STUDY AND MODIFICATION OF AERODYNAMIC BEHAVIOUR OF CAR

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Abstract **: The aim is to study and modify car body by keeping concepts and phenomena of automotive aerodynamics in consideration. In first phase, detail study of aerodynamic behavior of a car segment by considering drag coefficient, frontal pressure, rear vacuum and down-force. To measure drag coefficient in particular and observing airflow around the body numerical and CFD analysis is to be used. At the same time to decrease vehicle's resistance and to increase down-force, a comparative numerical analysis is to be performed. There are two means of measuring the drag, the first is by simulating the air flow via computational fluid dynamics (CFD) suite, and the second is by using wind tunnel experiment. For practical analysis approach, wind tunnel set up can be used. As a result of this project we will be able to get a perfect aerodynamic car design with reduced drag-force, higher efficiency, better performance and less fuel consumption.**

***Keywords* :** Automobile Body, CFD Analysis, drag-force,

I. INTRODUCTION

Modification of selected car model Mercedes Benz AMG-CLA resulting in an aerodynamic design model, main factors affecting its design process and possible modification are Drag force, Lift, Downforce, Frontal pressure, and Rear vacuum.

• Main factors affecting Segment-model Modification are……………….

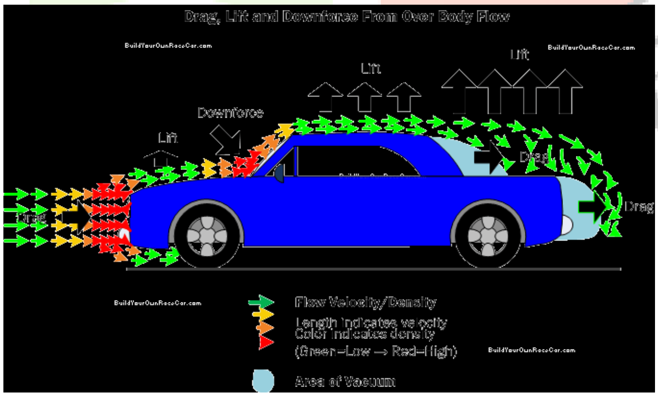
1) Maximum Drag Reduction

2) Minimum Lift and Rear Vacuum Generation

3) Optimum Downforce for Traction

4) Reduction as well as Effective Management and Utilization of Frontal Pressure

Further in process various components which can be modified to achieve these mentioned factors are Front Bonnet Grille, Boat Tail, Wheel Skirts and Ducts which are widely used to improve car design. Main consideration of Coefficient of Drag is taken in order to compare any car model with ideal aero-foil.



II Literature reviews:

Paper 1) Basics of vehicle aerodynamics: (Prof. Tamas Lajos, University of Rome-2002)

• By the study of this literature we understood various possible shape of automobile vehicle considering relation between pressure flow and streamlines.• Analysis and streamline distribution helps us to understand the behaviour of stream line by adding various components onto the car surface.

Paper 2) Formula-SAE Car: Experimental and Numerical Analysis of the external Aerodynamics: (University of Perugia, Perugia, Italy) • This paper gives brief about SAE Formula Car performance variation criteria based on a good aerodynamic design and CFD analysis.

Paper 3) Road-Vehicle Aero-Dynamics and Thermal Management: (Professor Lennart Löfdahl, Professor Simone Sebben)

• Study of this paper simplifies the effect of aerodynamics as well as thermal management of a passenger vehicle.

• It also provides detailed research of thermal aspects regarding engine, brake cooling with the help of managing air stream while in motion.

Paper 4) Research on Aerodynamic Drag Reduction by Vortex Generators: (Masaru KOIKE, Tsunehisa NAGAYOSHI, Naoki HAMAMOTO) • Various methods to reduce drag generation by eliminating vortex generation cause of tail, mirror and rear wind shield (glass).

• Vortex generation usually cause increment in drag force applied on the surface of the exterior of the vehicle, different drag reduction methods are explained in detailed research to implement on all car segments.

