INVESTIGATION ON DIMPLE INSPIRED MITIGATION OF AERODYNAMIC DRAG OF INTERCITY BUS



OUTLINE

- Introduction.
- Problem Statement.
- Methodology.
- CAD Model.
- Numerical simulation.
- Experimental results.
- Comparative study.
- Conclusion.

INTRODUCTION

- Bus transport is the essential part of everyone's life and if we look into the business point of view it is mostly non profitable.
- We can see it in many points of view, but to see it in an engineers perspective modifications and optimizations that can be done to improve the performance if the vehicle to lower the consumption of fuel.
- In this case, both the public as well as the companies/Government can make a considerable amount of profit.

PROBLEM STATEMENT

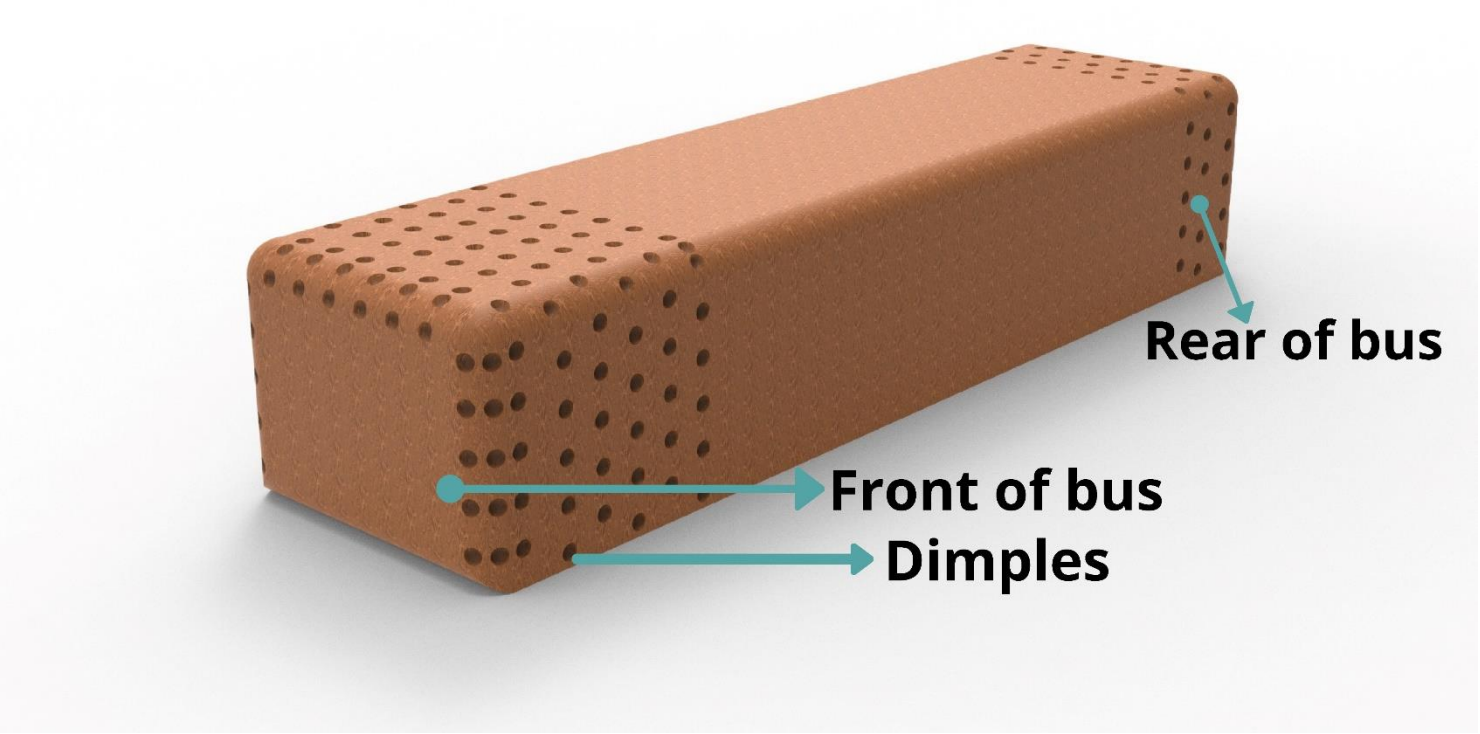
- There are lots of parameters which contribute to the fuel consumption in an intercity bus such as Rolling resistance, climbing resistance and aerodynamic drag.
- Among these the aerodynamic drag is the one contributes most to the high fuel consumption.
- From the literature survey, it is found that the aerodynamic drag part can be a possible variable to change and to reduce it, the design modification of specific parts of the bus can be done and analysed.
- In this article, we have done a design modifications to a standard bus and analysed it with available CFD codes and validated them with experimental tests to achieve drag reduction.

