Effectiveness of SLIFA device installation for transportation sector especially on truck and bus to reduce the environmental impact in urban area of DKI Jakarta

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Abstract. Based on data from the Ministry of Environment (KLH), the transportation sector is the largest source of air and greenhouse gas (GHG) pollutants in urban areas followed by other sources of fine pollutant emissions such as industry, households and commercial activities. GHG emissions from the transportation sector in the city are around 23% of total GHG emissions from all sources. The aim of this study is to reduce emissions on trucks and buses by installing the Speed Limiter and Driver Fatigue Analyzer (SLIFA). The SLIFA installed on trucks and buses that is operating in the city area. The analysis of smoke level with an exhaust emission meter for monitoring several pollutants such as Carbon Dioxide (CO₂), Carbon Monoxide (CO), Nitrogen Monoxide (NOₓ), and Sulphur Dioxide (SO₂). The average opacity index at truck SG 500 before is 22% and it was reduced to 16.6% after SLIFA installation. The analysis in bus OH 1526 obtained that the average opacity index before is 25.11%, and after installation, it was reduced to 20.17%, analysed with Fleet Management Toolkit (FMT) Air Pollutants, Particulate Matter PM₁₀, 3.3 ton/yr sulphur Oxides SOₓ 3.8 ton/yr, Nitrogen NOₓ Oxides ton/yr, Carbon Monoxide CO 77 ton/yr, Volatile Organic compound VOCs 11 ton/yr. The data showed that the installation of SLIFA was effective in reducing the exhaust emission of the trucks and buses and these tools can be used to reduce the risk of cancer, bronchitis and so on.

1. Introduction

International uses Air Visual as a measure of air quality in a city, Jakarta as the first transfer city in 2019 with an air pollution level index reaching 159 AQI [1]. In a survey conducted in Sweden state that speed limitation affects some very positive things, namely fuel economy can be achieved based on the target, thus pollutants released by the results of engine combustion can also be reduced, table 1.1 mentions survey results from 84 respondents mention that the use of speed limiter has an impact on reducing fuel consumption and pollution[2]. However, there are also potential benefits beyond safety. Higher speeds are less fuel-efficient. Speed limiters have been shown to be fuel-efficient and could lead to substantial fuel savings[3].
Less fuel consumption means a reduction in greenhouse gas emission [4]. The purpose of this study was to determine the opacity level of trucks and buses on the fleet owner or transportation company by analyzing the emission value in\% (percent) after the speed limiter (SLIFA) was installed from the total fleet owned.

| Table 1. Success of speed limiters in increasing fuel economy and emission |
|-------------------------------------------------|
| Very Successful | Successful | Neutral | Unsuccessful | Very Unsuccessful | Cannot Determine |
| %               | 35.7\%     | 40.4\%  | 17.9\%       | 2.4\%             | 0.0\%            | 3.6\% |
| N               | 30         | 34      | 15            | 2                  | 0                | 3      |

Out of 84 responses.

2. Methods

This study involved a transportation company in the Jakarta region that operation in urban areas, bus public transport was chosen because it was the largest emitter in the Jakarta area, trucks as emission contributors when road conditions was jammed, because high fuel consumption when the engine is idle.

The analysis of opacity conditions using a meter opacity tester in bus and truck vehicles. After carrying out emissions testing as a whole, it was analyzed with Fleet Management Toolkit (FMT) software that can be analyzed and concluded due to the effects of emissions on environmental impacts as well as some additional analysis of the results of the analysis provided such as actions that must be done.

To achieve the purpose of this research, we propose a methodology in Figure 1, and the methodology consists of the steps of emission analysis of the truck and bus engine.

![Flow chart of the research](image)

Fig 1. Flow chart of the research

2.1. SLIFA Safety Device
SLIFA is a safety device that can limit the speed of the vehicle by government regulations, namely when the toll is a maximum speed of 60 km/h and when in the preservation area the speed automatically decreases 30-50 km/h[5]

2.2. Cleaner Fleet Management Toolkit (FMT)

About the Cleaner Fleet Management Toolkit, developed by the United Nations Environment Programme (UNEP) and TNT in 2006-field tested by TNT Turkey and humanitarian aid fleets[6], the toolkit contains a number of tools that fleet managers to:
1. Evaluate the impact of their fleets on the environment and human health, and
2. Develop practical strategies and scenarios for corrective and cost-effective action

