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Energy Wastage on an Automobile Due to Speed Breakers: A Case Study on Woldia Town

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A B S T R A C T

Many numbers of speed breakers were constructed on different outlets and even inside the city of Woldia for the purpose of reducing car accidents that occurred due to over speed driving. Surely while the speed of the vehicle is reduced or the driver drives the vehicle at low speeds, the probability of accident occurrence is very low. But reducing the speed in such a manner or using sudden breaking will result in kinetic energy wastage due to change in velocity and wastage of potential energy due to climbing of the beaker height. In this study, the number of vehicles that were passed on the specified speed breaker was recorded in seven days and wasted energy was calculated and analyzed for each type of vehicle for the seven days. A total amount of 376,849.6kJ is wasted during those days on a single speed breaker which has a huge impact on the economy of the country by increasing fuel consumption of individual cars.

Keywords: Speed breaker, Kinetic energy wastage, Potential energy wastage.

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1. Introduction

The control of the traffic in the urban roads and in the highway has been a big challenge as the number of increase in the auto mobiles [1]. There is no certain classification for automotive industries globally. But some classifications collected and embedded this class with machinery, tools, equipment, and metal products industries [2]. Restrictions on access to fossil fuels and environmental degradation caused by the use of these resources have led humans to seek new sources of energy [3]. An energy crisis is any significant bottleneck in the supply of energy resources to an economy [4]. When a vehicle passes over the speed breakers, the kinetic energy of the vehicle is converted in heat energy and released to the environment without doing any useful work [5].

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Speed breakers are built in Woldia city main line in order to decrease the accident occurrence rate due to high speed driving. It is obvious that reducing the speed of a vehicle has a vital role in reducing accidents.

Those speed breakers are placed in every highway, which is found in the city as well as in the four direction outlets namely, Woldia to Mekelle, Woldia to Bahir Dar, Woldia to Addis Ababa, and Woldia to Hara Gebeya. While speed breakers were built everywhere in the city or outside, many of them were constructed by non-professionals without announcing the Federal Road Authority or the respected person around that area. Because of this, almost all of them were constructed without any standard like the height and width of a single speed breaker as well as the distance between successive speed breakers were emotionally decided by non-professionals.

As long as Woldia is found at the center of the northeast part of Ethiopia, many numbers of light duty, medium duty, and heavy duty vehicles are traveled from somewhere to the other. As a result, there are so many distractions due to a single speed breaker.

Even though speed breakers are used to reduce the occurrence of accidents, they have their own contribution to traffic congestion that can increase the collusion of cars and loss of fuel economy because of sudden breaking and conversion of kinetic energy into heat energy. The maximum speed of the Bajaj is about 65 km/hr at level roads and its GVW is 678 kg [6].

Friction will produce heat and some of them are radiated through conduction and convection of brake pair, while others are absorbed by physical–chemical reactions and wear behaviors on friction interface [7]. Frequent braking has also a result of brake lining material wear, tire wear, and it may have a consequence of mechanical brake failure which increase the maintenance cost in general. All the generated energy due to such vehicles is going to waste. So we need to have a mechanism that could able to utilize the energy of the vehicles [8].

Traffic-related sources have been known as a major contributor of particulate matter, mainly within major cities. Exhaust and non-exhaust traffic-related sources are predicted to contribute almost 50% traffic-related PM_{10} emissions [9].

Frequent braking will also damage the tires as well as wear out the brakes and suspension early. Frequent harsh braking increases the probability of collision with the car in a front, behind or side. In addition to this, it will have an increment in fuel consumption due to acceleration to recover lost momentum [10].

2. Materials and Methods

This section describes the materials used and methods followed during the research in order to achieve the overall objectives of the study. Therefore, those things are listed and discussed one by one as follows.

2.1. Materials

Different materials were used for conducting this research among those Microsoft Excel were used for tabulating, plotting, and analyzing the data.

