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## INVESTIGATION OF LORRY NOISE AND FUEL CONSUMPTION DURING ACCELERATION

©ZDANEVIČIUS, M.

Marijampole College (Marijampole, Lithuania)

Email: [zdamin@gmail.com](mailto:zdamin@gmail.com), ORCID ORCID 0000-0002-9036-3299

©JOTAUTIENĖ, E.

Vytautas Magnus University Agricultural academy (Kaunas, Lithuania)

Email: [Egle.Jotautiene@asu.lt](mailto:Egle.Jotautiene@asu.lt), ORCID ORCID 0000-0003-1692-4032

**Abstract.** The relevance of the research is the intensity of noise emitted by lorries depends on the regime of the vehicle movement. One of the main negative factors caused by road vehicles is air pollution with exhaust gases. **The article presents results for noise caused by lorries and gas usage while the vehicle is accelerating. The subject of the study** is 4 lorries (MAN lorries, the total mass of which is ~18000 kg, whereas the lorry itself weights ~8000 kg and has the power of 420-460 HP), and they also feature fuel recording systems which are less than 5 years old. **Research methodology.** The level of noise emitted by heavyweight transport vehicles is measured according to Lithuanian standard LST ISO 1996-2:2008 requirements. During the tests the noise levels of  $L_{A,eq}$ ,  $L_{C,eq}$ ,  $L_{C,peak}$  were measured. The tests were done 5 times each and the results are presented as arithmetical averages. Fuel consumption is registered in vehicle data registration system. The researched vehicles have to comply with environmental safety normative requirements; that the vehicle carbon monoxide (CO), particulate matter (PM), nitrogen oxides (NO<sub>x</sub>), unburned fuel (HC) and other hazardous substances contained in the combustion gases must not exceed the prescribed limits. **The results** of the experimental studies show that EURO6 lorries (440 and 460 AJ) noise level is the lowest compared to the EURO4 and EURO5. After carrying out the analysis of the caused noise and gas usage, it was found that noise pollution and gas usage are higher without speed control system. The noise caused by lorries can be described in square polynomial which defines the noise inclination change while vehicle is accelerating. **Scientific novelty of the research** a complex research on noise and fuel consumption of lorries by using and not using speed control system. **Research idea and problem** is to achieve sustainable transport development objectives, in particular the reduction of greenhouse gas emissions under the Kyoto Protocol. It is very important to find ways to forecast and reduce transport noise pollution, while also reducing overall pollution, as well as mitigating the impact on the global climate.,

**Conclusion** – after conducting a lorry noise and fuel consumption analysis, it was determined that not using speed control system increases the noise and fuel consumption and if the system is used both of these factors decrease drastically.

**Key words:** lorry, noise level, analysis of noise and gas, speed control system, vehicle acceleration

**The problem is presented in with important scientific or general terms and its connection practical tasks.** Lorry transport flow

intensifies each year because Lithuania is an important transit country in Eastern Europe with well-developed and constantly improved road transportation system. Mobility and transportation flow increases due to ongoing economic, social and political changes [1, 2]. Besides the economical factor, environmental protection aspects are also important. Noise level depends on the type of the vehicle. Heavier vehicles emit significantly more noise than lighter ones. While driving, a light car emits 70 - 80 dBA, a bus 80 - 85 dBA, a lorry 80 - 90 dBA, and a motorcycle 90 - 95 dBA[1].

Heavy vehicles moving uphill in summer emit maximum noise measured at 83 dBA. During acceleration vehicle equivalent noise level  $L_{A,eq}$  can reach up to ~87 dBA [2]. There are increasing talks in Europe about transport noise as a primary source of noise. According to European Federation for Transport and Environment, ~200 million people in the EU suffer because of the transport noise [3, 4]. Atmosphere pollution by exhaust gas is also one of the main negative transport factors for environment. The biggest part of pollution is comprised of fuel combustion products. Along with the exhaust gas, during the combustion process, more than 200 various chemical compounds are released to the environment, most of which are harmful to people and biosphere. The amount of fuel consumption and exhaust pollution greatly depends on driving speed [5]. The faster the vehicle is moving, the more noise increases.

In order to achieve coherent transport development, it is very important to find means to reduce the transport pollution and the effect on the climate.

**Aim of the research** – to examine the impact of speed on pollution cause by lorries and their fuel consumption.

#### **Research methodology**

The level of noise emitted by heavyweight transport vehicles is measured according to Lithuanian standard LST ISO 1996-2:2008 requirements, and evaluated according to the approximation of the laws of the Member States relating to the permissible sound level and the exhaust system of motor vehicles 70/157/EEC by the Directive of the European Parliament and of the Council [6, 7]. The noise emitted by vehicles is classified as volatile noise.