3. Result and Discussion

3.1. Effective of Speed Limiter (SLIFA) on environment
The environment impact of SLIFA implementation was through the engine combustion that produced air pollution. Data acquisition was performed when truck and bus wherein accelerated condition at a minimum speed of 20 km/h and a maximum speed of 70 km/h.
Table 2. Emission analysis before and after installation of SLIFA

| Engine Type | Speed (km/h) | rpm | Before Emission Testing (%) | After Emission Testing (%) |
|-------------|--------------|-----|-----------------------------|---------------------------|
|             | 1            | 2   | 3                          | 1                         | 2   | 3                         |
| Truck SG 500| 20           | 1300| 21                          | 17                        | 17  | 16                        | 9  | 14                       |
|             | 50           | 2000| 22                          | 18                        | 19  | 13                        | 14 | 14                       |
|             | 60           | 3000| 23                          | 22                        | 20  | 21                        | 18 | 17                       |
|             | 70           | 3500| 19                          | 28                        | 34  | 20                        | 22 | 24                       |
| Average (%)| 22           | 16.6|                            |                            |     |                           |    |                          |
| Bus OH-1526| 20           | 1300| 24                          | 19                        | 26  | 14                        | 14 | 20                       |
|             | 40           | 1500| 32                          | 25                        | 24  | 38                        | 20 | 20                       |
|             | 50           | 2000| 24                          | 20                        | 22  | 13                        | 16 | 18                       |
|             | 60           | 3000| 22                          | 26                        | 23  | 16                        | 18 | 20                       |
|             | 70           | 3500| 20                          | 34                        | 36  | 19                        | 29 | 30                       |
| Average (%)| 25.111       | 20.167|                          |                            |     |                           |    |                          |

The percentage of opacity index value was obtained through three cycles of the procedure to make sure the accuracy of the data. The opacity index of exhaust emission of both vehicles showed the total pollutant in the exhaust emission gas. SLIFA was applied in the diesel engine of both vehicles. The opacity of this study consisted of several pollutants such as Carbon Dioxide (CO₂), Carbon Monoxide (CO), Nitrogen Monoxide (NOₓ), and Sulfur Dioxide (SO₂). Table 2, and Figure 4, shows the decreasing value of the opacity index percentage after SLIFA implementation on the truck and bus.

3.2. Analysis with Cleaner Fleet Management Toolkit (FMT)

After installation of SLIFA on a truck and bus engine then it is analyzed by entering the test data into a toolkit (FMT) to find out how much impact it has if the emission conditions released by the combustion company, and other actions that need be made in addition to the use of speed limiter on the engine, Figure 4 shows the data that obtained by data processing toolkit (FMT).

**Fig. 4** Result of using data base-on fleet owner

Some of your options for potential savings analysis from clean fleet management summary:
a) Eco driving & Maintenance
Eco driving can reduce your fuel consumption by 5 to 10% (7.5% on average), reducing your fuel cost by approximately 170538 EUR/yr (on average) and your CO₂ emissions by 317 tonnes/yr of CO₂.

b) Better maintenance can help reduce your fuel consumption by 4 to 7% (5.5% on average), depending on your maintenance level now. It can reduce your fuel cost by approx. 125061 EUR/yr, and your CO₂ emissions by 232 tonnes/yr of CO₂ (on average).

c) Fuels
You can reduce your SOx emissions by switching to cleaner diesel. Currently you are using diesel with a sulphur level of 5000 ppm. If you switch to 500 ppm diesel, your fleetwide SOx emissions will reduce by 90%. If you switch to 50 ppm diesel, your fleetwide SOx emissions will even reduce by 99%. If you would use 10% blended biofuels your fleetwide CO₂ emissions would be reduced by 5% to 10%, depending on the type of biofuel you use. You can even decide to use high blended biofuels to reduce your emissions even more.

d) In-use vehicles
Retrofitting some of your trucks is possible if you have low sulphur diesel available. If you retrofit all your Euro I - V trucks and buses with Diesel Oxidation Catalysts (DOCs), you will save the emission of approximately 534 kg/yr of Particulate Matter, which equals 16% of your current fleetwide PM emissions. For DOCs a diesel sulphur level of 500 ppm or less is required, therefore it is not recommended. If you retrofit all your Euro III - V trucks and buses with Diesel Particulate Filters (DPFs), you will save the emission of approximately 37 kg/yr of Particulate Matter, which equals 1,1% of your current fleetwide PM emissions. For DPFs diesel with 50 ppm or less sulphur is required (<15 recommended), therefore it is not recommended at this time.