2.2. Methods

This section explains and describes the methods followed during this work for the specific tasks and it is mainly dependent on data collection, analysis, and reflection. Those methods are explained as follows.

2.2.1. Data collection

Different data were collected during this work. The major data that has been collected was grouped under two categories called qualitative data and quantitative data. The quantitative one was focused on the number of vehicles that passes through the specified speed breaker which is the backbone of this study. And the other data collection was the specification of the benchmark vehicle called Bajaj and Mini Bus. A sample data was taken and recorded in seven days (1 week) which is displayed in ***Table 1*** below. The phenomenon of the vehicle while it passes over the speed breaker is demonstrated in ***Figure 1*** below.

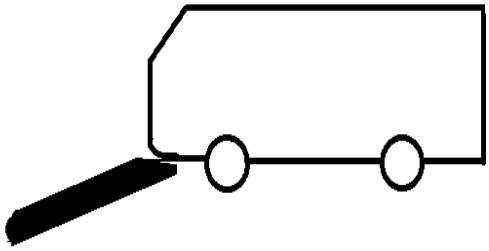

Figure 1. Demonstration of a vehicle passes over a speed breaker.

Table 1. Number of passenger vehicles passing through the selected route.

Days	Collected data for each day No. of Bajaj/day (n) 400kg	 Mini Busses ≈ 1800kg
Monday	553	98
Tuesday	678	164
Wednesday	359	112
Thursday	415	121
Friday	443	93
Saturday	318	118
Sunday	387	86

2.3. Analysis

2.3.1. Energy wastage in a Bajaj

While decreasing the speed of a fast moving vehicle its kinetic energy is changed into heat energy and released into the surrounding. The minimum average velocity of the Bajaj during passing over the speed breaker is about 0.5 m/s, whereas the maximum velocity is 16.67 m/s. So that wasted kinetic energy due to a single speed breaker for a single Bajaj is

$$\mathrm{KE} = \frac{1}{2}\mathrm{m}(\mathrm{v}^2 - \mathrm{u}^2) = \frac{1}{2} \times 400(0.5^2 - 16.67^2) = 55.52\mathrm{kJ}. \quad \textbf{(1)}$$

The total number of Bajaj passed over the selected speed breaker is

$$\mathrm{y} = \sum_{\mathrm{i=monday}}^{\mathrm{i=sunday}} \mathrm{ni} == 3{,}153. \quad \textbf{(2)}$$

And the mean is

$$\frac{\mathrm{y}}{\mathrm{no.\,of\,days}}\ \bar{\mathrm{Y}} = \frac{3153}{7} = 450.42 \quad \textbf{(3)}$$

Therefore the wasted kinetic energy in all the seven days will be

$$\mathrm{E_T} = \mathrm{KE} \times \mathrm{y} = 55.52 \times 3153 = 175{,}054.5\mathrm{kJ}. \quad \textbf{(4)}$$

The speed breaker is 15 cm high and 30 cm wide; wasted potential energy due to climbing the speed breaker will be

$$\mathrm{PE} = \mathrm{mgh}\ \mathrm{PE} = 400 \times 9.81 \times 0.15 = 588.6\mathrm{J}. \quad \textbf{(5)}$$

The subtotal wasted potential energy is

$$\mathrm{PE_T} = \mathrm{PE} \times \mathrm{y}\mathrm{PE_T} = 588.6 \times 3153 = 1855.8\mathrm{kJ}. \quad \textbf{(6)}$$