It is difficult to measure the noise level emitted by a vehicle when it is accelerating because it is complicated to keep the exact distance between the vehicle and the microphone. For the research, a road stretch was chosen according to the requirements of the 70/157/EEC directive and ISO 362-2:2009 standard, meaning that the width of the driveway is at least 3 meters and that there are no objects or secondary noise sources which could affect the test. A paved road near a transport company was chosen for the test.

Integrated noise meter CEL – 440 was used for the measurement. The device complies with the requirements of Lithuanian LST IEC 804+A1+A2: 1999 en. Standard „Integrated Medium Noise Level Meters”. The

measurements were performed when the wind speed was less than 5 m/s. The noise was measured with 1.5 meter distance from the ground, more than 3.5 meters from buildings [8]. The noise meter was placed on a stand with the distance of 7.5 meters from the driving trajectory centre, at the height of 1.2 meters from the ground. In order to avoid mistakes, the measurements were conducted by placing the measuring person at the distance of 0.5 meters from the microphone. The noise level was recorded when a vehicle would be passing by and accelerating up to 50 km/h. Vehicle with automatic transmission would accelerate until reaching a steady speed (from 10 to 50 km/h, in a distance of 100 meters) and then they would increase the speed within 10 meters before the microphone. The Engines of the measured vehicle were heated until the operating temperature and during the testing when the engine is at maximum power the engine speeds are maintained automatically. During the tests the noise levels of  $L_{A,eq}$ ,  $L_{C,eq}$ ,  $L_{C,peak}$  were measured. The tests were done 5 times each and the results are presented as arithmetical averages.

Research object: 4 lorries (MAN lorries, the total mass of which is ~18000 kg, whereas the lorry itself weights ~8000 kg and has the power of 420-460 HP), and they also feature fuel recording systems which are less than 5 years old. The fuel consumption is recorded in the vehicle data records system. The tested vehicles have to comply with environmental safely normative requirements; the emissions of carbon

monoxide (CO), particulates (PM), nitrogen oxides (NOx), unburnt fuel combustion (NC) and other hazardous substances in the combustible materials of the vehicle must not exceed the limits for green procurement requirements.

Factors that may affect performance: vehicle technical condition (by mileage); fuel quality (fuel was be taken from the same gas station); driving style (all cars were driven by the same driver).

The mathematical statistics methods and the electronic calculator of the Microsoft Office program package were used for data processing and presentation. Measuring results are transferred from the device to the EXCEL by using.

### Research results

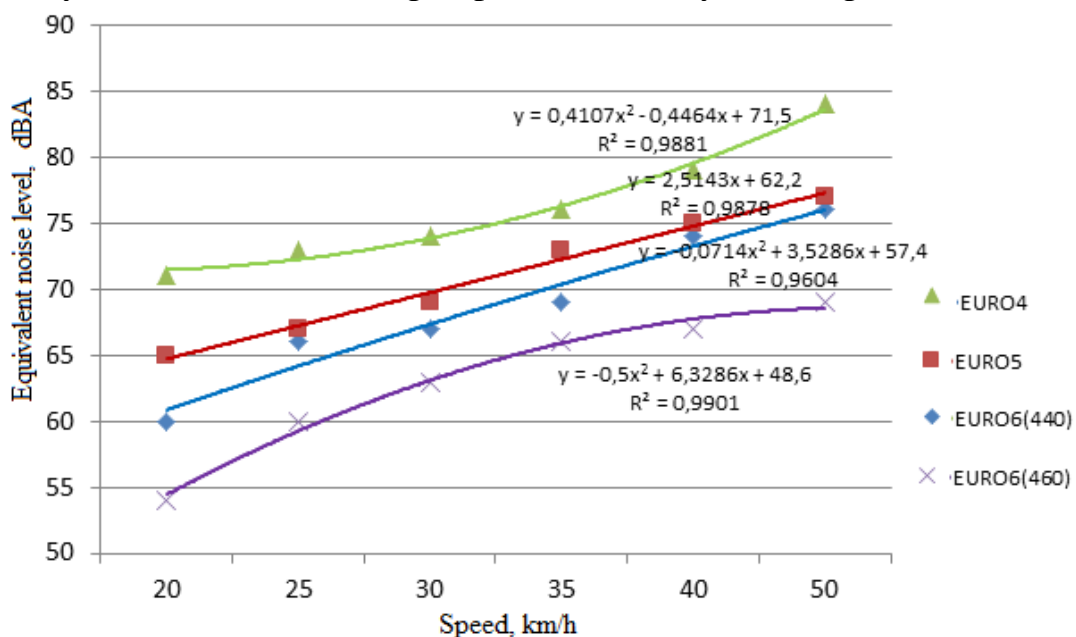
According to the data of the lorry registration system, factors influencing fuel consumption are selected. For this purpose, 4 lorries were selected: EURO4 with a trailer (MAN TGA 18.420), EURO5 (MAN TGX 18.440), EURO 6 (MAN TGX 18.440), EURO6 (MAN TGX 18.460 (338kW)). After analysing the factors it can be stated that the height of the vehicle has a significant impact, if we compare a vehicle with the height of 4 meters consumes 3.6 l/100 km more than its counterpart which is 4 meters in height,. The driving behaviour and the conditions of use of the vehicle influence fuel consumption the most. An analysis of factors influencing fuel consumption shows that driving in the city in comparison with the motorway has the greatest influence on the fuel consumption of a commercial vehicle. This can be explained by the fact that

