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# Design and Analysis of an Adaptive Spoiler for Optimum Performance and Control of Racing Cars

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**ABSTRACT:** The lateral stability and the safety of road vehicles is dependent on the vehicle design and operating conditions. Under operating conditions such as slippery roads, high lateral acceleration and tight cornering, the forces and torques due to the interactions between the tire and road may be saturated. Various active safety systems have been proposed and developed to mitigate these concerns but they all work based on the manipulation of tire forces. Thus, the capability of the current active safety systems cannot go beyond the performance limitation determined by the interactions between the tire and road. On the other hand, at high speeds, significant down force can be generated by employing aerodynamic wings on the vehicle body to enhance its road holding ability. A split rear wing is proposed to control the aerodynamics of high-speed road vehicles to closely manipulate the dynamics of the vehicle.

**keywords:** Road vehicles; lateral stability; active safety systems; aerodynamic control; split rear wing; Active Aerodynamics Control, vehicle dynamics and control, active spoiler, longitudinal load transfer, normal load distribution, yaw rate control, active controller, vehicle active safety.

## I. INTRODUCTION

The movement of a road vehicle is primarily due to the forces generated at the tire-road interface. However, tire forces are limited by the maximum adhesion capability between the tire-road interface. The maximum adhesion capability is a function of the vertical load on the tire and tire-road friction coefficient. Scenarios, such as negotiating around a tight corner at a high speed, travelling on slippery surfaces, etc., may result in losing traction and lateral stability of a vehicle, thereby leading to a large number of road accidents all over the world. Therefore, there is a crucial need to supplement the tire forces to increase the safety of road vehicles and, in particular, those travelling on curved paths at high speeds. Intelligently manipulating the aerodynamics of high-speed road vehicles may meet the critical requirement. Many vehicle technologies, including driver assistance systems, have greatly amended vehicle safety. Technologies such as the Anti-lock Braking System (ABS) or Electronic Stability Control (ESC) decrease vehicle accidents by providing assistance to the drivers during emergency manoeuvres. Four Wheel Steering (4WS) and the Torque Vectoring System (TVS) allow increasing the safety margins and also improving vehicle performance. Automotive engineers try to introduce and improve new technologies to enhance the handling and safety of vehicles. The aerodynamic forces represent one element that deeply influences the vehicle response, especially at high speed. The two main aerodynamic forces are the lift/downside-force and drag. Wings are commonly used in airplanes for the purpose of generating upward forces or lift. Wings may be inverted to create down forces or negative lift. By employing an inverted wing on the rear end of a road vehicle, downside forces can be generated on the vehicle body to increase the road holding capability. On the other hand, the accompanying drag hampers the longitudinal performance of the vehicle in situations which doesn't involve braking.

However, a split rear wing can be used to generate a corrective yaw moment by means of setting different attack angles for the right and left wings, thereby improving the yaw stability of the vehicle. This is achieved by the resultant difference between the down forces on the right and left tires. The split allows for the elimination of unnecessary drag forces. Moreover, the split wing can also be used to favourably manipulate the lateral load transfer during cornering manoeuvres. To improve the lateral stability and increase the safety of road vehicles, the proposed split wing should be intelligently controlled and manipulated considering the current vehicle dynamic states, which are determined by the operating conditions, e.g., vehicle forward speed, straight line or curved path, dry or wet road surfaces, etc.

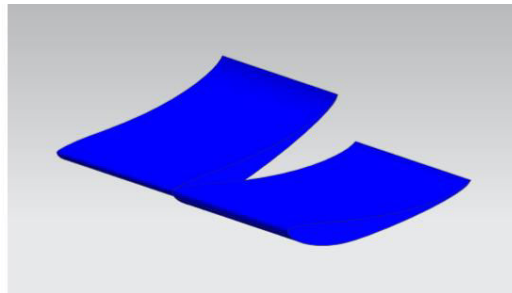


Figure 1: Spoilers for different flow conditions

## II. EXPERIMENTAL SETUP AND METHODOLOGY

Collection of suitable airfoil designs from the literature survey, to make a 3d cad model using any readily available modelling software's in the market (e.g., fusion 360, AutoCAD, etc). Further all the 3d models of the AAC spoilers were integrated with the CFD software. Then carried out flow simulation over the spoilers for different flow conditions. Results were obtained.



Figure 2: Spoilers

## III. CFD MODELLING

Computational fluid dynamics (CFD) is the mathematical simulation of flow based on the governing equations, turbulence models and different types of solvers. CFD codes are numerical algorithms to solve fluid flow problems. A CFD program is based on three main modules, the pre-processor, the solver, and post processor. The pre-processor contains all the input selections which are used to solve a fluid problem; the solver contains the numerical solver which performs the integration of the governing equations, Navier-Stokes equation and turbulence models. The post processor performs the analysis of the calculated flow problem in terms of visualization, force calculation, particle tracking, and many more.

