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CFD Analysis of Aerodynamic and Aero Acoustics in Truck Trailer Body

Prakash Shakti[1], V. Pathak Tanmay[2], H. Abhani Savan[3], P. Soni Rishank[4]
[1]*Assistant Professor, Department of Automobile Engineering, KJIT, Vadodara, India*
[2,3,4]*UG Student, Department of Automobile Engineering, KJIT, Vadodara, India*

***Abstract*: The aerodynamic and aero acoustics of trailer truck have been of interest to researchers for, mainly with a view to reducing drag, reducing noise, controlling tire traction and consequently improving fuel efficiency by controlling engine power. Although developments in the design of low drag vehicles exclusive devices in various forms remain the most effective method of reducing drag on the majority of vehicles in current use. These things decrease the engine performance for a heavy trailer truck.**

***Keywords*: Aerodynamic Drag, Pressure, Velocity, Trailer, CFD, Aeroacoustics**

1. Introduction

The aerodynamics of trailer truck is a complicated discipline and many specific topics are outside the scope of this project. The discipline of aerodynamics contracts with the motion of air around and through a body and the interactions associated with this relative motion between the air and the vehicle system. The aerodynamic stuffs of a road vehicle include effects on trailer performance, handling, safety, and comfort. In the circumstance of this report, performance is the serious issue, and in specific the effect of aerodynamic and its effect on fuel consumption.

Fuel is consumed by a vehicle's engine as it travels on the road, with engine power output contributing to 5 main factors, as shown in Table 1. For the highway purpose, in which most commercial goods are transported, aerodynamic losses which are dissipative and cannot be recovered are the leading source for power and fuel consumption.

Table 1
Engine power balance for fully-loaded class 8 tractor trailer

Source	Urban	Highway
Drivetrain	10-15%	5-10%
Inertia/braking/grade	35-50%	0-5%
Rolling Resistance	20-30%	30-40%
Auxiliary Loads	15-20%	2-10%
Aerodynamic Losses	10-25%	35-55%

The Fig. 1, show the leading percentage drag regions on a trailer truck which are the trailer front face cabin-Container gap, under carriage/wheels, and container base. The frontal and rear area of tipper has 25% of drag and 30% drag occur undercarriage and 20% in between the cabin and Container body and this all cause in high pressure on a trailer which effect the fuel economy of the truck. [3] To better understand the technical challenge of drag reduction, it is important to understand the distribution of the drag between the cabin and Container [3].

Aerodynamic drag is normally immaterial at low vehicle speed yet the size of air resistance gets to be definitely imposing with rising velocity. Right now most trucks are furnished with different fuel Saving device or additional items utilizing streamlined shapes in front as well as various parts of the truck to limit drag. Without out changing the anticipated frontal range of the truck, it is conceivable to change the states of the truck incorporating the holder confine a more streamlined way. These outside connections can limit streamlined drag in view of their outer shapes, sizes and positions [3].

Table 2
Example of the distribution of power consumption at various speeds

Vehicle	Speed	Aerodynamic Rolling & Accessories
32 km/h	28%	72%
53 km/h	33%	66%
64 km	36%	64%
80 km/h	50%	50%
96 km/h	62%	38%
105 km/h	67%	33%
113 km/h	70%	30%

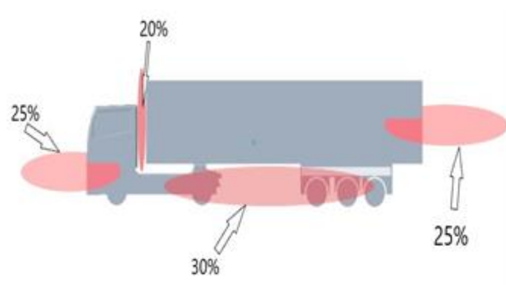

Fig. 1. High pressure in trailer

2. Design and working of project

A. *Design of drag reduction device in tail*

Based on the computational fluid dynamics analysis of the truck, aerodynamic devices are installed at the tail and bottom of the truck trailer respectively to reduce resistance and fuel consumption.