a car in the city must often stop and accelerate. Factors can interact with each other, but they cannot always be summed up with each other.

The automobile data registration system provides data on the fuel consumption of each vehicle in various driving modes. The data system records not only fuel consumption but also speed variation, driving conditions, brakes, accelerations, engine parameters, etc. These recordable parameters provide detailed information on the entire nature of the lorry's journey. Based on the data, it is possible to control the economy parameters of each vehicle. Speed control system is used to increase lorry economy and improve the drive. The data analysis revealed that a part of drivers use speed management system about 19.3% of driving time, while other drivers use this system more than 60% of the time. Noise tests are performed with one lorry from each of these groups.

The results presented here do not include noise levels associated with gear shifting. Noise measurements are made for two driving ranges: the speed control system is not used, 50 km/h speed is reached in 9 or less seconds; and the speed-up system is used, the 50 km/h speed is reached within 14 s and more.

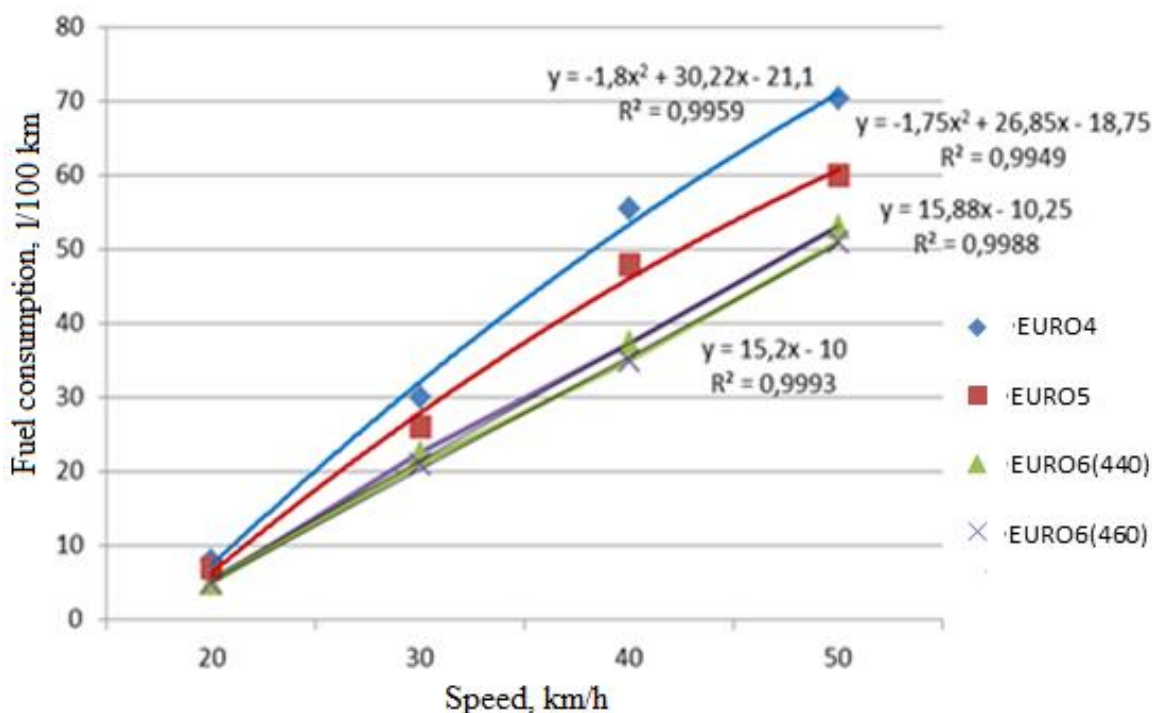
As the vehicles accelerated, the loaded lorry generated a much higher noise level.  $L_{Aeq}$  was up to 84 dB (A). The background noise from the measurement results is not eliminated. Vehicle acceleration means a significant increase in noise levels. The acceleration is higher at lower starting speeds. The loaded EURO4 lorry was the noisiest over the test speed range. EURO6 with different engines (440 and 460 AJ), the noise level was the lowest. Even at 35 km/h the noise level would not increase. The following noise results were obtained from lorries using a speed-control system (Figure 1).



