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Faculty of Mechanical Engineering

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Content

KEYNOTE LECTURES

MECHANICS AND DESIGN

PRODUCTION TECHNOLOGIES AND ENGINEERING

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TRANSPORT AND MEANS OF TRANSPORT

MECHATRONICS

MAINTENANCE OF TECHNICAL SYSTEMS, OCCUPATIONAL SAFETY

PREFACE

Dear colleagues,
DEMI Conference has brought us together for the 11th time to show the current state of research in the field of Mechanical and Electrical Engineering as well as Information Technology.

From the very beginning, the Conference has aimed strengthening cooperation between companies and science. However, we live at the time of a severe economic crisis that even affects the richest economies. Furthermore, stagnation of the real economy and unemployment are present in technologically developed countries, whereas investments in the R&D sector are small, all of which reflects on the field of scientific research.

There was concern that such a state of the economy may cause a lack of interest and potential of scientific workers to participate actively in the work of scientific conferences. However, DEMI will not flinch. With great pleasure, I would like to point out that the DEMI 2013 Conference gathered a record number of participants so far. The Conference Proceedings contains 174 papers by authors from 14 countries. Scientists and researchers have traditionally been the most active in the field of Production Technology and Engineering (41 papers), followed by Energy and Thermal Engineering (37 papers), Mechanics and Design (28 papers), Transport Vehicles and Transportation (23 papers), Mechatronics (20 papers), Maintenance of technical systems, Occupational safety (17 papers).

On behalf of Organizational Board of the 11th International Conference on Accomplishments in Electrical and Mechanical Engineering and Information Technology, DEMI 2013, I wish all our guests a warm welcome to Banja Luka and successful work to all participants. Furthermore, I would like to express my gratitude to all the authors, members of the Scientific Committee, institutions, companies and individuals who have contributed to successful organization of the DEMI 2013 Conference.

In Banja Luka, May 2013
Chair of DEMI 2013 Organizational Board
Valentina Golubović-Bugarski

PREDGOVOR

Poštovane kolege,
Konferencija DEMI okupila nas je po 11. put da prezentujemo trenutno stanje istraživanja u području mašinstva, elektrotehnike i informacionih tehnologija.

Konferencija DEMI odavno je za svoj cilj postavila jačanje oblika saradnje između privrednih preduzeća i nauke. Međutim, živimo u vrijeme teške ekonomske krize koja pogađa i najbogatije ekonomije, stagnacija realne privrede i nezaposlenost prisutni su i u tehnološki najrazvijenijim zemljama, ulaganja u razvoj i istraživanja su mala, što se sve reflektuje i na područje naučnih istraživanja.

Postojala je bojazan da će ovakvo stanje privrede uzrokovati i manjak interesovanja i mogućnosti naučnih radnika da aktivno učestvuju u radu naučnih konferencija. Ipak, DEMI ne posustaje.

S posebnim zadovoljstvom ističem da je Konferencija DEMI 2013 okupila do sada rekordan broj učesnika. U zborniku radova objavljeno je 174 radova autora iz 14 zemalja. Naučnici i istraživači tradicionalno su najaktivniji u području Proizvodnih tehnologija i inženjerstva, a rezultati istraživanja u ovom području saopšteni su kroz 41 radova. Slijede područje Termotehnike i energetike (37 radova), Mehanika i konstrukcije (28 rada), Saobraćaj i transportna sredstva (23 rada), Mehatronika (20 radova) i Održavanje tehničkih sistema i zaštita na radu (17 radova).

U ime Organizacionog odbora Konferencije DEMI 2013 iskazujem svim našim gostima toplu dobrodošlicu u Banju Luku i želim uspješan rad učesnicima Konferencije. Takođe, zahvaljujem se svim autorima, članovima Naučnog odbora, institucijama, firmama i pojedincima koji su svojim angažovanjem doprinijeli da Konferencija DEMI 2013 bude uspješno organizovana.

U Banjoj Luci, maj 2013. godine
Predsjednik Organizacionog odbora
Konferencije DEMI 2013
Valentina Golubović-Bugarski

CONTRIBUTION TO THE REDUCTION OF TRAFFIC NOISE BY APPLICATION OF THE CNG BUSES

Saša Milojević[1], Jovanka Lukić[2], Radivoje Pešić[3]

Abstract: *The noise that comes from the road traffic, along with other emitters of environmental noise has a largely negative impact on quality of life. In the Republic of Serbia as in communities everywhere in the world, the noise that comes from the road traffic has become an increasingly noticeable and serious problem which is especially pronounced in large industrialized cities. Regarding to the current situation, as a special contribution to reducing noise in road traffic, it is proposed solution in terms of replacement of the existing city buses with original engines or vehicles on Compressed Natural Gas CNG, that produce less noise emission. This was confirmed with parallel tests of the buses with drive on diesel and CNG. The results obtained by measuring the noise of the vehicles according to the Regulation UN ECE No. 51, are shown a significant noise reduction compared to the situation when used diesel buses.*
Keywords: *Road traffic noise, CNG buses, ecology.*

1. INTRODUCTION

European Union (EU) indicates the noise emission as one of the ecological problems of modern society. According to the EU statistics, nearly 40% of the population today is exposed to the noise level in excess of 55 dB(A), that is upper limit for clearly residential territory. Through 20% of the population is exposed to the noise level in excess of 65 dB(A), that is upper limit for urban center, commercial and administrative area with residences, zone along highway, main route and city roads, until above 30% of the European population is exposed to the noise level in excess of 55 dB(A) nightly, that challenge the problems with dream [3,7].