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Fig. shows the truck trailer model with the drag reduction device at the tail and has a spoiler at the rear of the trailer container. The flaps can be installed at the top and side edges of the trailing edge of the trailer.

Airflow around the Truck will flow toward the trailer with this Flaps. Negative pressure behind the vehicle is avoided and air resistance is also reduced. In the end, the fuel consumption of the truck is reduced and the travel efficiency is increased.

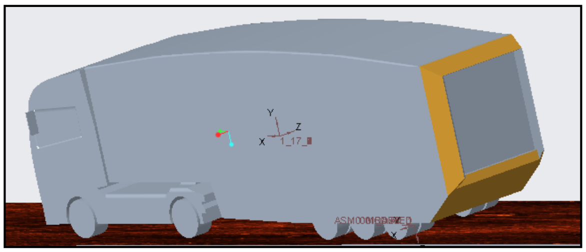

Fig. 2. Rear flaps mechanism

After installing additional rear moving flaps, due to the diversion effect of Stream line, the air flow becomes a little smoother. Because of the regular flow of air, vortex and the truck trailer aerodynamic drag are reduced.

B. Design of drag reduction device at bottom

In the area between the front and rear wheels of the truck a very complex phenomenon of turbulence will be formed because of the long distance between its front and rear wheels. The complex turbulence will greatly increase air resistance, which affects the truck trailer speed and greatly increases fuel consumption.

In order to improve the smoothness of the air flow at the bottom of the truck, a kind of drag reduction structure at the bottom of the truck is presented. The device, located between the front and rear wheels of truck, is an air flow passage that is composed of side plates.

The figure shows that the bottom airflow velocity of the improved truck is more uniform. Because the air flow at the bottom of the truck is more complex, the turbulent kinetic energy is relatively large, which is a factor in producing truck resistance.

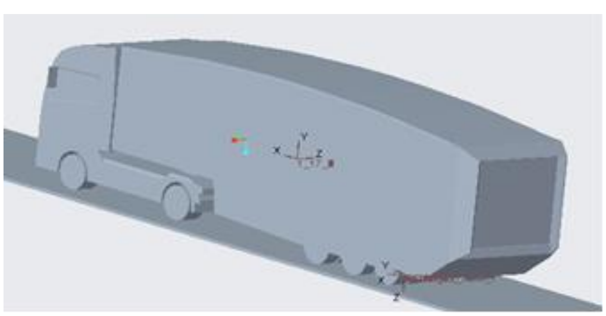

Fig. 3. Flaps at side of trailer

After installation of the bottom deflector, the smoothness of the airflow is significantly improved and the turbulent kinetic energy and aerodynamic drag are significantly reduced. The simulation results show that the aerodynamic drag coefficient of the truck model with the drag reduction device at the bottom is 0.6238, which is reduced by 7.136 % compared with the original model. This shows that the bottom drag reduction device in this paper can reduce the drag coefficient of the truck trailer.

C. Design of drag reduction device in front

A high degree of air flow separation and vortex are produced between the driver cabin and the container. In order to reduce airflow resistance here and achieve a little smoother air flow, a drag reduction device is installed upon the driver cabin, as the contrast of the pressure contour of the symmetry plane of the truck, showing a smoother air flow near the container and driver cabin of the improved truck as well as reduced vortex. Pressure in the front of the improved truck is reduced. Fig. shows the contrast area with roof deflector at the top of the driver cabin.

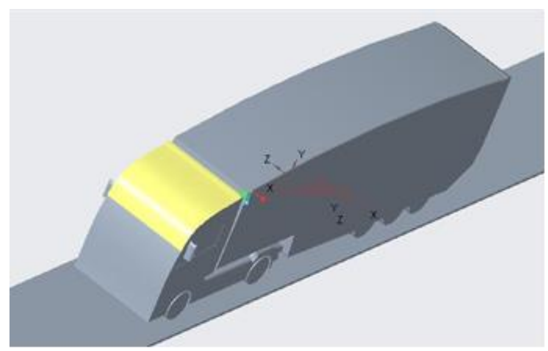

Fig. 4. Drag reduction device in front

3. Aeroacoustics study

Aeroacoustics is the major component of external vehicle noise at speeds above 70 km/h in trailer trucks. It is typically tested at steady vehicle speeds between 65 km/h and 80 km/h, by using CFD Simulation.

