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CFD Aerodynamic Analysis of Spoiler and Splitter

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ABSTRACT

This study examines how the addition of spoilers and splitters impacts the airflow around vehicles using CFD analysis. This research here uses Catia V5 designing software to create models of spoilers and splitters and Ansys Fluent analysis software for simulations to study the flow of air. This research here demonstrates that the addition of spoilers and splitters to a car can improve its performance analyzing airflow around the vehicle. This paper shows that these changes make the car more aerodynamic and steadier.

Keywords: Ansys Fluent, Catia V5, CFD, Splitter and Spoiler.

INTRODUCTION

The automobile sector has seen a significant advancement in design and performance driven by advances in innovation and engineering. One crucial aspect of this advancement is the integration of streamlined components such as spoilers and splitters which were traditionally seen on high-performance vehicles into more budget-friendly models. These components play a really critical part in upgrading the vehicle's aerodynamic performance, stability, and fuel efficiency. Spoilers and splitters are streamlined gadgets strategically set on the outside of vehicles to modify airflow around the vehicle. Spoilers typically mounted on the back side of the vehicle work by reducing aerodynamic lift and drag improving stability at higher speeds. On the other hand, splitters found at the face of the vehicle manage airflow underneath decreasing lift and improving downforce. This upgrades grip and stability particularly during cornering which are very important for drivers. This can impact the performance up to a big extent.

RELATED WORK

Krishna S Nair [1] carried out the flow examinations on numerous cars of different body types like Sedan, Hatchback and SUV. They performed the CFD analysis of these vehicles using the Ansys Fluent Software. Also, the pressure and velocity distribution were done for three different velocities 30m/s, 50m/s and 75m/s. They concluded that the Sedan body type car is more agile and aerodynamically effective than the Hatch Back and SUV vehicle models.

Dan BARBUT [2] did analysis to illustrate the significance of the CFD analysis considering the air flow beneath the car. For the flow analysis, they selected Sedan body type of cars. For their study and analysis, they optimized the design of vehicle’s bottom section and found out that the drag was reduced from the initial value of 0.2411 to 0.2105, that is the reduction of drag force by 12.7%.

R.Varun [3] expected to decrease the aerodynamic drag by considering the flow field around the car. They compared the results of the current model and the new model adding the duct to the top of a sedan car. They carried out analysis using ANSYS Fluent Software, and the car 3D model was created using CATIA V5 Software. They concluded that the modified model has a less pressure drag as the pressure difference at front and the rear end is low.

Daniel Syafiq Baharol Maji [4] The goal of their research was to see how adding a rear spoiler to a car affects how air moves around it and how stable it is. Both the car vehicle demonstrates with and without the raise spoiler models were built utilizing CAD computer program. Then the data was analyzed in CFD software to identify the downforce and lift acting of the at motion at various velocity i.e. 16.67m/s, 25m/s and 30.56m/s. Drastic increase in lift force and drag force was seen by rear wing while slight increase was seen in ducktail spoiler. Their result showed that a slow-moving vehicle has more air resistance than a fast-moving vehicle.

METHODOLOGY

Project Statement

This study centers on the CFD aerodynamic examination of automobiles, emphasizing the importance of aerodynamics in upgrading the performance and effectiveness of economical cars. It particularly analyzes the role of spoilers and splitters for optimizing the aerodynamic productivity of vehicles, thereby improving steadiness and fuel efficiency. The examination points to provide valuable bits of knowledge into how these components can be utilized to optimize the streamlined design of budget vehicles, eventually contributing to a more sustainable and economical car industry.

Solid Modeling

The spoilers and splitters are modeled using CATIA V5a flexible modeling software. CATIA V5's advanced features and capabilities are utilized to make exact and detailed 3D models of the spoiler and splitter components. By utilizing CATIA V5, the modeling stage was conducted proficiently, allowing for precise control over the design parameters and ensuring that the final models are optimized for aerodynamic performance.