**Figure 1.**  $L_{Aeq}$  noise levels and lorries speed without using a speed-control system

Using this system,  $L_{Zmax}$  (the highest value was 89 dB) and  $L_{Aeq}$  (73 dBA maximum) noise levels were lower than the values obtained without using the speed-control system ( $L_{Zmax}$  peaked at 120.5 dB,  $L_{Aeq}$  had a maximum value of 84 dBA). A quadratic polynomial is used to analyse the measured data, which defines the nature of the noise

variation when the vehicle accelerates (with increasing acceleration).  $R^2$  is between 0.999 and 0.962, with a reliability of more than 90%. Because the reliability is high, the quadratic polynomial is really suitable for describing the change of the results. Fuel consumption was recorded at the same time as the measurement of the lorry noise (Figure 2).



**Figure 2.**  $L_{Aeq}$  noise levels and lorries speed without using a speed-control system

After analysing fuel consumption of lorries, it has been found that fuel consumption is higher without using the speed control system. Almost a linear dependence is found when using a quadratic polynomial to describe the change of fuel consumption.  $R^2$  is between 0.9988 and 0.9912.

## Conclusions

1. Analytical review and analysis showed that driving the city in comparison with the motorway has the greatest impact on the consumption of fuel for a commercial lorry. Some drivers use speed-control system to increase fuel economy 19.3% of driving time. Another part of the drivers use this system for about 60% of driving time.

2. Experimental research revealed that the noise level of EURO6 lorry (440 and 460 AJ) was 76 dBA at 50km/h<sup>-1</sup>.

3. After analysing the noise and fuel consumption of lorries, it was found that noise and fuel consumption were higher without the use of a speed-control system (LAeq was up to 84 dB (A) noise level, fuel consumption of 71l/100km while driving 50kmh<sup>-1</sup>). Meanwhile, using

the speed-control system, lowered the LAeq's noise level to 73 dB (A), fuel consumption to 51.5l/100km while driving 50kmh<sup>-1</sup>).

4. The noise caused by lorries can be described by a square polynomial, which describes the nature of the noise when the vehicle accelerates. A linear dependence is found for fuel dependence on the speed of the vehicle.

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**ЗДАНЯВІЧУС, МІНДАУГАС** – лектор Маріямпольської колегії (Маріямполе, Литва)

E-mail: [zdamin@gmail.com](mailto:zdamin@gmail.com), ORCID [ORCID 0000-0002-9036-3299](https://orcid.org/0000-0002-9036-3299)

**ЙОТАУТЕНЕ, ЕГЛЕ** – доктор технічних наук, професор, Сільськогосподарська Академія Університету Вітаутаса Великого (Каунас, Литва)

E-mail: [Egle.Jotautiene@asu.lt](mailto:Egle.Jotautiene@asu.lt), ORCID [ORCID 0000-0003-1692-4032](https://orcid.org/0000-0003-1692-4032)

### ДОСЛІДЖЕННЯ ШУМУ І СПОЖИВАННЯ ТОПЛИВА ДЛЯ СТІЙКОГО РОЗВИТКУ ТРАНСПОРТУ

**Анотація.** Актуальність дослідження в тому, що інтенсивність шуму, що виробляється вантажними машинами, залежить від режиму руху автомобіля. Одним із основних негативних чинників, викликаних дорожніми транспортними засобами, є

*Investigation of lorry noise and fuel consumption during acceleration*

забруднення повітря вихлопними газами. **Наукова новизна** дослідження - комплексне дослідження шуму і розходу палива вантажних автомобілів з використанням і без використання системи управління швидкістю. Ідея і проблема дослідження - в досягненні цілей стійкого розвитку транспорту, зокрема скорочення викидів парникових газів у відповідності з Кіотським протоколом. Надзвичайно важливо знайти способи прогнозування і пониження рівня забруднення транспортного шуму, пониження загального забруднення, а також пом'якшення впливу на глобальний клімат.