METHODOLOGY

- It is obvious that the most part of the drag was due to the frontal area of the bus and due to its larger area, it produces high pressure drag.
- The sides of the bus contributes in the form of skin friction drag.
- The idea is to modify the design of the outer body of the bus without affecting the comfort of the passengers.
- The dimensions of the bus were scaled down and with the help of CATIA, a CAD Model with the calculated dimensions were generated.
- Dimples are generated in the same model and flow analysis are conducted and the variation of C_d and drag forces are investigated.

CAD MODEL

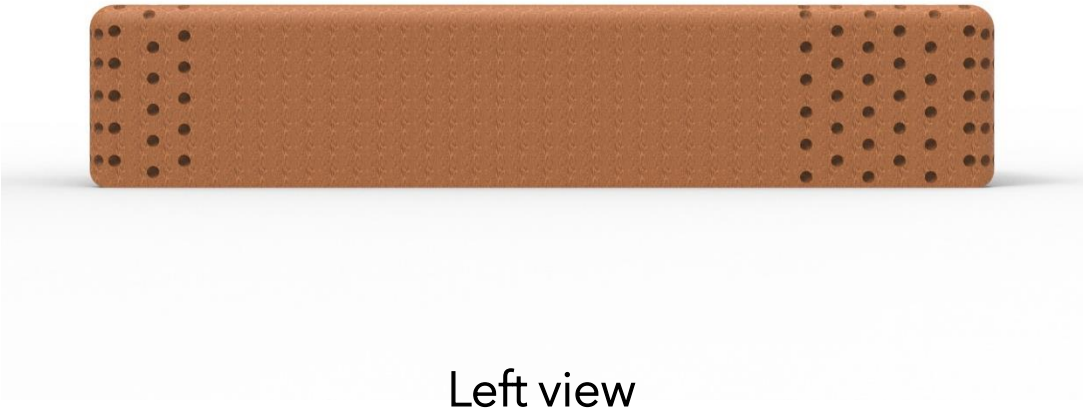
ISOMETRIC VIEW



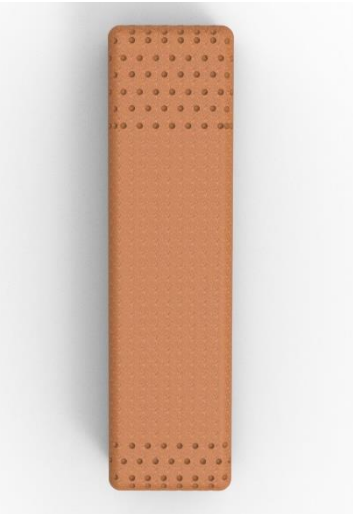
MULTI VIEW



Front view



Left view



Top view

NUMERICAL SIMULATION

BOUNDARY CONDITIONS

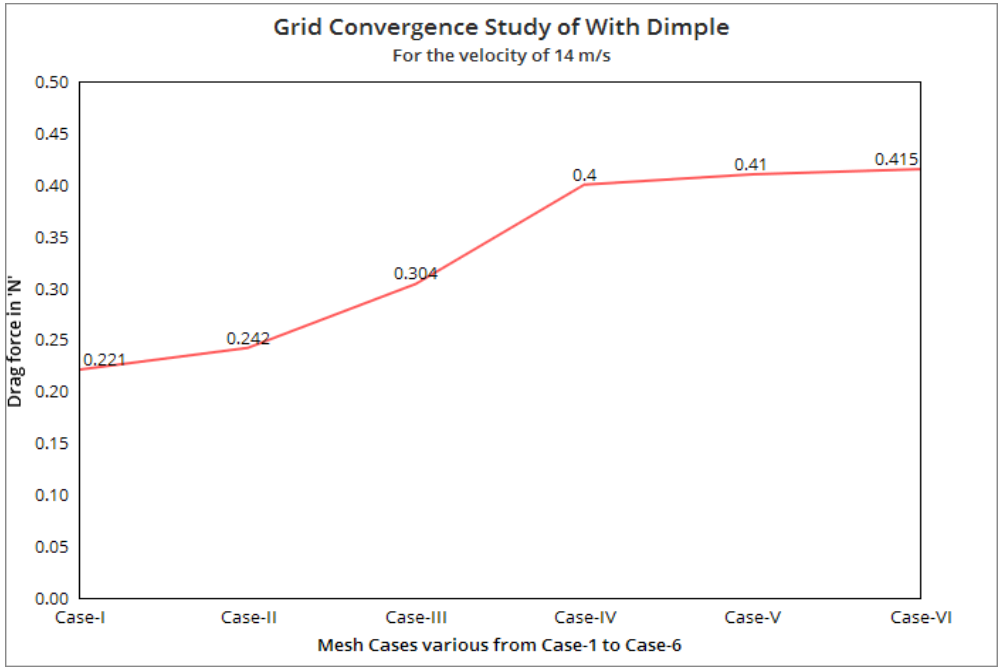
- We know that the boundary conditions plays the vital role in CFD analysis to get near accurate results.
- Steady, pressure-based flow simulation.
- Viscous model: k-omega with shear – stress model (To capture near wall effects).
- Inlet: Velocity inlet (Analysed in various velocities within a range).
- Outlet: Pressure outlet.
- No slip conditions were applied on FSI regions (Bus).
- Hybrid initialization is used.