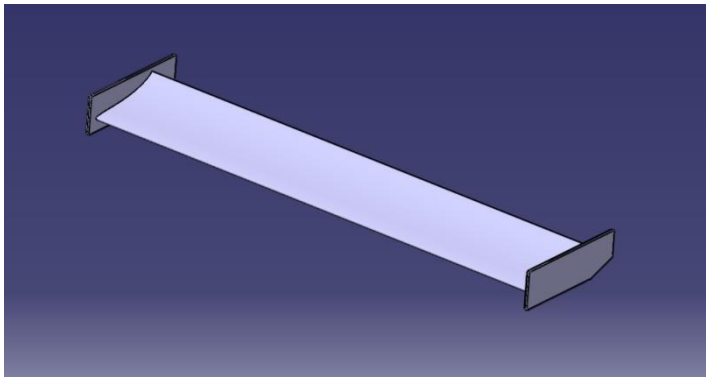

Figure 1: Design of Spoiler

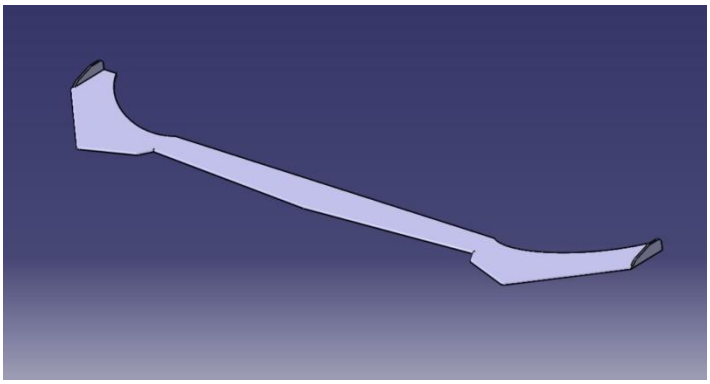

Figure 2: Design of Splitter

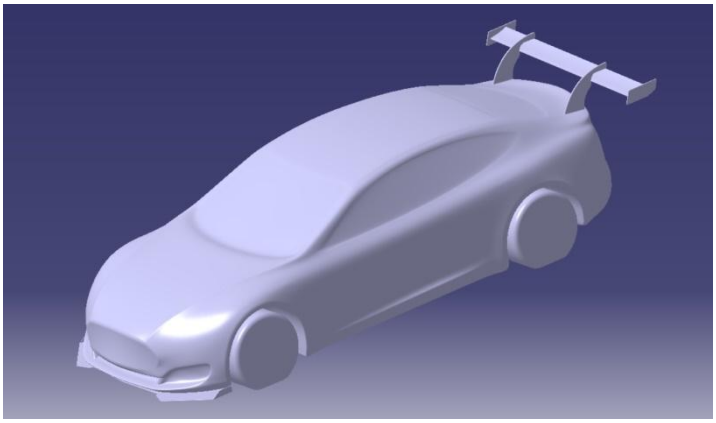

Figure 3: Design of Assembly

Meshing

Meshing plays a significant role in CFD aerodynamic examination of vehicles by discretizing the vehicle surface into small elements, permitting for precise flow simulation. It specifically impacts the precision and productivity of the examination, as the mesh quality influences solution convergence and result exactness. Proper meshing techniques, such as utilizing structured or unstructured meshes, are basic for getting reliable aerodynamic results.

