1) Spoiler
2) Rear wing
3) Mud flaps
4) Roof racks
5) Windshield wipers

Among these all add on devices we had selected the spoilers for the aerodynamics study of vehicle and its effect on the drag force of vehicle that too on various angle with respect to the ground.
Spoilers: It is an add-on devicewhich is used mostly in high speed cars whose function is to diffuse the unfavorable fluid movement around a body. These are used to reduce the turbulence created at the back end of the vehicle due to pressure difference.[2]
We had used the spoiler at the end of the vehicle and are termed as rear spoiler.
Functions of spoilers are as follows:

1) Better traction control
2) Avoid Lift
3) Increase braking stability
4) Aesthetics

As the spoiler reduces the lift hence provide better ground contact which results in better traction control.
COMPUTATIONAL FLUID DYNAMICS (CFD)
Computational fluid dynamics is the science of predicting fluid flow, heat transfer, mass transfer,
Chemical reactions and related phenomenon by solving the mathematical equations.[3]
Advantages of CFD

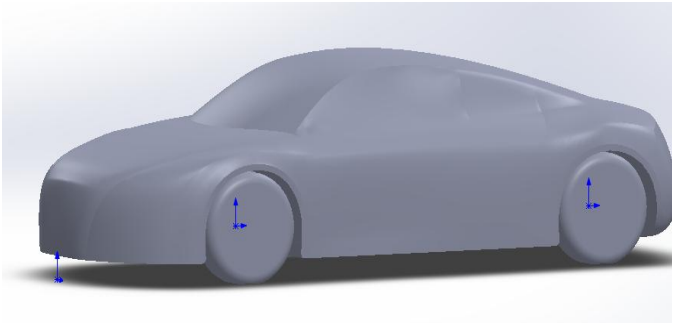
1) Low cost
2) High number of iterations
3) Less time consuming

4) Real time simulations
5) Less error
6) Can examine various locations of vehicle

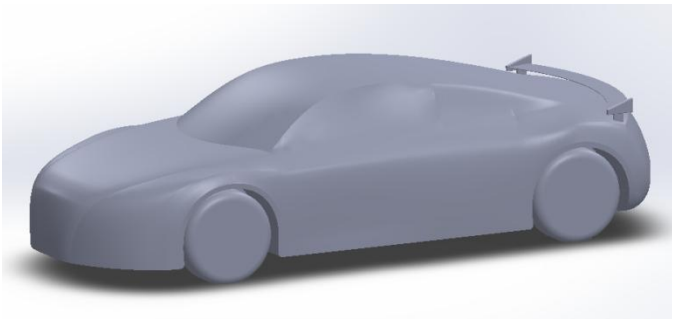
FEA Model

We designed a vehicle model on **solid works 2016 x 64 Edition** and after which we had designed an spoiler and assembled it with vehicle at several angles.

WITHOUT SPOILER



WITH SPOILER



COMPUTATIONAL MODEL (NUMERICAL SCHEME AND BOUNDARY CONDITIONS)

Space	3-D, Pressure based
Time	Steady
Viscous	Spalartallmaras

BOUNDARY CONDITIONS

Fluid	Air
Solid	Aluminum
Velocity Inlet	25 m/s
Density	1.225 Kg/m^3
Viscosity	1.7894e-04
Pressure outlet	Ambient(Gauge 0)
Wall	No slip

DESCRETIZATION SCHEMES

Pressure	Second order
Momentum	Second order upwind
Turbulent Kinetic energy	First order upwind
Turbulent Dissipation rate	First order upwind
Wind Tunnel	Cuboidal
Mesh	Tetrahedral-Default

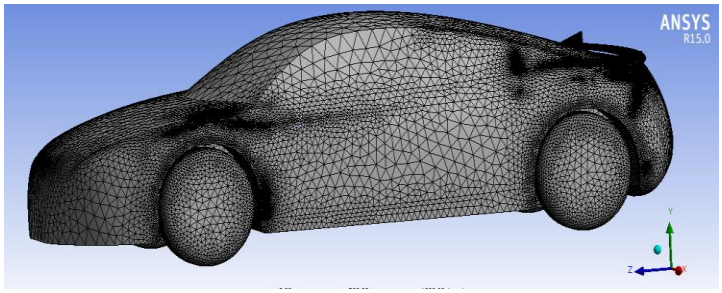
MATERIAL PROPERTIES

Density (Kg/m3)	2719
Specific heat (J/Kg-K)	871
Thermal Conductivity (w/m-k)	202.4
Magnetic permeability (h/m)	1.257e-06
Electrical conductivity (1/ohm-m)	3.541e+07