**Метою дослідження** є вивчення залежності вантажного транспорту від шуму і витрати палива при прискоренні автомобіля.

**Виклад основного матеріалу.** У статті представлено результати дослідження шуму, викликаного використанням вантажних автомобілів під час прискорення автомобіля. Результати експериментальних досліджень свідчать, що рівень шуму вантажних автомобілів EURO6 (440 і 460 АД) є самим низьким у порівнянні з EURO4 і EURO5. Після проведення аналізу викликаного шуму і використання газу було встановлено, що шумове забруднення і використання газу без системи контролю швидкості зверху. Шум, викликаний вантажними автомобілями, може бути описаний у вигляді квадратного поліному, який визначає зміни нахилу шуму при прискоренні транспортного засобу; щоб добитися стійкого транспорту, важливо знайти способи зменшення забруднення транспорту, щоб зменшити пом'якшення впливу на глобальний клімат. Потоки вантажних перевезень збільшуються з кожним роком, постільки Литва є важливою транзитною країною у Східній Європі з добре розвинутою системою автомобільних перевезень, що покращуються.

**Висновки** - після проведення аналізу шуму вантажного автомобіля і розходу палива було визначено, що відсутність системи управління швидкістю збільшує шум і витрата палива, а при використанні системи обидва чинники різко зменшуються.

**Ключові слова:** вантажний автомобіль, шум, аналіз шуму і газу, система контролю швидкості, прискорення транспортного засобу

**МИНДАУГАС, ЗДАНЯВИЧУС** - лектор Маріямпольской колегии (Маріямполье, Литва)

E- mail: zdamin@gmail.com, ORCID 0000-0002-9036-3299

**ЙОТАУТЕНЕ, ЭГЛЕ** – доктор технических наук, профессор, Сельскохозяйственная академия Университета Витаутаса Великого (Каунас, Литва)

E- mail: Egle.Jotautiene@asu.lt, ORCID 0000-0003-1692-4032

## ИССЛЕДОВАНИЕ ШУМА И ПОТРЕБЛЕНИЯ ТОПЛИВА ДЛЯ УСТОЙЧИВОГО РАЗВИТИЯ ТРАНСПОРТА

**Аннотация.** Актуальность исследования в том, что интенсивность шума, производимого грузовиками, зависит от режима движения автомобиля. Одним из основных негативных факторов, вызываемых дорожными транспортными средствами, является загрязнение воздуха выхлопными газами.

**В основе исследования.** Научная новизна исследования - комплексное исследование шума и расхода топлива грузовых автомобилей с использованием и без использования системы управления скоростью. Идея и проблема исследования заключается в достижении целей устойчивого развития транспорта, в частности сокращения выбросов парниковых газов в соответствии с Киотским протоколом. Очень важно найти способы прогнозирования и снижения уровня загрязнения транспортного шума, а также снижения общего загрязнения, а также смягчения воздействия на глобальный климат

**Целью исследования является** изучение зависимости грузовика от шума и расхода топлива при ускорении автомобиля.

**Изложение основного материала** В статье представлены результаты исследования шума, вызванного использованием грузовиков во время ускорения автомобиля. Результаты экспериментальных исследований показывают, что уровень шума грузовых автомобилей EURO6 (440 и 460 АJ) является самым низким по сравнению с EURO4 и EURO5. После проведения анализа вызванного шума и использования газа было установлено, что шумовое загрязнение и использование газа без системы контроля скорости выше. Шум, вызванный грузовыми автомобилями, может быть описан в виде квадратного полинома, который определяет изменение наклона шума при ускорении транспортного средства. чтобы добиться устойчивого транспорта, важно найти способы уменьшить загрязнение транспорта, чтобы уменьшить глобальный климат. Потоки грузовых перевозок увеличиваются с каждым годом, поскольку Литва является важной транзитной страной в Восточной Европе с хорошо развитой и улучшающейся системой автомобильных перевозок.

**Выводы** - после проведения анализа шума грузовика и расхода топлива было определено, что отсутствие системы управления скоростью увеличивает шум и расход топлива, а при использовании системы оба эти фактора резко уменьшаются.

**Ключевые слова:** грузовик, уровень шума, анализ шума и газа, система контроля скорости, ускорение транспортного средства.

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