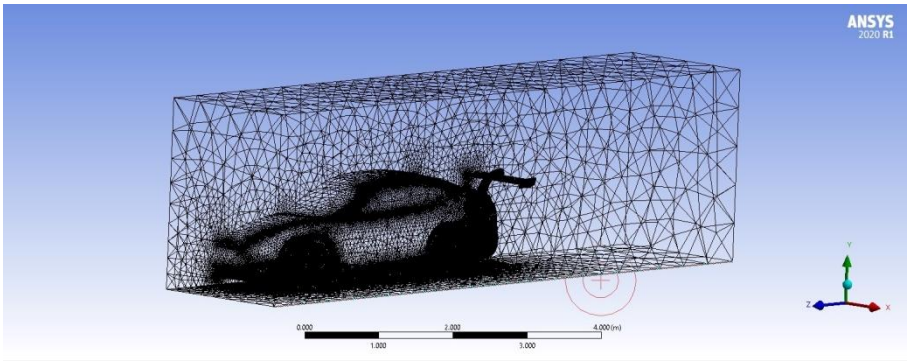

Figure 4: Meshing of Car with Spoilers and Splitters

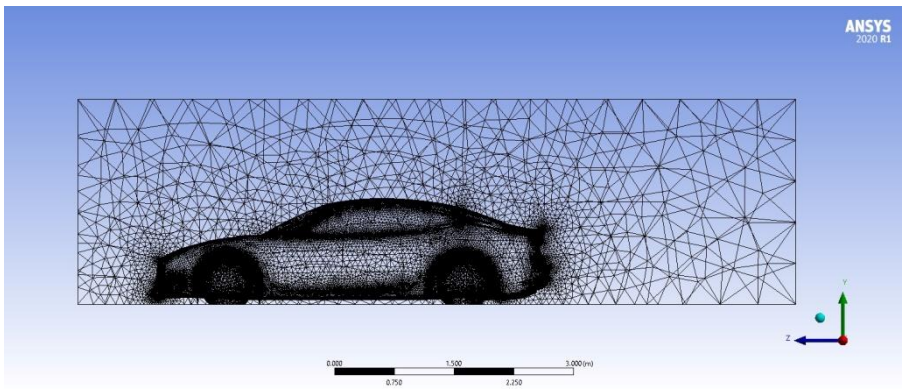

Figure 5: Meshing of Car without Spoilers and Splitters

Boundary Conditions

In CFD aerodynamic analysis of vehicles, boundary conditions characterize the flow behavior at the domain boundaries, influencing simulation accuracy. Appropriately defined boundary conditions, such as inlet velocity and wall conditions, ensure realistic flow simulations. Ansys Fluent offers different boundary condition options, permitting users to precisely mimic complex flow phenomena around vehicles. Understanding and implementing suitable boundary conditions are essential for getting reliable aerodynamic results.

1. Inlet Velocity Magnitude = 28m/s
2. Wall Motion = Stationary Walls

RESULTS AND DISCUSSIONS

Spoiler and Splitter Improve Car's Handling at High Speeds.

This data analysis showcases the significant aerodynamic enhancements achieved by equipping a car with a spoiler and splitter.

Down force Generation

A key advantage is the considerable downforce produced by the spoiler and splitter. The lift force on the vehicle is reduced from a positive value of 111.395 N (lift) to a negative value of -321.871 N (downforce). This downforce presses the vehicle towards the road, improving grip and stability during high-speed maneuvers and cornering.