2.3.2. Energy wastage in a Mini Bus

The total number of Mini Bus passed over the selected speed breaker is

$$\mathrm{x} = 98 + 164 + 112 + 121 + 93 + 118 + 86.$$
$$\mathrm{x} = 792.$$

Wasted kinetic energy due to a single speed breaker for a single car is

$$\mathrm{KE} = \frac{1}{2}\mathrm{m}(\mathrm{u}^2 - \mathrm{v}^2).$$

$$\mathrm{KE} = 249.8\mathrm{k}.$$

The subtotal wasted Kinetic energy of all cars for seven days is

$$\mathrm{KE_{Tc}} = 249.8 \times 792 = 197{,}841.6\mathrm{kJ}.$$

Wasted potential energy will be

$$\mathrm{PE} = \mathrm{mgh}.$$

$$\mathrm{PE} = 1800 \times 9.81 \times 0.15 = 2648.7\mathrm{J}.$$

The subtotal wasted potential energy is

$$\mathrm{PE_T} = \mathrm{PE} \times \mathrm{x}.$$

$$\mathrm{PE_{Tc}} = 2648.7 \times 792 = 2{,}097.7\mathrm{kJ}.$$

Total energy wastage in cars and Bajaj due to speed breaker is

$$\mathrm{E_T} = \mathrm{PE_T} + \mathrm{PE_{Tc}} + \mathrm{KE_T} + \mathrm{KE_{Tc}}.$$

$$\mathrm{E_T} = 2{,}097.7\mathrm{kJ} + 197{,}841.6\mathrm{kJ} + 1855.8\mathrm{kJ} + 175{,}054.5\mathrm{kJ}.$$

$$\mathrm{E_T} = 376{,}849.6\mathrm{kJ}.$$

3. Results

The results of the analysis are listed in the ***Table 2*** below

Table 2. Wasted energy.

Type of Automobile	Kinetic Energy Wastage	Potential Energy Wastage	Total
Bajaj	175,054.5kJ	1855.8kJ	176,910.3
Mini Bus	197,841.6kJ	2,097.7kJ	199,939.3
	Total		376,849.6

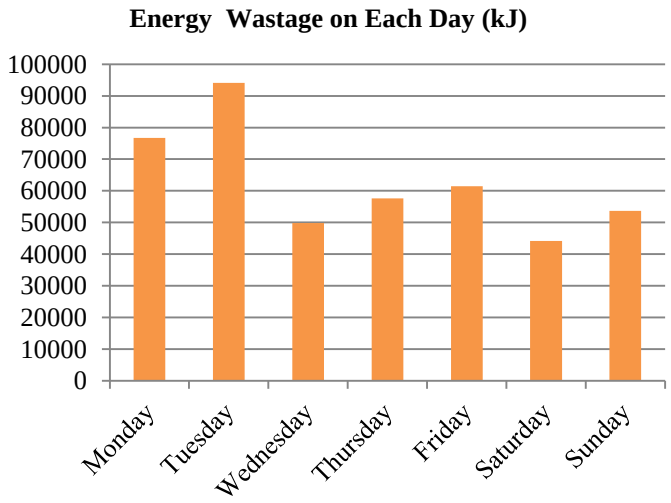

Figure 2. Energy wastage on each day.

4. Discussion and Conclusion

Automobile energy is wasted on speed breakers that are built in Woldia city while climb it and reduce its speed in order to keep stability. As we can see the results of the analysis in ***Table 2*** above the wasted energy on minibuses is higher than that of Bajaj; this is because of the difference in the gross weight of the vehicle which indicates that heavier vehicles will lose much more energy during passing over speed breakers. It is indicated that Ethiopia loses 376,849.6 kJ energy per a week due to a single speed breaker and those two types of vehicles result fuel wastage without doing any useful work. This leads to an extra dollar expense of the country and even will cause a shortage of fuel that will have a negative impact on the end users or servants by bringing shortages of transportation as well as making their life complicated by facilitating inflation.

As it is shown in ***Figure 2*** much energy is wasted on Tuesday as compared to the other six days; this is because a higher number of vehicles were recorded on the specified day since Tuesday is the market day on Woldia Town which a higher number of transportation need was available. Because so many heavy duty vehicles are passed through the specified speed breakers, the energy wastage is much more than the calculated value, therefore the respected authority should give an attention and set the solution by using different methods in order to control the over peed driving otherwise we are going to lose much amount of energy in a few months.

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