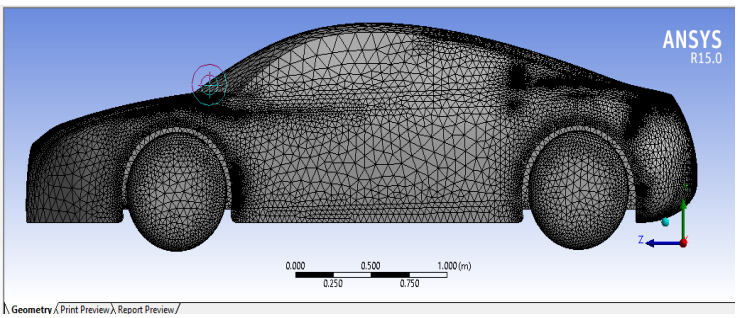
METHODOLOGY

1) Designed CAD Model
2) Imported Model to ANSYS
3) Mesh Generation

MESH WITH SPOILER



MESH WITHOUT SPOILER



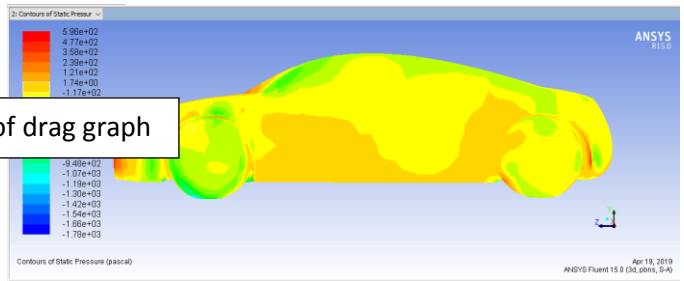
4) **Selected the material for car body.**
5) **Given Boundary condition.**
6) **Added drag option from monitors.**
7) **Hybrid initialization**
8) **Run Calculations (1000 iterations)**
9) **Results and solutions**