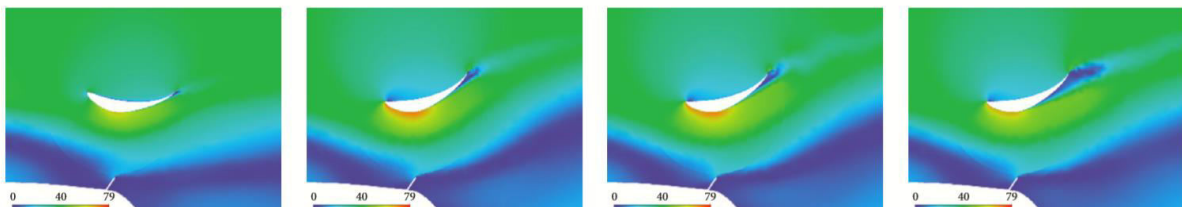


Figure 3: Flow visualisation

## IV. MULTI-ELEMENT AEROFOIL DEVELOPMENT

A multi-element aerofoil was developed to be used for the front and rear wing of the vehicle. Selection of five aerofoils was analysed in the ANSYS software to determine a suitable candidate the multi-element configuration. The aerofoil was chosen due to their high lift characteristics.



SR.NO.	AIRFOIL
1	S 1223
2	S 7055
3	NACA 7412
4	E 423

**V. PREPARATION OF CAD MODEL**

The coordinates obtained from the Design FOIL workshop software are fed into CATIA sketcher and then extruded up to one meter, this gives the foam part and then the same coordinates are used to form the skin by giving thickness as 3mm and then extruding up to 1.3m.

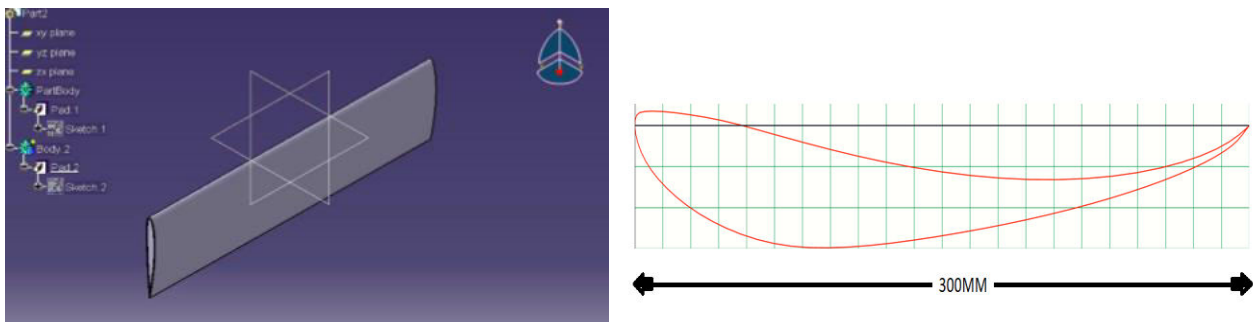


Figure.4: CATIA Sketcher

**VI. RESULTS**

SR.NO.	AIRFOIL	LIFT	DRAG	L/D
1	S 1223	128kg	15.5kg	8.25
2	S 7055	68.3kg	4.66kg	14.65
3	NACA 7412	95.6kg	8.9kg	10.74
4	E 423	117.5kg	16.08kg	6.99

Table 1: Results for CFD Calculation



After doing analysis of all the four spoilers as mentioned above in ANSYS FLUENT using laminar flow (k epsilon) at flow velocity of 300km/hr, the conclusion is made that the spoiler having highest L/D ratio is of S 7055. And thus this airfoil is most optimum for spoiler design.

#### REFERENCES

- [1] Arash Hosseinian, Ahangrnejad and Stefano Melzi 2018. Numerical analysis of the influence of an actively controlled spoiler on the handling of a sports car
- [2] P. Gunasekar, S. Manigandan, Dr. K. Vijayaraja, Dr. Anderson, S. Venkatesh, Rakesh Vimal & R. Gokulnath 2019. Numerical analysis of an automatic deployment to enhance the down force of the vehicle
- [3] Robert J. Englar 2001. Advance Aerodynamic Devices to Improve the Performance, Economics, Handling and Safety of Heavy Vehicles
- [4] Krzysztof Kurec, Michal Remer, Jakub Broniszewski, Przemyslaw Bibik, Sylwester Tudruj, and Janus Piechna 2019. Advance Modeling and Simulation of Vehicle Active Aerodynamic Safety
- [5] Zhaowen Deng, Sijia Yu, Wei Gao, Qiang Yi, Wei Yu 2020. Review of effects the rear aerodynamic analysis on ground vehicle performance
- [6] [https://scholarcommons.scu.edu/cgi/viewcontent.cgi?article=1000&context=mech\\_mstr](https://scholarcommons.scu.edu/cgi/viewcontent.cgi?article=1000&context=mech_mstr)
- [7] [https://www.researchgate.net/publication/323906437\\_Effect\\_of\\_Spoilers\\_on\\_Aerodynamic\\_Properties\\_of\\_Car](https://www.researchgate.net/publication/323906437_Effect_of_Spoilers_on_Aerodynamic_Properties_of_Car)
- [8] [https://www.researchgate.net/publication/320876955\\_Fluid\\_Dynamics\\_Simulation\\_Of\\_a\\_Car\\_Spoiler](https://www.researchgate.net/publication/320876955_Fluid_Dynamics_Simulation_Of_a_Car_Spoiler)
- [9] [https://www.academia.edu/36215751/Effect\\_of\\_Spoilers\\_on\\_aerodynamic\\_properties\\_of\\_a\\_car](https://www.academia.edu/36215751/Effect_of_Spoilers_on_aerodynamic_properties_of_a_car)
- [10] [https://www.ripublication.com/ijmer\\_spl/ijmaerv5n1spl\\_23.pdf](https://www.ripublication.com/ijmer_spl/ijmaerv5n1spl_23.pdf)





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