Today, increased noise, due to emission from diesel vehicles intensified the applications of CNG vehicles. As a contribution, we started the proper researches during it was realized the reconstruction of the low floor city bus with diesel engine, for CNG drive, by mounting of original CNG engine (eng. dedicated NGV) [4].

During the tests, we are measured the emission of noise on the new bus variant according to the Regulation UN ECE 51R [2]. Based on the results, we are verified the reduction of noise in the case when used gas instead of the diesel engine.

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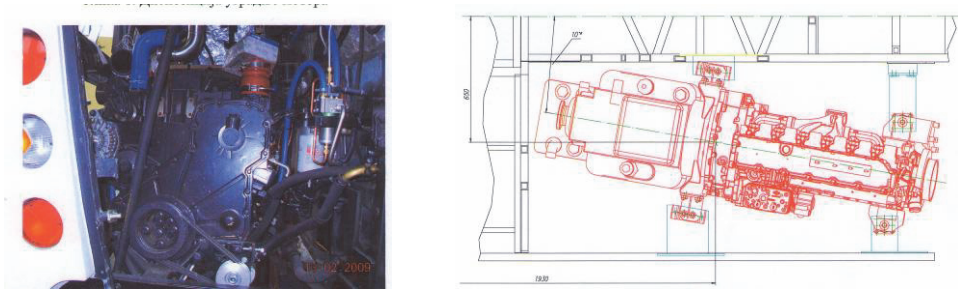
2. STANDARDS FOR LIMITING NOISE LEVELS OF MOTOR VEHICLES

Exterior vehicle noise is standardized with the Regulations UN ECE No. 51, Amendment 02. EU Directive 70/157EEC also applied [2,3].

Directive 2002/49/EC relating on the protection of the noise emission and the Regulation about the noise indicators, with defined limits and methods for evaluating the indicators of noise disturbance and adverse effects of noise in the environment also applied. Both are introduced/ legislated in the Republic of Serbia (Official carrier No. 75/10), and have the objective at preventing/ reducing harmful effects on the population, to establish an adequate database, which will be used to determine the strategic measures to reduce noise in the future [3].

3. RECONSTRUCTION OF THE DIESEL BUS TO DRIVE ON GAS FUEL

The reconstruction of the city bus powered by diesel engine into dedicated NGV, is started through the adaptation of engine compartment for the mounting of original CNG engine type C Gas Plus, Fig. 1. CNG engine is supported by means of dampers with corresponding damping characteristics. We used the classic engineering methods to calculate the best characteristics of the mounts for engine supporting and joint assembling solution. The position of the CNG engine and rest equipment was confirmed by using Finite Element Method analysis (FEM/ PAK below), developed at the Faculty of Mechanical Engineering in Kragujevac. Specifically we are took into account the requirements regarding to the lowering noise and vibrations.



(a) Rear engine support/ traverse *(b) Engine supporting cross four point*

Fig. 1 *CNG engine position on the appropriate supports*

4. EXPERIMENTAL MEASUREMENTS

In order to verify the reconstructions, we are measured the noise emission of the CNG bus at polygon conditions pursuant the Regulative UN ECE No. 51 [2].

4.1 Measuring equipment

Table 1 shows the specifications of measuring equipment used for noise measurement according to the Regulation UN ECE No. 51 [2, 4].

Table 1 *Measuring equipment specification [6]*

Description / Name	Specifications / Type
Sound level meter type	Bruel & Kjaer 2231
Microphone type	B&K 4155
Filter set type	1625
Sound level calibrator type	4230

4.2 Technical characteristics of the experimental buses

The basic dimensions of the reconstructed bus powered by CNG are shown in Fig. 3. The comparative technical characteristics of both analyzed buses, first powered by diesel fuel, and the reconstructed bus powered by CNG, are showed in table 2.

