DESIGN AND ANALYSIS OF AERODYNAMIC MODEL OF BUS

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Abstract

Public transportation is one of the most important ways of transport in our life. This is considered as one of the most important industry that grows steadily and rapidly. Buses are important part of a man's transportation system. There are many types of buses such as traditional Buses, Articulated Buses, Bi-articulated Buses etc. These types of buses are made to satisfy the steadily growing demands by users.At present, transportation by bus is cheaper and easier, but it has disadvantages due to the air pollution that comes from engine exhaust gases.This study is an attempt to reduce the gas rejection from buses by added a drag reduction device the core objective is reduce fuel consumption. ANSYS-FLUENT was used to conduct this study. In this study, six different drag reduction devices were conducted on the original bus Shape. In these cases, a curved device (with closed and open sides), side ducts, and curvature in front and rear of bus were investigated. The investigation revealed a promising 8.4 % reduction in fuel consumption. The effect of side ducts was very low or negligible.Moreover, a neuro-fuzzy technique was used to predict the values of pressure drag coefficientbased on the present computational results.

Introduction

Buses are one type of heavy vehicles that consume much fuel. They are road vehicles designed to carry passengers. Buses can have a capacity as high as 300 passengers. The most common type of bus is the single-decker rigid bus, with larger loads carried by double-decker buses and articulated buses, and smaller loads carried by midi buses and minibuses. Coaches are used for longer distance services. Bus manufacturing is increasingly globalized with the same design appearing around the world. Buses may be used for scheduled bus transport, scheduled coach transport, school transport, private hire and tourism. Promotional buses may be used for political campaigns and others are privately operated for a wide range of purposes. Horse-drawn buses were used from the 1820s, followed by steam buses in the 1830s, and electric trolleybuses in 1882. The first internal combustion engine buses were used in 1895. Recently, there has been growing interest in hybrid electric buses, fuel cell buses, electric buses as well as the one powered by compressed natural gas or bio-diesel.

Importance of Aerodynamics

Looking at the design of airplanes, it is a well-known fact that the impact of design decisions on overall costs reduces with increasing information about the aircraft, i.e. with progress during the design process. In other words, those decisions which are made early in the design process, have the highest impact on the technical and financial success of the aircraft.

Aerodynamic design is one of those disciplines involved in the very early stages of aircraft design and must consequently provide mature technologies and use methods which assure sufficiently exact prediction of aerodynamic efficiency. A level of confidence of 2% remaining uncertainty at ATO (Authorization to Offer), or 1% before first metal is cut, must be guaranteed. On the other hand, amount and quality of available data is very limited in the early design phases. In order to cope with these opposite trends, the product development cycle was reconsidered. Fig. 2 gives an Indication of increased pre-development work, which must be heavily complemented by technology preparation and validation. Although initially a higher cash flow before Go-Ahead is required, the maturity of the design at that milestone is increased. The intended consequence is that actual development cost and time summed up until Entry into Service (EIS) can be reduced significantly. The main message here: boost the spending for technology and pre-development activities in order to reduce the total development costs.

OBJECTIVE

1. This research aims to modify the outer shape of the existing bus aerodynamically in order to reduce the effect of drag force which in turn results in the reduction of fuel consumption of the bus using softwares as mentioned below.
2. To model an existing Bus and the two new models using SOLIDWORKS (CAD modeling software).
3. To mesh the models using ANSYS workbench.
4. To compare the pressure force, viscous force, total drag force, lift force, drag coefficient, lift coefficient and pressure coefficient of 2 models in 3 different high speeds.
5. Drawing out the outcomes of the rolling resistance, power required and fuel consumption comparing the two models in 3 different high speeds.
6. Analyze the results and draw the conclusion between the cases on the aerodynamic performance and drag.

Review of literature

J. Vasanthe Roy, T. Santhosh Kumar, R. Ashish Kumar, S. Jeeva, V. Vinoth Kumar, presents improvement of bus aerodynamic shape by drag reduction techniques of vehicle i.e. chamfering, rounded corners, tapered rear end etc. and import this model in Flow Design for drag analysis. The flow lines pass over the body and free vortex create near the rear side of the bus which increases with the speed of vehicles. The frontal area is curved as compared to the original styling.

Eyad Amen, Mohamed Muhammad, Naeem Radhwi, Ahmed Farouk, Abdel Gawad presents the total drag on the bus decreases with the bus speed. The idea of transferring high pressure from the upwind zone of the bus to its downwind zone to increase the pressure at the rear surface of the bus did not succeed. This may be attributed to the relatively big length of the ducts. Thus, internal friction causes losses and overall pressure drops in the ducts. So, the pressure at the rear surface of the bus is nearly the same as that of the bus wake.

Chandrashekhar R. Jadhav, Rashmi P. Chorage, conclude that the existing bus body drag is slightly changes with speed but the modified bus drag is reducing with respect to speed increases. It indicates, air moves over vehicle is the smoother air flow over the body and the air guided properly at high speed than low speed.