Aerodynamic noise or Aeroacoustics prepared by the vehicle as it moves at high speed through a stable medium (air). This is associated to the aerodynamic (or drag) coefficient of the vehicle, which is a function of the vehicle shape, design and its frontal and rear cross-sectional area [4].

Aerodynamic noise occurs in trailer truck due to turbulence through “holes/gapes,” near doors, hood, windshield, frontal area etc., which is connected to strongly seal the vehicle [4].

Aerodynamic noise also occurs due to exterior changing wind conditions, such as cross-wind on a highway and this type of wind noise is fluctuating [4].

Very low-frequency (8 to 16 Hz) beating noise occurring when either a window are partially open in trailer truck and also created by side mirrors. This is due to the Helmholtz resonance of the vehicle cabin, which is excited by the air flow along the boundary of the window opening. In trailer truck wind noise is also occur due to it travel over the cabin and it meet with the dump body, then noise is occurred [4].

A. Aerodynamic noise

For road vehicles this can be broken down into three noise generating components:

1. Boundary layer circulated over the vehicle body
2. Boundary layer noise inclines to be random in character
3. Absorbent materials

Edge effects

4. Noise level higher than boundary layer noise caused by vortices formed at edges
5. Vortex shedding

B. Minimizing aerodynamic noise

Reducing protrusions from the body surface, making the body surface smooth and continuous and ensuring that gaps around apertures such as doors are well sealed [4].

1. Vortices produced at windscreen pillars
2. Very little which can be done to improve as aerodynamics at Pillar denies reflectivity requirements
3. Side mirrors and wheel rims also reason for vortices– f=SU/d where S is the Strouhal Number (based on geometry),
   U is speed of air, d – obstruction dia –f = 640 Hz, for d=10 at 70mph
4. Inlet and outlet holes are carefully sited and designed should not generate noise and noise from engine compartment should not be transferred to the occupant

Noise from the cooling fan Blades shed helical trailing vortices. Result in periodic pressure variations when they attack problems fan rotors are made with unequally spaced blades and with an odd numbers of blades [4].

4. Simulation details

Aerodynamic calculation of air flow over an object can be performed using simulation method or CFD approach. The basic air flow tunnel is shown in figure.

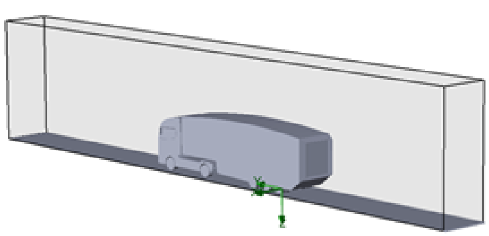

Fig. 5. Computational domain

A. Dimension of computational domain

- X: 1500mm
- -X: 18303.1271mm
- Y: 5300.53182mm
- -Y: 2341.87674mm
- Z: 2000mm
- -Z: 2000mm

