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Aerodynamic Analysis of Motion of Two Vehicles and Their Influence on Drag Coefficient.

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Abstract: Aerodynamics is the study of influence of gases (mostly air) on moving bodies. In automobiles aerodynamics are responsible for lift and drag forces that become an obstacle in its motion. However , if properly controlled their effects can be minimized. This study gets even more interesting, when aerodynamic flow over one vehicle gets influenced by its neighbouring one. This project deals with the study of the influence of fast moving bus on a car. The main focus will be on the transition in the drag coefficient of the car at different speeds. Ansys software is used for simulating the situation. Meshing is done with the help of Ansys Mesh and fluent solver is used for simulation. The main focus will be on the transition of drag coefficient as a function of distance between bus and the car.

Keywords: Aerodynamics, drag coefficient, aerodynamic flow, fluent.

I. Introduction

Automotive aerodynamics is the study of the aerodynamics of road vehicles. Its main goals are reducing drag and wind noise, minimizing noise emission, and preventing undesired lift forces

And other causes of aerodynamic instability at high speeds. Air is also considered a fluid in this case. For some classes of racing vehicles, it may also be important to produce down force to improve traction and thus cornering abilities.

In fig 1. we can analyse the various forces on the car.

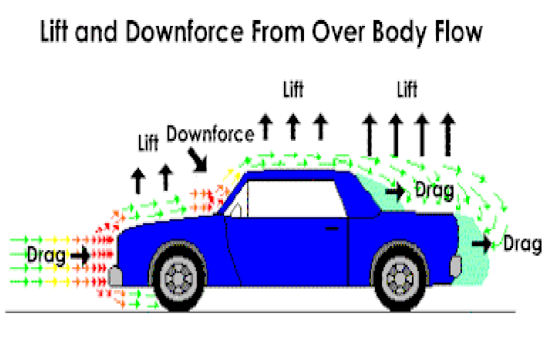

Fig 1. Aerodynamic forces on a car

They can be classified into two types

a) Lift force
b) Drag force

In automobiles, lift force needs to act downwards and drag force needs to be minimized. The primary focus in this research work will be drag force.

Drag force is a frictional force caused by movement of the wind. A lot of energy is wasted in overcoming this friction. So in order to reduce the drag, many design modifications are considered. Even accessories are added in order to divert the air flow. Recently, another method of reducing drag is gaining importance. In order to understand this method, it is important to analyse the influence of one moving vehicle on another; especially in terms of aerodynamic forces.

II. Project Methodology

The project as discussed earlier will deal with the influence of moving bus on a car that is following it at various distances and speeds. The main focus will be on the change in drag coefficient of car as a function of its distance from bus.

A research was conducted in order to identify various design models of car, bus. After taking into consideration the available data, drag coefficient values of vehicles and flexibility in designing the car, bus designs shown I figure 2 are selected.

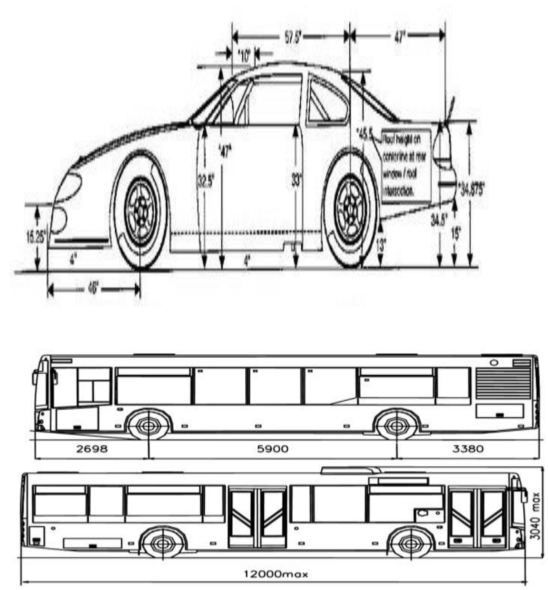

Fig 2. [1,2] Designs of car and bus Designing and Meshing.

The car, bus were designed in Ansys geometry. Ansys meshing was used to used mesh the following dimensions as shown in figure 3.