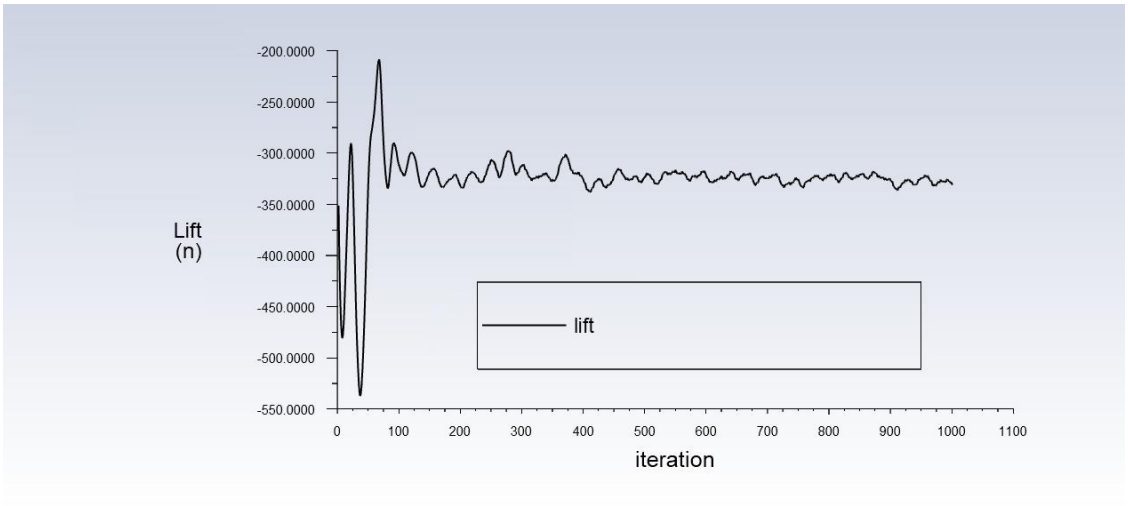

Figure 6: Iteration vs. Lift Force Graph of Car with Spoiler and Splitter

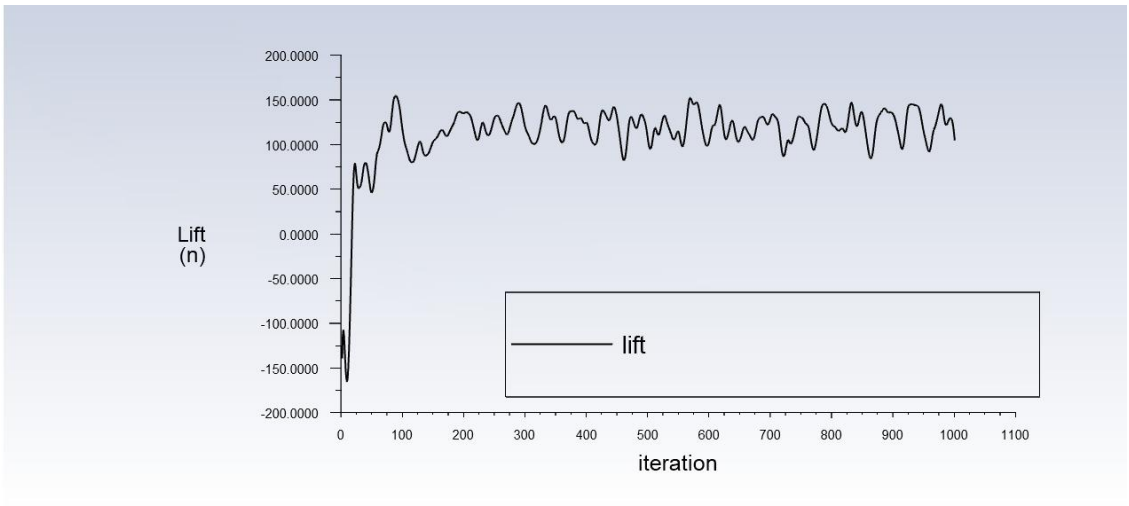

Figure 7: Iteration vs. Lift Force Lift of Car without Spoiler and Splitter

Increased Drag

Whereas the drag force on the car does increment slightly with the addition of the spoiler and splitter (394.996 N compared to 346.036 N without), the gain in downforce far outweighs this downside. The car gets to be more planted and predictable at high speeds, improving driver confidence and safety.