B. Results

Table 3
Pressure and Velocity

	Maximum	Minimum
Pressure	101933.54	101128.33
Velocity	85.466 km/hr	6.105 km/hr

Table 4
Drag, Wind Noise and Reynold Number

Drag Coefficient	80kmph	1.1381
Wind Noise	3.4621E+02	
Reynold Number	8.8404E+06	

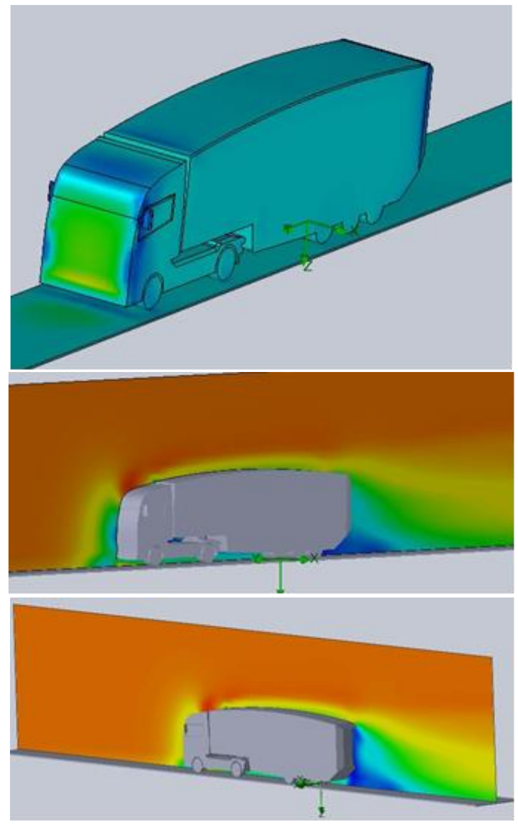

Fig. 6. Pressure

5. Advantages

The goal of this project is to design such a truck body or vehicle body that will experience minimal amount aerodynamic drag while the vehicle running at higher speeds, that will.

- Increase the fuel economy.
- Reduce the effect of aeroacoustics (wind Noise).
- Better stability in windy weather and cross wind condition.
- Better design in heavy vehicle.

6. Conclusion

The Aerodynamic analysis of a trailer truck with new modified design is an efficient drag coefficient as compare to normal trailer truck and in which the fuel consumption can be improved as there would be less opposing force acting on its frontal area and on a container body. Changing the overall design of trailer truck decreases aerodynamic drag by 25 % which thusly lead diminishment in fuel utilization by 2.3 %.

References

[1] Prakash Shakti, S.Patel, J.K.Desai, The Concept of Hydroplaning of Commercial Vehicle on Wet Road, IJSRD International Journal for Scientific Research & Development| Vol. 5, Issue 08, 2017
[2] Prakash Shakti, “Aerodynamic improvement for tipper” IJRTER, Volume 02, Issue 06; June – 2016.
[3] Prakash Shakti, S.Patel, S.Patel, Commercial Vehicle Aerodynamic Drag Reduction: (Tipper Truck), International Journal of Engineering Trends and Technology (IJETT) – Volume-44 Number-4 -February 2017.
[4] Prakash Shakti, Effect of External Aerodynamic, Aeroacoustics And Aquaplaning & Hydroplaning On Commercial Vehicle Performance: Cfd Investigation On Trailer Truck, 2018, IJNRD, Volume 3, Issue 2 February 2018.
[5] Murad, M. M. and Abaza, K. A. Pavement friction in a program to reduce wet weather traffic accidents at the network level. In Transportation Research Record: Journal of the Transportation Research Board, No. 1949, TRB, National Research Council, Washington D.C., 2006, pp. 126-136.
[6] Horne, W. B. and U. T. Joyner. Pneumatic Tire Hydroplaning and Some Effects on Vehicle Performance. In SAE International Automotive Engineering Congress, 11-15 Jan, Detroit, Michigan, USA. 1965.
[7] Mosher, L. G. Results from studies of highway grooving and texturing by several state highway departments: Pavement traction and grooving studies. NASA SP-5073, National Aeronautics and Space Administration, Washington, D.C., 1969.
[8] Ge J., Z. Wang, Y. Long and R. Gall. Application of Tire/Road Noise in Tire Design. Paper 2002-01-1237, Proceedings of SAE 2002 World Congress & Exhibition, SAE International, Detroit, MI., 2002
[9] Roopsandeep Bammidi, B. V. Ramana Murty, “Ansys-cfx analysis on a simple automobile design” IJSR volume 3 issue 6 June 2014.
[10] RamMohan Rao Pamoti and Raval Chetan",Cfd external aerodynamics Mahindra Navistar"
[11] Automotive engineering fundamentals by Richard Stone and Jeffrey k. Ball.
[12] Advanced vehicle technology by Heinz Heisler.
[13] A Guide of Vehicle Aerodynamics, SEI.