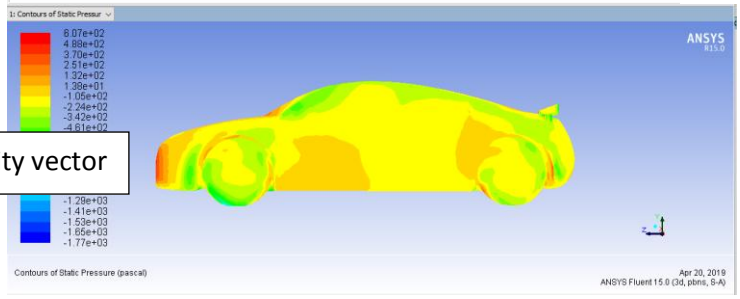
CFD RESULTS

Vehicle without spoiler

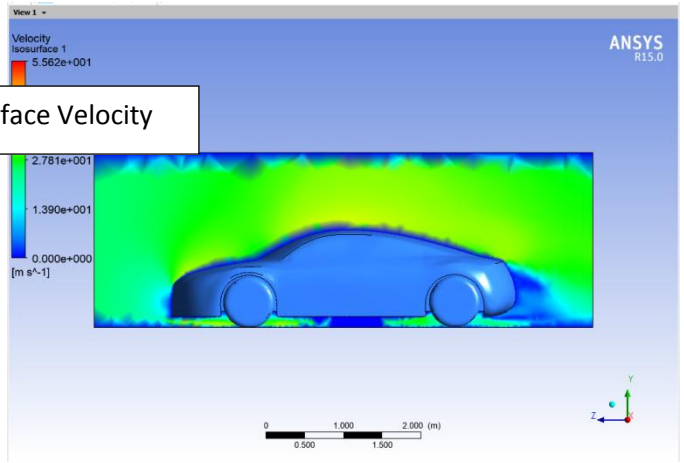
Vehicle with 0 degree spoiler

Coefficient of drag graph

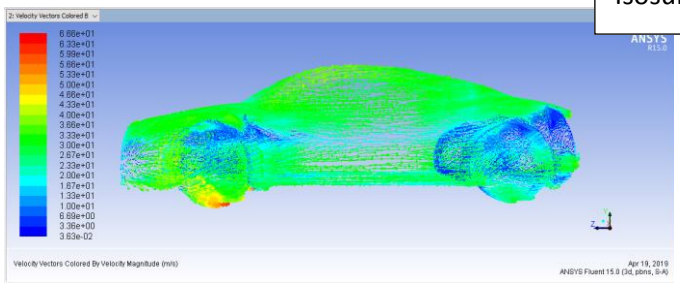


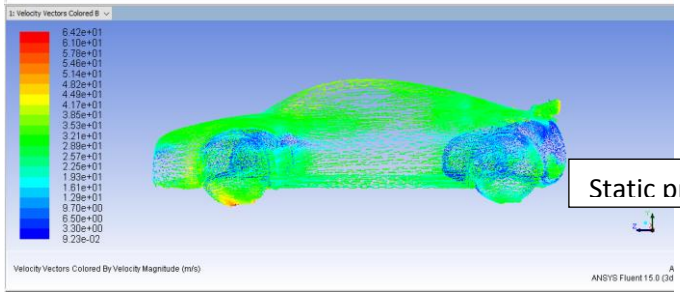


Velocity vector

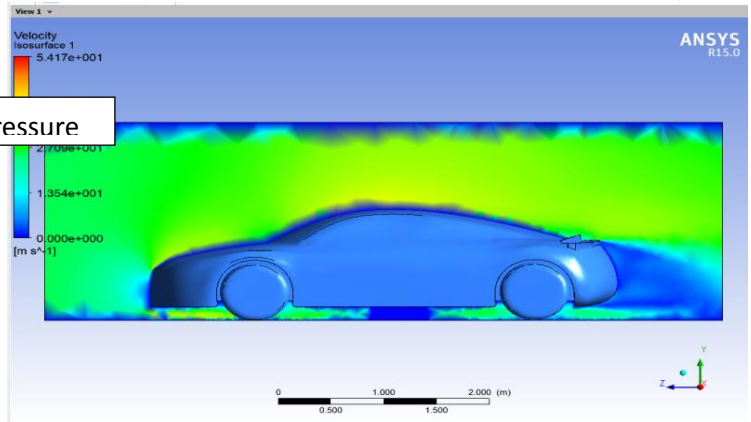


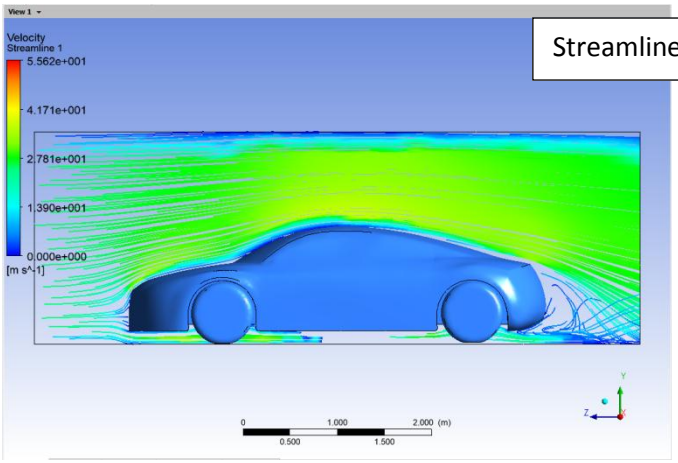
Isosurface Velocity



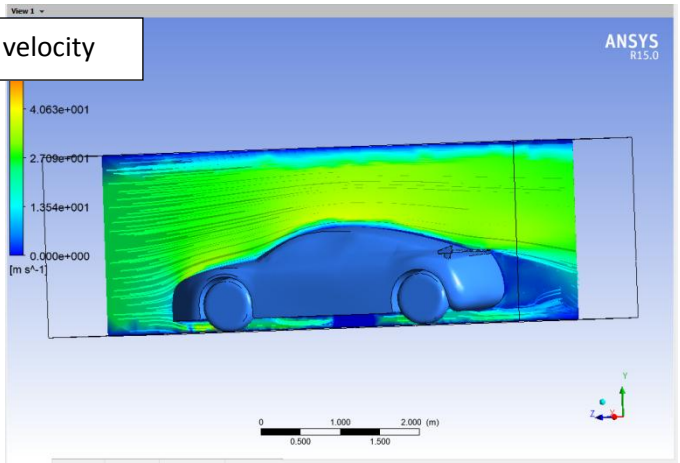


Static pressure



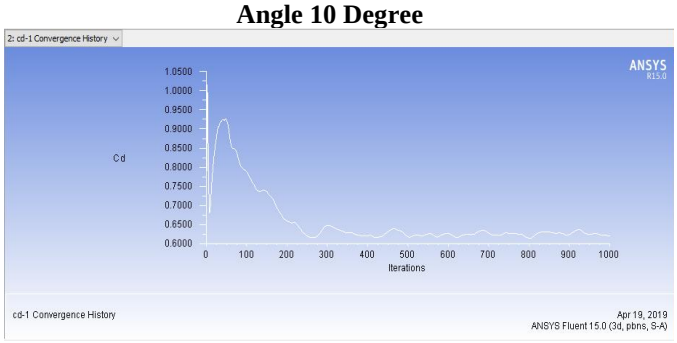


Streamline velocity

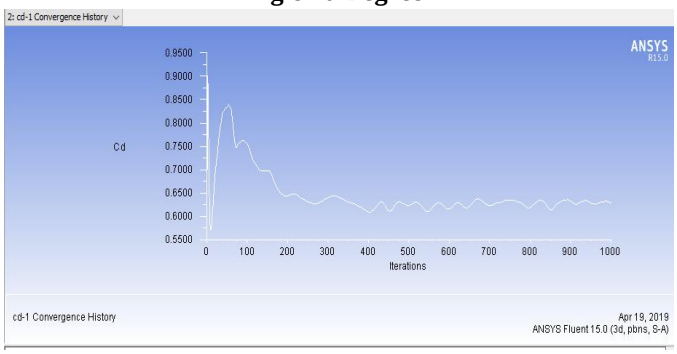


Other Drag coefficient graph for different angles

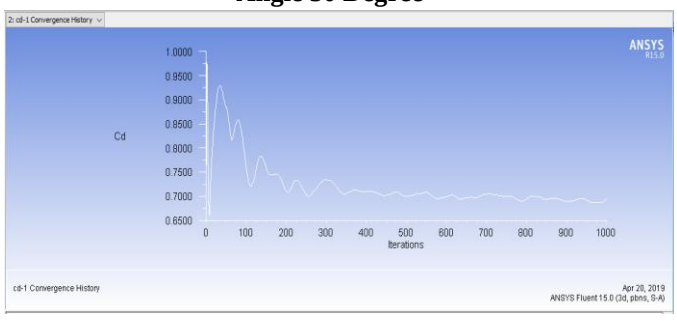
Angle 10 Degree



Angle 20 Degree



Angle 30 Degree



COMPARISION TABLE

CONDITION	COEFFICIENT OF DRAG	DRAG FORCE
Without spoiler	**0.628759**	**472.838**
Spoiler 0 degree	**0.615661**	**473.397**
Spoiler 10 degree	**0.619300**	**471.157**
Spoiler 20 degree	**0.628789**	**483.050**
Spoiler 30 degree	**0.694949**	**536.740**

CONCLUSION

The drag coefficient here first decreased when we used spoiler at zero degree angle with respect to ground and further it increased with increase in the angle with respect to the ground.

The coefficient of drag in case of 0 degree angle decreased by **0.013098** then it was earlier without spoiler. The coefficient of drag in case of 30 degree increased by **0.06619** then it was earlier in without spoiler.

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