III Basic AIM and Objectives:

In Most of the car main factors affecting its aerodynamic design can be a typical box design, large front area, large surface/cross-sectional area, blunt/ short rear end, etc. Thus, to improve overall design, terminologies under the concept of aerodynamics in which main terms taken in account are frontal pressure, rear vacuum, drag- force, downforce, vortex generation, lift and windage helped to improve overall design of a car segment to achieve solution such as optimum aerodynamic design, improved ergonomic design and aesthetic look, higher efficiency, high speed, and low fuel consumption rate.

IV Problem Specifications:

- Sedan Class car is selected in order to study and analyze effects of aerodynamic terminologies onto the exterior surface of the car body. As sedan class can be used for all mode of transportation, behavior of this segment with terms mainly drag-force, lift, frontal pressure, rear vacuum, and downforce.

Segment Class: Sedan
Vehicle: Mercedes-Benz AMG-CLA 45 Matic

V Components/ Materials / Tools required and its specification:

For Clay Model: -
- Model Clay
- Hydro-Foam (High Density Foam)
- Sculpting Tools
- File (Rough/Smooth/Curved)
- Tenon Saw
- Vinyl Tape / Aluminium Foil

For Wind Tunnel Apparatus: -
- High Grade Metal Sheets
- Mild Steel C-shape Bar
- Glass
- Pressure Gauge (U-Tube Manometer)
- Fan / Blower
- Grille
- Wood Plate
- Smoke / Fog Nozzles
- Metric Grade Fastener

VI Actual Implementation: -

- Major Modifications of the segment parts with its significant effect are listed below:

1) Variable Front Overhang Angle
2) Retractable Spoiler
3) Diffuser
4) Side Skirt & Duct
5) Multi-Position Damper Grille

Listed Modifications are explained in brief bellow:

1) Variable Front Overhang Angle - To reduce contact surface area and to stimulate streamline smoothly.

Research Methodology:
1) Based on Drag Force
2) Based on Lift induced drag
3) Based on Downforce
4) Based on Frontal pressure and Rear Vacuum

1) Based on Drag force

The drag equation

$$F_d = \frac{1}{2} \rho u^2 c_d A$$

Where:

- Fd is the Drag Force
- ṗ is the Density of air
- u is the Velocity of air stream
- Cd is Coefficient of Drag
- A is the Contact Surface Area

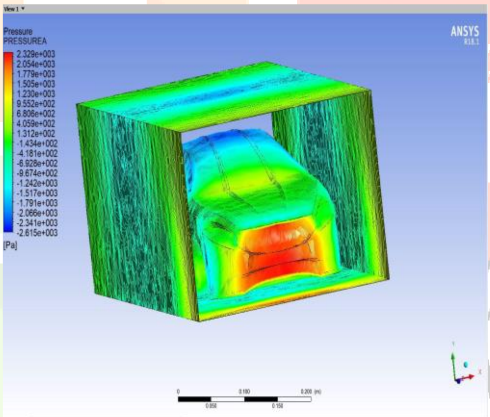
CFX-Analysis:-

As a surface model is procured, Thus in order to analyze the actual implemented modifications it is subjected in a test segment having inlet, outlet and boundary walls having test conditions identical to the actual wind tunnel test conditions such as air stream velocity, pressure, temperature, & humidity which are observed as follows:

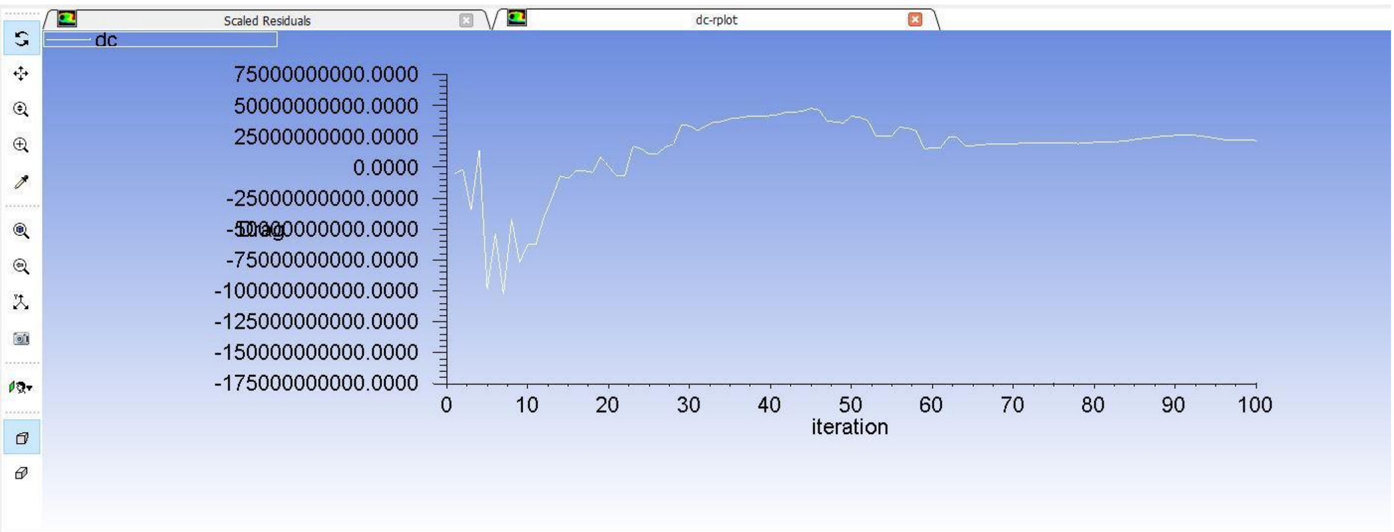
Air Stream Velocity = 80-110 Km/hr
Pressure = 1.01325 bar
Temperature = 22' C
Relative Humidity = 40-60 %

VII Result

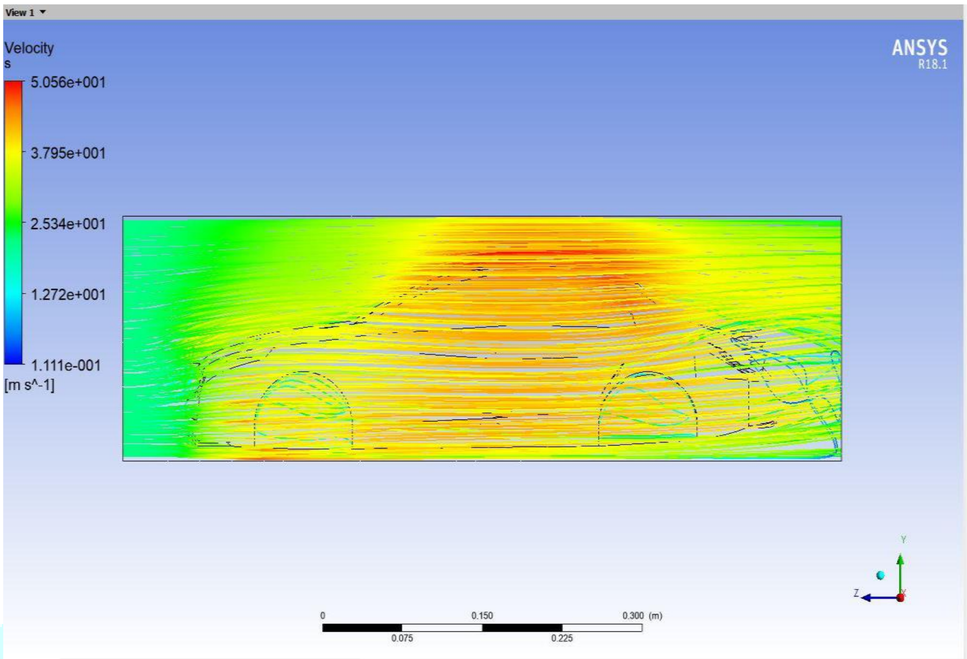
1. Pressure Contour



2) DC Graph



3) Velocity Streamlines



Conclusion:-

As a conclusion analyzed result indicates positive modification outcome in Model: AMG-CLA. Results states that Actual Co-efficient of drag of the car is 0.30 which is reduced by 76.667%, Thus Processing Surface Model in ANSYS-CFX for 70 number of Iterations resulted Modified Co-efficient of drag is 0.23. As combined study and modification of the selected model processed through Numerical as well as CFD analysis resulted as a successful approach to improve the automotive design considering vehicle aerodynamics and performance criterion in as a priority. Multiple iteration & Analytical approach in analyzing Mercedes Benz AMG-CLA concluded with reduced Drag Co-efficient of 0.23.

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