e) New vehicles
Switching your petrol passenger vehicles to diesel vehicles will reduce your fuel, consumption, fuel costs and CO₂ emissions. The reduction in CO₂ emissions will be 41 tonnes/yr of CO₂, which is about 1,1% of your current fleetwide, CO₂ emissions. In addition, 40404 EUR/yr will reduce fuel cost.
Replacing your conventional passenger vehicles with hybrid electric passenger vehicles, This equals an annual fuel cost saving of 747 EUR per passenger vehicle for each year it is driving, resulting in a payback time of the investment for the hybrid technology of approximately 2 years. Furthermore it reduces your fleetwide CO₂ emissions by 112 tonnes/yr of CO₂.
By replacing all pre-Euro-III trucks and buses with Hybrid Electric Trucks and Buses, you save 447978 L/yr of diesel, worth 618210 EUR/yr. Besides, it reduces your annual emissions of CO₂ by1165 tonnes/yr of CO₂, and 3,1 tonnes/yr of PM.
By replacing all pre-Euro-III trucks and buses with Euro-V Trucks and Buses, you save 149326 L/yr of diesel, worth 206070 EUR/yr. Besides, it reduces your annual emissions of CO₂ by388 tonnes/yr of CO₂, and 3,1 tonnes/yr of PM.
By replacing all pre-Euro-III trucks and buses with CNG Trucks and Buses, you reduce, your annual emissions by 194 tonnes/yr of CO₂ and 3,1 tonnes/yr of PM. The data was supported by previous researchers that according to Hidayati et al., [7] that speed reduction is not only to the benefit of road safety but can also lead to a reduction in fuel consumption and CO₂ emissions. Increasing the weight and the power of motor vehicles increases emissions and has an important impact on road safety. Reducing the power to weight-ratios of motor vehicles is one of the most effective ways to reduce vehicle fuel consumption [8]. Matínez et al., [9] investigate 9100 vehicles and the result shows that 8% of vehicles exceeded the speed of 90 km/h, and 90% exceeded the speed of 60 km/h. From that previous results, they use between Euro I-V that shown the increment of speed will be increased the exhaust gas emission, increase weight and power will increase exhaust gas emission.
4. Conclusion
From the results of this study, it can be concluded that the use of speed limiter has a very positive impact on the decrease in emission caused by the results of engine combustion in trucks and buses, this can occur because of the speed limiter (SLIFA) which automatically limits speed based on government regulations. Vehicles that previously operated at high speeds due to inconsiderate drivers with installed safety devices became reduced and the speed became constant so that the opacity or emissions of combustion results can be minimized from all levels of speed, such as fuel consumption being more economical. The analysis of the tools kit (FMT) found that when your Particulate Material Emission conditions are harmful to public health and the environment and death/year, plus many other people affected by other diseases such as non-fatal cancer, bronchitis, etc. Air Pollutants, Particulate Matter PM$_{10}$ 3.3 ton/yr sulphur Oxides Sox 3.8 ton/yr, Nitrogen NO$_x$ Oxides ton/yr, Carbon Monoxide CO 77 ton/yr, Volatile Organic compound VOCs 11 ton/yr and than before install SLIFA opacity index 25 % and after install SLIFA opacity index 20%.

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References
[1] P. A. S. Aranditio, 2019 “Jakarta-masih-diperingkat-kualitas-udara-terburuk-di-dunia,” Suara.com, Jakrta, p. 1.
[2] J. S. Hickman, G. Bergoffen, D. C. Murray, W. McDonald, and R. Bishop, 2016 “Safety Impacts of Speed Limiter Device Installations on Commercial Trucks and Buses."
[3] R. Home, C. Meller, and T. Dalton, 2014 Low Carbon, vol. 42, no. 4.
[4] H. Pranoto, A. M. Leman, Y. Gunardi, and T. Pangaribowo, 2018 “Testing speed limiter integrated fatigue analyzer and its effect on fuel efficiency and reduction in greenhouse gas emission on truck engine with 17 ton,” no. 2, pp. 1237–1245.
[5] H. Pranoto, A. M. Leman, F. Anggara, and M. Kholil, 2019 “Speed limiter integrated fatigue analyzer (SLIFA): engineering design and concept,” TELKOMNIKA (Telecommunication Comput. Electron. Control.), vol. 17, no. 1, p. 508.
[6] B. Evans, “School Library Journal Reviews, 2010 ” Libr. Journals LLC, no. August 2008, pp. 2008–2009.
[7] Hidayati, N., Liu, R., & Montgomery, 2012 F. “The Impact of School Safety Zone and Roadside Activities on Speed Behaviour : the Indonesian Case,” Procedia - Social and Behavioral Sciences, vol. 54, pp. 1339–1349.
[8] Soehodho, S. 2017 “Public transportation development and traffic accident prevention in Indonesia”, Safety Science, vol. 40, pp. 76–80.
[9] Mañónez, A., Mántaras, D.A. and Luque, P. 2013 “Reducing posted speed and perceptual countermeasures to improve safety in road stretches with a high concentration of accidents.” Safety Science, vol. 60, pp. 160–168