GRID CONVERGENCE STUDY

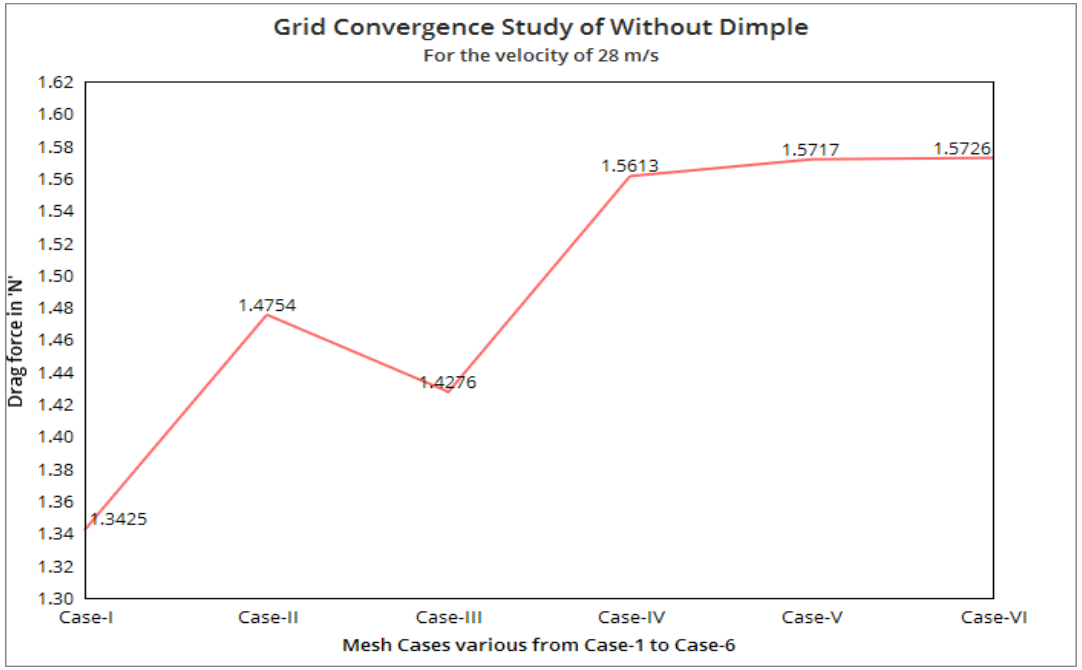
- Six cases of grids are analysed for the trust worthiness of the numerical analysis.

Cases	Parameters
I	Coarse – Proximity & Curvature
II	Medium – Proximity & Curvature
III	Fine - Proximity & Curvature
IV	Face mesh – Refinement is used
V	Entire control volume refinement
VI	Inflations on the bus surfaces is introduced