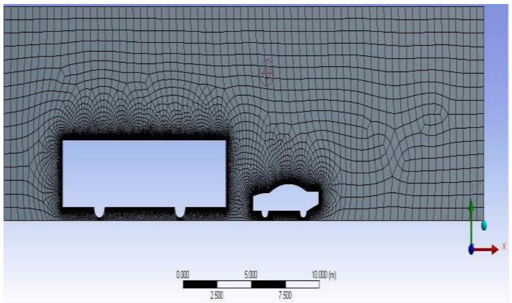

Fig 3. Meshing of bus-car system

Hybrid meshing was used to mesh the 2-D designs. The number nodes and inflation layers were given as follows:
Number of nodes: 79110
Inflation details:
Number of layers: 9
Growth rate: 1.2
Maximum thickness: 0.02 m

Computational experimental setup:

Fluent solver was used to analyses the fluid flow on the bus and car. The entire problem was solved on pressure based criteria (incompressible flow). This was selected based on low velocity values of practical bus and car applications. Spalart Allmaras equation (as shown in figure 4) was used to solve the turbulent parameters.

$$\frac{\partial}{\partial t}(\rho\tilde{v})+\frac{\partial}{\partial x_i}(\rho\tilde{v}u_i)=G_v+\frac{1}{\sigma_{\tilde{v}}}\left[\frac{\partial}{\partial x_j}\left\{(\mu+\rho\tilde{v})\frac{\partial\tilde{v}}{\partial x_j}\right\}+C_{b2}\rho\left(\frac{\partial\tilde{v}}{\partial x_j}\right)^2\right]-Y_v+S_{\tilde{v}}$$

Fig 4.

Spalart Allmaras Equation

The boundary conditions used are as follows:

S No	Boundary	Condition
1	Inlet	Velocity-Inlet
2	Outlet	Pressure-Outlet
3	Top	Stationery Wall
4	Bottom	Moving Wall (velocity same as inlet)
5	Bus	Stationery Wall
6	Car	Stationery wall

All other settings were set at default values. The equation was solved using double order. Drag coefficient of car was monitored. The distance between bus and car, velocity of air was the variable input parameters and drag coefficient, pressure distributions were output parameters.

III. Results and Tables

Initially, car alone was simulated and drag coefficient obtained was 0.88 which is approximately equal to standard data (0.79), even the pressure distributions were similar to the standard ones. This was necessary for validation. Then various distances and input velocities were considered; interestingly the drag value of car started decreasing as the distance and velocity increased. However, after a certain point the drag coefficient again started increasing to reach its original value. The highest change in drag coefficient was observed at 13 meters. Figure 6 shows the variation of drag coefficient with distance at 40 kmph and 60 kmph.

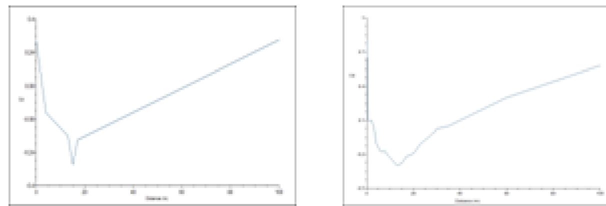

Fig 6(a). At 40 kmph 6(b). At 60 kmph

The influence of moving bus on car drag coefficient is shown in figure 7. As we can see there is a drop in drag coefficient due to moving bus.

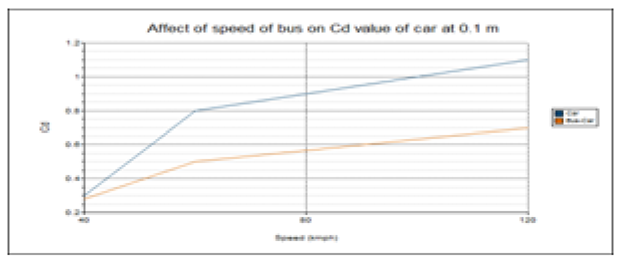

Fig7.Affect of speed of bus on Cd value of carAt 0.1m

The various points of transition of drag coefficient and their values for different values are as follows:

Speed / Points	60 kmph	60 kmph	40 kmph
	Distance (m)	Value	Value
1	0.1	0.5	0.28
2	4	-0.1	-0.05
3	13	-0.3	-0.3
4	30	0.026	0.02

A significant change was also seen in pressure contours at transition points with velocity of 60 kmph as shown in figure 8

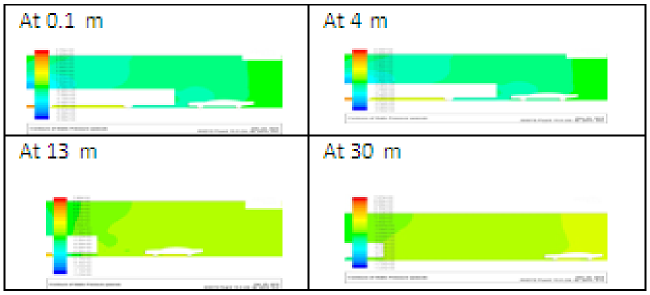

Fig 8. Pressure contours at 60 kmph

IV. Conclusion

The results reveal that as speed increases the amount of decrease in drag coefficient also increases. Initially as distance increases, the drag coefficient starts decreasing. However after a certain distance, the drag coefficient starts increasing. Within optimum distance, the car can take an advantage of the moving bus to move at the same speed with less energy utilization to overcome drag. As the drag coefficient reaches a negative value, the car can take maximum advantage with almost zero utilization of energy to overcome drag.

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