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Aerodynamic research, a solution for the growing freight transport due to e-commerce

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1. Introduction

Since a few years the trade throughout internet has encountered an enormous boost. The online trade or e-commerce has become a rising trend and ever increasing share of the market. This phenome doesn't only affect the way how local stores and small business need to reorganize their shop to compete with the rising commerce. It also affects the logistic organisation behind the trade throughout the internet. Transportation throughout the truck sector will encounter a rise. In this paper the effect of e-commerce on the rise of the amount of trucks on national highways will be investigated. On the other hand several solutions will be proposed for reducing the fuel consumption and energy efficiency of those trucks. Aerodynamics could be the solution in trying to achieve a reduced fuel consumption linked with a positive ecological impact.

2. Domain of Aerodynamics

Aerodynamics is a branch of fluid dynamics which investigates the motion of air, especially the motion of air around solid geometries. The domain of aerodynamics is quite a new branche in science, but has already proven its significance in modern society. One simple example, which has been of great importance, was the realisation of commercial aviation, a part of transport you can't imagine not being available nowadays.

One of the principles which led to modern aviation is the principle of lift. The lift force is the upward force acting on a solid geometry due to the incoming air. Together with the lift force, another principle has been studied, the drag force. The drag force is the resistance force a solid body encounters due to the incoming air. This force is highly depended on the geometry and the velocity of the immersed object.

These principles of drag and lift force are entwined with each other. The drag force can be minimised to an optimal value, but due to the geometrical adjustments the lift coefficient will change.

A great example of finding the optimal balance between both principles is the Formula 1 Racing car. In this example drag has been minimised, taken into account the speed of the car, but besides the drag reduction geometrical adjustments have been applied in giving the vehicle enough downforce.

This example is taken from a highly technological research branch in sports, but these concepts aren't solely applicable in these domains. Drag reduction is a well known phenomena in optimizing modern standard production cars.

3. Purpose of Aerodynamics for modern vehicles

A lot of work has already been done in improving the aerodynamics of the modern car. The improvements made are rather small adjustments which coincide with the geometry of the car. An example of a simple adjustment made nowadays is the small rear spoiler which extends the streamlines of the roof. The main advantage of the small rear spoiler is the fact that it is easy to incorporate with the standard geometry of the car. In general it can be stated that although improvement is still possible, modern production cars already have several small aerodynamic improvements.

The purpose of drag reduction in this domain has economical and ecological aspect. Drag reduction on standard production cars doesn't has the purpose to achieve higher limits according to speed. The main purpose of decreasing the drag coefficient of a modern production car is reducing its fuel consumption.

According to Trading Economics [1], the use of diesel fuel is rising, up to 7090 kt of oil equivalent per year in 2009. This is a tremendously increase compared with the 6300 kt of oil equivalent in 2007. Aerodynamcis can be used as a tool in the fight against increasing fuel consumption. Due to aerodynamic improvements of the car geometry, modern production cars can be made more energy efficient. As a result modern production cars will need less energy to propel themselves leading to a lower fuel usage.

Cars however aren't the major concern regarding aerodynamic efficiciency on our highways. A far more bigger concern on our highways is the increase of freight transport, especially the truck sector. According to a study of US DOT in 2002 [2] there were 2.2 millions trucks registered. These trucks were responsible for 138.6 billion miles on the nation's highways with an increase of 3-4% a year. For this reason the truck industry stands for 12-13% of total US petroleum usage.

4. E-commerce and rising truck transportation

The number of trucks on the road is rising constantly. One of the main reasons for this is the increase of e-commerce. E-commerce is the term overarching term for trade which makes use of computer developed networks. According to eMarketer [3],the total share of e-commerce will increase from 5,9% to 8,8% in 2018. Most of those will be from the US and China (55%). People buy more and more online and want to see their goods being delivered the same day or the day after. For this reason companies are obliged to send more trucks on the road, often half empty.

According to Taniguchi [4], the increase in e-commerce will definately affect the transportation sector. Logistic companies are being converted to e-commerce deliveries. This of course increases the amount of trucks on the road, orchestrated by the consumer's behavior. This will not happen unnoticed. Besides the fact that the amount of trucks an natianol highways will grow and could lead to more traffic jams there is the ecological aspect. The major problem of these trucks is the fact that they are highly unefficient cocerning aerodynamics. The problem doesn't lie with the engine's consumption, but duet o their bad aerodynamic design modern trucks consume a huge amount of. For this reason, increasing their efficiency due to geometrical design, should be one of the most important research topics of modern transportation.

5. Possible solutions

As suggested earlier one of the best options in making more efficient trucks is improving their aerodynamics. These improvements will increase the fuel economy of the trucks. According to CleanTechnica [6] the fuel economy of trucks can ben improved by even more than 50%. Today we allready have such a solution called the Bullet truck (fig. 1), made by Airflow Truck Company.

Figure 1: Bullet truck

Currently, American trucks can run 6 MPG (Miles per gallon) going from the westcoast to the eastcoast. With the design of the bullettruck, an aerodynamically designed truck, an increase up to 13,4 MPG can be reached. Seeing this immense amount of increase, it is worth researching and regulating the aerodynamics of trucks.