GRID CONVERGENCE PLOTS

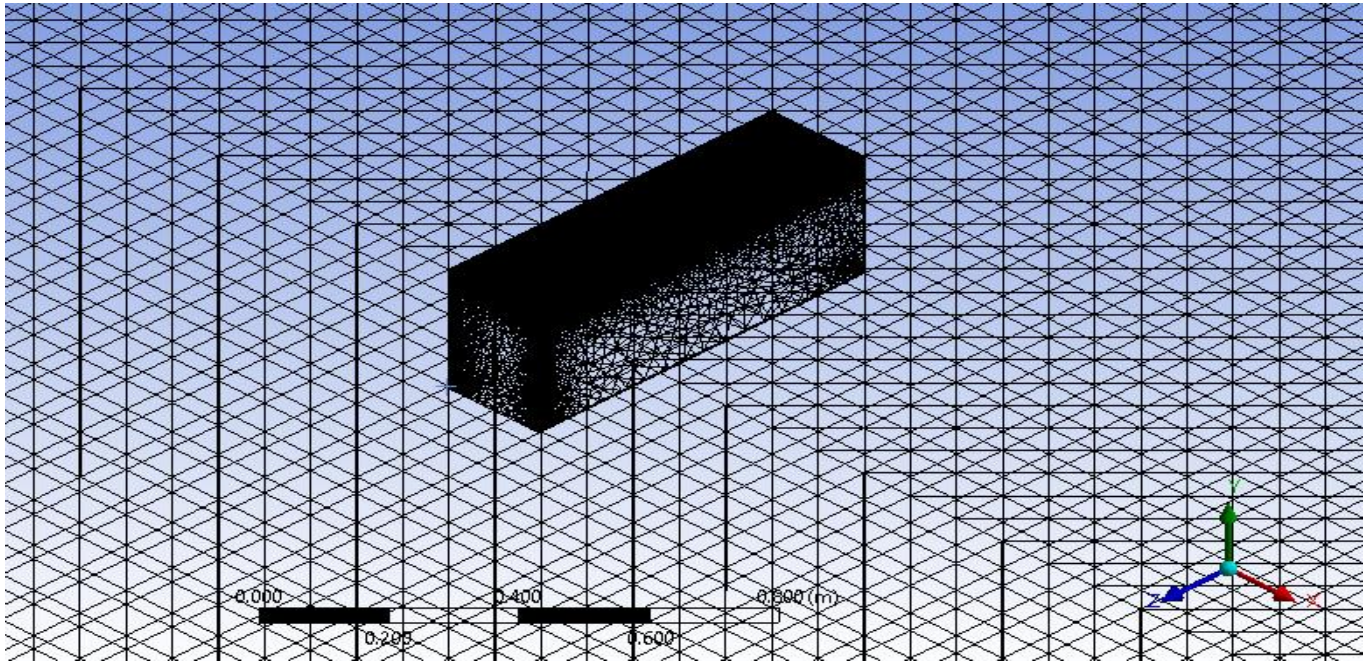


COMPUTATIONAL SENSITIVITY TEST – I



COMPUTATIONAL SENSITIVITY TEST – II

MESH OF THE MODEL



FINE MESH SET-UP (CASE - IV)

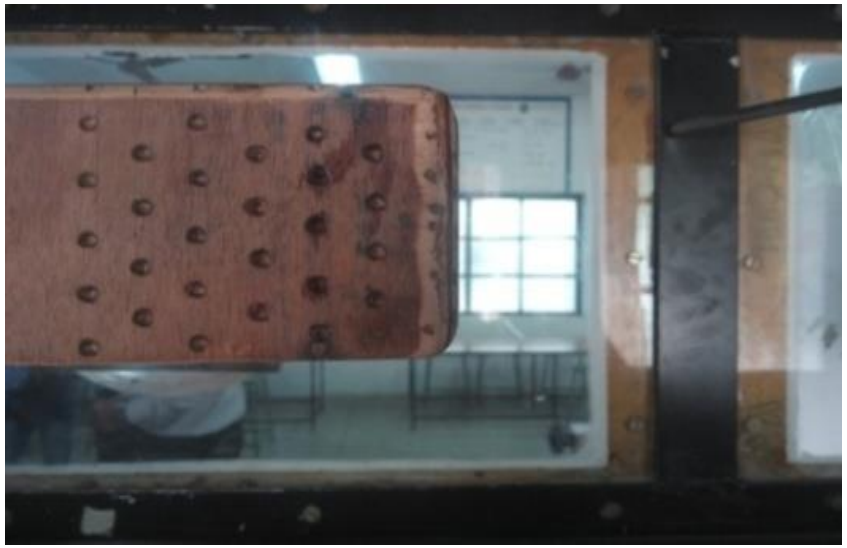
EXPERIMENTAL TEST

BOUNDARY CONDITIONS

- A low speed wind tunnel setup was used to do the validation study.
- The wind tunnel was calibrated and the analysed with the model inside it with various velocities.



Wind tunnel with the model



Zoomed view of the model with dimples

COMPARATIVE RESULTS

Velocity (m/s)	Drag (N) [Without Dimples]		Drag (N) [With Dimples]	
	Experimental	Numerical	Experimental	Numerical
14	0.26	0.2428	0.45	0.4
17	0.59	0.494	0.57	0.45
20	0.78	0.770	0.71	0.606
22	1.1	0.108	0.81	0.7957
25	1.3	1.2940	1.10	1.073
28	1.57	1.5613	1.32	1.2973
35	1.7	1.63	1.42	1.406

CONCLUSION

- The co-efficient of drag and drag forces have been monitored throughout the convergence of iterations.
- It is found that the C_d starts to reduce from the velocity of 20 m/s which is the average speed of the buses.
- We can able to reduce the 20 % of the drag with the inclusion of Dimples at average speeds of the bus.
- Drag can be further reduced if concepts of dimples are investigated.

THANK YOU