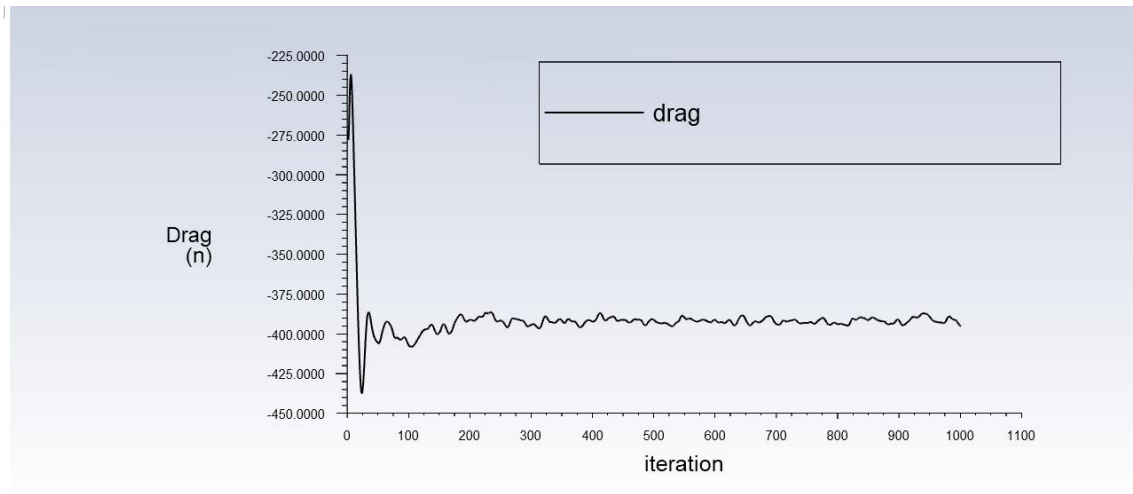

Figure 8: Iteration vs. Drag Force Graph of Car with Spoiler and Splitter

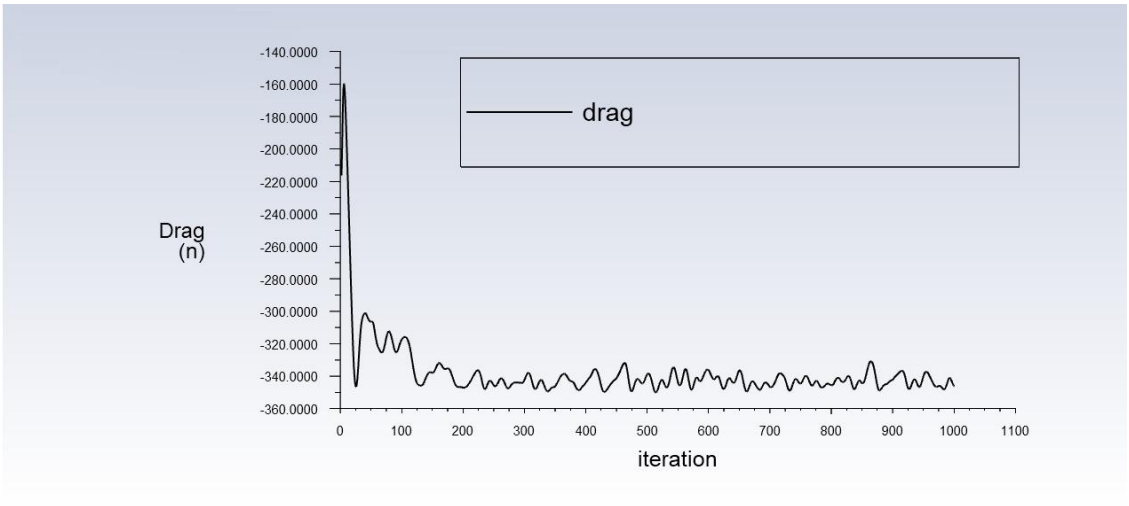

Figure 9: Iteration vs. Drag Force Lift of Car without Spoiler and Splitter

Optimized Lift-To-Drag Ratio

The lift-to-drag ratio could be a significant metric in aerodynamics. A positive ratio shows lift, whereas a negative ratio means downforce. The car without the spoiler and splitter has a ratio of 0.320 (lift), whereas the car equipped with spoiler and splitter boasts a much better ratio of -0.814 (downforce). This negative value emphasizes the effectiveness of the spoiler and splitter in generating downforce and improving handling.

Reduced Front Pressure

The data shows a lower pressure at the frontal area of the car equipped with the aerodynamic components (741.712Pa) compared to the car without (795.637Pa). This suggests the spoiler and splitter work together to manage airflow, potentially reducing air resistance at the front end. The addition of the spoiler and splitter resulted in a pressure difference of 53.925Pa at the frontal area of the car.