Oscar Arteaga, Hernán Morales, Héctor Terán, Sonia Chacon, Mario A Lara, Juan Rocha-Hoyos, ÉdisonArgüello and Ronny P Aguirre presents the three designs obtained through the analysis in the wind tunnel were very similar to the values generated in the computational analysis by means of the designing software, which let us to determine that this wind tunnel can be used for analysis of prototypes to scale. The number of values obtained in the wind tunnel tests was reduced with the help of the BoxPlot diagram, due to the fact that not all the values are real, which would cause a bad analysis of this one, after separating the atypical values from the real ones we proceeded to the analysis of them.

J. Vasanthe Roy, T.Santhosh Kumar, R.Ashish Kumar, S.Jeeva,V.Vinoth Kumar concluded that the improvement of bus aerodynamic shape by drag reduction techniques of vehicle i.e. chamfering, rounded corners, tapered rear end etc. and import this model in Flow Design for drag analysis. The flow lines pass over the body and free vortex create near the rear side of the bus which increases with the speed of vehicles. The frontal area is curved as compared to the original styling.

Advantages

Aerodynamics being the aid to form a body shape that maximizes the down force, the negative lifts and minimizes the force that opposes the forward movement and the drag forces. The aerodynamically efficient design of the bus reduces the drag force improving the fuel efficiency.

Formulation of Problem

- Drop in efficiency as speed increases due to shape.
- Aerodynamics models are not cost effective.
- As efficiency drops fuel consumption increases hence increase in fuel cost.
- As speed increases drag increases and hence the overall payload on engine increases, hence lowering life of the engine components causing maintenance cost.

Calculations: -

Theoretical calculation of Drag Force: -

$$F_D = C_D\,A\,\frac{\rho V^2}{2}$$

Where,

$A = l \times b = 3.5 \times 3\ m^2$

$\rho = 1.225\ kg/m^3$

$C_D = 1.2$ For flat bus

$= 0.9$ For Curved bus

Speed kmph	Speed m/s	F_D for flat bus	F_D for curved bus	Reduced F_D in %
60	16.22	2030.38	1522.78	25

80	22.22	3810.34	2857.76	25
100	27.77	5951.52	4463.64	25

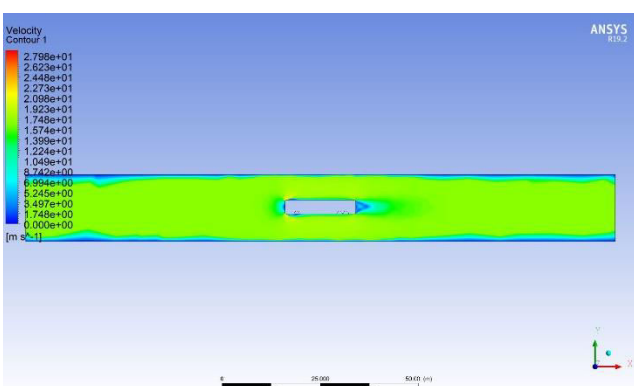
CAD models of bus

1. Flat Bus: -

2. Curved Bus: -

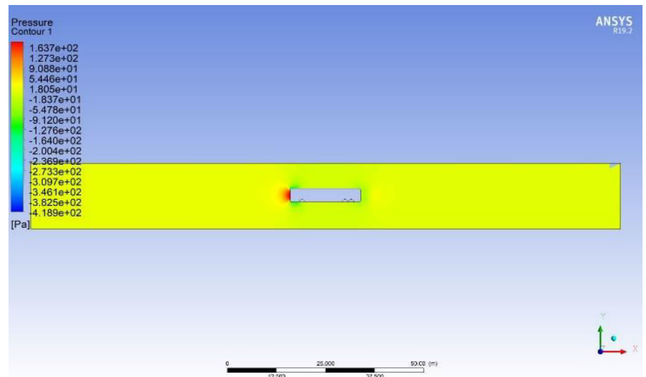
Analysis of Buses

1. Velocity Analysis of Flat Bus



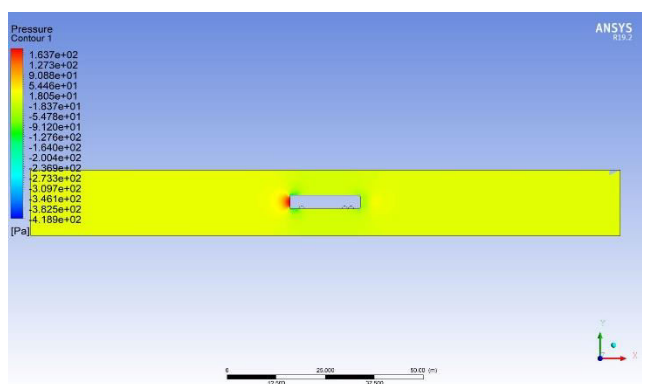
Velocity kmph	Maximum Velocity m/s	Colour Region
60	21-22.7	Yellow
80	29-31	Yellow
100	36-38	Yellow