However the big changes remain unperformed. A few small changes have been made like the slanted roof, but the overall aerodynamics are still horrible. Research has been done about the aerodynamics of those trucks, but the few solutions that have been found are not incorporated at the moment. It seems that for trucks, esthetics and space use are still much more important for companies than aerodynamics.

From our point of view, the development of more aerodynamic trucks, would be a great investment. For companies, it could mean a reduction in transportation costs. Saving money on logistics could lead to a reduction of selling price and could strengthen their market position. On the ecological point of view, less harmful gases will be emitted into the atmosphere leading to a more climate friendly environment. One of the main goals which can be achieved if more aerodynamic trucks, like the bullet truck are used.

On the other hand there could be a far more simple solution which can be find in the formulation of the drag force itself. The drag force is given by the following formula:

$$F_d = \frac{1}{2}\rho A C_d v^2$$

Where:

Fd = Drag Force
A = Frontal Area
ρ = Density of Fluidum
C_d= Drag Coefficient
v = bulk velocity

From the relation it is clear that the drag force is highly dependend on the bulk velocity of the object. For this reason the Flemish Government proposed to lower the speed limit of trucks from 90 km/h to 80 km/h. In understandying the effects of the speed reduction three studies were executed by TMC (Transport and Mobility Leuven) [5]. The studies of TMC were focused upon different aspects regarding:

1. The economical impact upon Belgian truck transport
2. The impact on road safety in Flanders
3. The environmental impact in Flanders

The economical impact encounters the greatest change of them all. Lowering the speed limit to 80 km/h will lead to an increase in costs for the Belgian Truck sector of 1,46 % or 104 million euro. An even bigger change of 3,71 % could be perceived when only taken into account the trucks riding on national highways.

The impact on road safety is a reduction of 1 till 3% of traffic accidents. The main reduction however is the severity of accidents, 8% less deadly accidents and 6% less severly wounded. These numbers are only due to the speed reduction, much better results can be achieved when the reduction is combined with other measures.

The environmental impact mainly consists of a reduction in fuel usage and CO2 emmission.The CO2-emmission can be reduced with an amount of 5-15%.

Despite the promised advantages of the safety and environmental aspect the economical aspect still takes the upper hand. The increase of costs coherent with the speed limit of 80km/h are still too negative, fort his reason the regulations aren't approved yet.

Another problem, in achieving a lower fuel consumption and CO2 emmission, is the load capacity of the driving truck. According to the European regulations there are different laws concerning maximum load of trucks in different European countries. According to the article of Verbond van Belgische Ondernemingen [7] there are still too many trucks which don't ride at full capacity. The reason is the fact that the maximum load for trucks on Belgian highways is fixed at 44 ton while in adjacent European countries like France the maximum tonnage is fixed at 40 ton. Due to the lack of European unification concerning some regulations companies are obliged to send out more trucks.

6. The rebound effect

This brings us to an important part of fuel economy, the rebound effect. The rebound effect means that if our vehicles become more and more fuel economic, we will spend less money on fuel. Spending less money on fuel means there is more money available to spend on a more expensive (and probably more polluting) car and drive further. The effect of the better fuel economy is being rebounded and in the end the use of fuel economy is being reduced. This is probably very important for the car, but for trucks, this will be less of a problem. Companies buy trucks out of necessity and will always try to reduce their costs.

7. Discussion

We believe that aerodynamics are an important factor in increasing the fuel economy of trucks and should not be neglected. Especially because the tremendous rise of e-commerce is a fact. Due to this phenomenon, more and more logistic companies will arise leading to an increase of trucks on the national highways. For this reason, the aerodynamics of a truck is becoming more and more important.

We think it is an improvement which really can make a difference. Global climate is changing now is the time to act. There are different ways to do this as we proposed earlier, but aerodynamics will play an important role in this improvement.
From the solutions given, the bullet truck gives the best results. The reason however that this truck is nearly visible on the national highways is the high purchase cost. As a stimulation for companies to purchase those aerodynamic trucks we believe the government could come up with some kind of a subsidy. Companies who have a certain norm of aerodynamic efficiency will be rewarded for their effort.

On the other hand the responsibility could be led with the truck manufacturers themselves. A regulation could be formed around the fuel economy of trucks, so that truck manufacturers have to work on their aerodynamics, to reach the imposed norm. For example, a standard could be set that trucks have to reach at least 12 MPG for a truck, whereas the current trucks have only 6 MPG.

We regret the bad regulations and communication between European countries regarding road transportation. These are just simple small adjustments which can already make a big difference. The fact that the speed limit of 80 km/h still isn't active on our national roads isn't a surprise. Due to the modern competence in the transportation sector cost reduction has become very important. The money gained throughout the lower fuel consumption doesn't offset the losses due to the longer time of one transportation.

In the end there will be a rebound effect on the fuel economy, we think the rebound effect will not be big enough to ignore the fuel economy of trucks.

8. Conclusion

Despite a lot of effort already being put into the aerodynamics of heavy traffic, still a lot of evolution is possible. With global warming being a major issue of modern society, aerodynamics become a quite simple solution in trying to achieve more efficient trucks. Further investigations could tip the balance back with researching and applying aerodynamics of heavy transportation. These aerodynamics, together with logistic planning, needs to deal with the growth of e-commerce concerning the ecological impact of this phenome.

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