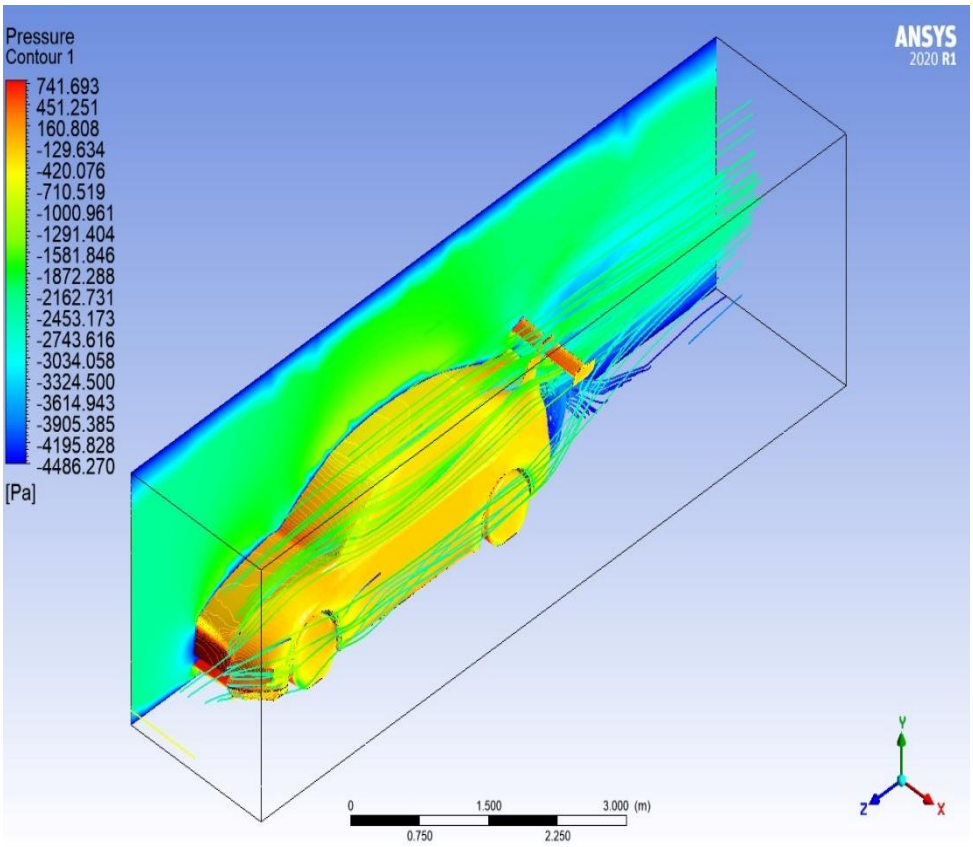

Figure 10: Pressure at Front of Car with Spoiler and Splitter

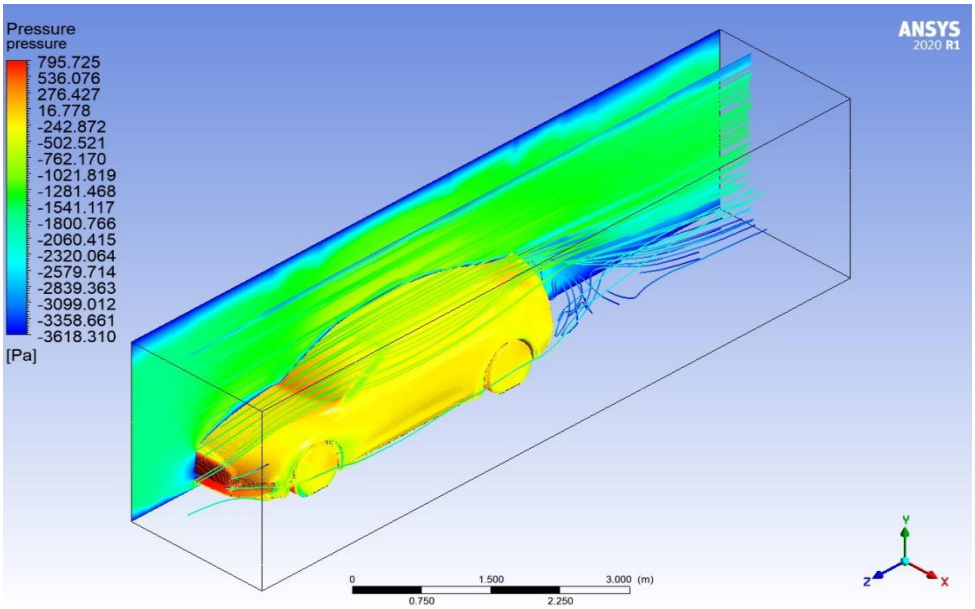

Figure 11: Pressure at Front of Car without Spoiler and Splitter

CONCLUSION

The data clearly illustrates the advantages of using a spoiler and splitter for improved car handling. Whereas there's a slight increment in drag, the critical downforce generation and optimized lift-to-drag ratio translate to better stability and control at high speeds, giving the car driver a safer and more enjoyable driving experience. As the pressure at front of the car decreases by 53.925Pa.

Table 1: Comparision Of Results

Model	Car with Spoiler and Splitter	Car without Spoiler and Splitter
Lift Force	-321.871N	111.395N
Drag Force	394.996N	346.036N
Lift Force to Drag Force Ratio	-0.814	0.320
Pressure at Front	741.712Pa	795.637Pa

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