2. Velocity Streamline Analysis of flat Bus: -



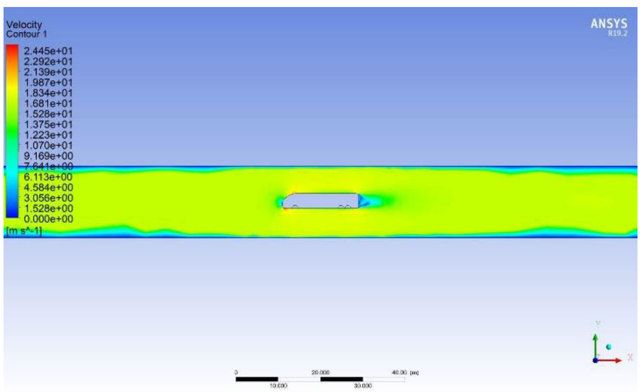
Velocity kmph	Maximum Velocity Streamline Value m/s	Colour Region
60	22	Yellow
80	29.5	Yellow
100	37.5	Yellow

3. Pressure Analysis of Flat Bus



Velocity	Maximum	Maximum

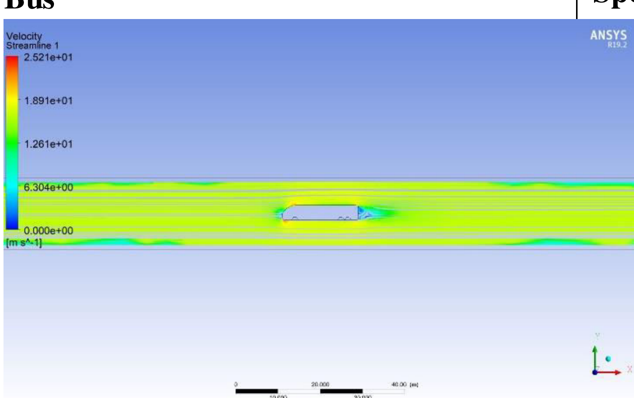
kmph	Pressure Value Pa	Pressure Region
60	164	Red
80	290	Red
100	450	Red



4. Velocity Analysis of Curved Bus

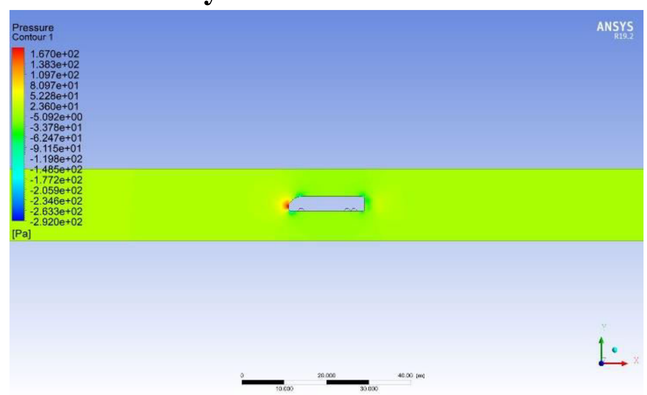
Velocity kmph	Maximum Velocity Value m/s	Colour Region
60	21-24	Red
80	28-32	Red
100	34-40	Red

5. Velocity Streamline Analysis of Curved Bus



Velocity kmph	Maximum Velocity Streamline Value m/s	Colour Region
60	21-24	Red
80	27-32	Red
100	35-42	Red

6. Pressure Analysis of Curved Bus



Velocity kmph	Maximum Pressure Value Pa	Maximum Pressure Region
60	167	Red
80	295	Red
100	460	Red

Analysis Result: -

Speed ph	Speed m/s	F_D for flat bus in N	F_D for curved bus in N
0	16.22	2149.33	1561.85
0	22.22	3805.97	2771.47
00	27.77	5875.34	4321.35

Calculation of Coefficient of Drag: -

Speed kmph	Speed m/s	C_d for flat bus	C_d for curved bus	Reduced C_d in %
60	16.22	1.2702	0.9230	27.33
80	22.22	1.1986	0.8728	27.18
100	27.77	1.1845	0.8713	26.44

Conclusion: -

1. Aerodynamically shaping the front end, rounding of the corners, providing optimum diffuser angle and lowering the floor panel height leads to reduction of drag and lift for the modified models.
2. The existing bus body drag is slightly changing with speed but the modified bus drag is reducing with respect to speed increases. It indicates, air moves over vehicle is the smoother air flow over the body and the air guided properly at high speed than low speed.
3. The total drag on the bus decreases with the bus speed. However, the considerations of traffic and safety limit this option of increasing the bus speed.
4. The drag coefficient of curved bus as compared to flat bus is reduced by 27%.
5. Reduced drag force improves fuel consumption and stability.

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