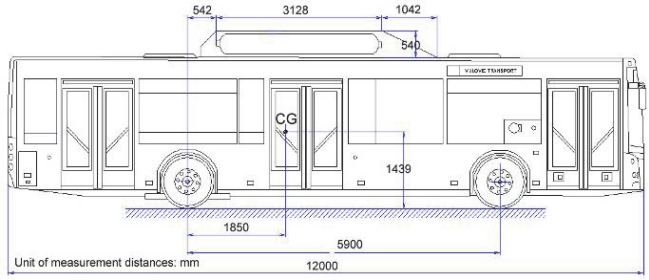


Fig. 3 *The main dimensions of CNG bus*

Table 2 *Technical dates of the test objects – the experimental buses*

The technical dates of buses and equipments	**Diesel bus type 203**	**Gas bus type 203 CNG**
Engine maker - Type - configuration - Version - No. of cylinders / Cycle - Engine capacity (ccm) - Maximum net power - Maximum net torque - Combustion system - Fuel - Type of catalytic action	Mercedes-Benz 2005/55-59C01 OM 906 LA.V/3 (125 L Kat) 6 in-line / four stroke 6 374 210 kW @ 2200 rpm 1120 Nm @ 1200-1600rpm Compression Ignition - CI Diesel **S**elective **C**atalytic **R**eduction, SCR- System	Cummins Engine Comp. D553005BX02 CGe4 280 (TWC) 6 in-line / four stroke 8 268 206.9 kW @ 2400 rpm 1148.8 Nm @ 1400 rpm Spark Ignition - SI Natural Gas - CNG Oxidation – Ceramic in Muffler casing
Gearbox maker - Type - Gear change / number	Voith D 864.3E Automatic / 4 gear speed	Allison T325 R Automatic / 6 gear speed

The CNG engine is mounted in compartment behind the rear driving axle, Fig. 1. To lowering the noise emission and vibration is made the coating and isolation of the engine compartment.

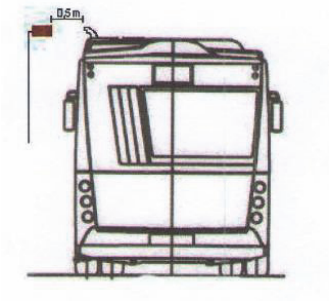
The CNG engine is supported in three points on the anti-vibration mountings Maker VCE, model No. 10-IM.

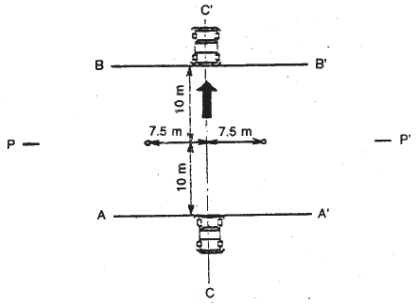
The noise emission due to compressed air in the pneumatic installation during operation of the air brake and air suspension system also analyzed.

4.3. Measuring of the buses noise emission at stationary conditions

Those measurements are realized according to the terms defined in Regulation UN ECE No. 51. We are used the sound level meter with microphone as defined in the table 1. The measuring point was translated for 0.5 m out of exhaust pipe in horizontal direction, Fig. 4.a.

During the measurements, the engine was operated under low idle speed and 1800 rpm (which is 3/4 of the speed at maximal power conditions). It is important to accentuate that the cooling fan was operated in first gear speed that is normal operation, while on the CNG bus exists one more fan speed. All the time, the bus is stopped while the automatic gear change lever is in neutral mode.





(a) Position of gage during exploring at stationary conditions

(b) Position of gage during exploring at drive conditions

Fig. 4 *Positions of the gage during exploring*

Table 3 *Conventional diesel v. CNG stationary internal noise levels - idling, dB(A)*

Parameter	Powertrain	Measurement	Engine speed	
			Low idle	High idle, 1800 rpm
Average	Diesel	1st	76	97.5
		2nd	77	98
		Results …	**77**	**98**
	CNG	1st	64*/70**	76
		2nd	63.9*/69**	75
		Results …	**64*/70****	**76**

*Comment: *1st cooling fan speed, **2nd cooling fan speed.*

In the Table 3 are presented the values obtained by measuring of the noise emission at stationary conditions for two variant of bus type (diesel and CNG). CNG bus meets the limits regulated with standard. The noise emission obtained during the measurement where significantly less than noise emission which demanded by ECE

regulative, where exists the limit value of 80 dB(A). The noise emission of the CNG bus under idle speed is lower for 7 (*1st cooling fan speed*) and 13 dB(A) (*2nd cooling fan speed*), if we compare the obtained results with those on the diesel bus. During the operation under 1800 rpm, the noise emission of CNG bus is lower for 22 dB(A). The measured values are rounded to the next bigger integer number, according to the standard demands, as presented in the Table 3.

4.4. Measuring of the buses noise emission at drive conditions

Positions of the measuring device related to the bus under the measuring of the bus noise at drive conditions were presented on the Fig. 4.b. The microphone is positioned at the height of 1.2 m above the ground in the vertical direction and looking in the horizontal direction on the distance of 7.5 m left and right from the reference line CC', which represents a direction of drive. On the polygon marked two lines AA' and BB', positioned at a distance of 10 m ahead and behind of the previous defined microphone position.

The Regulation also defines the measuring conditions in the event if vehicle is equipped with automatic transmission. Then, under drive conditions, the bus approaching to the line AA' at constant speed of V=30, 40 and 50 km·h^{-1}. The driver rapidly accelerates the vehicle from the moment when the front end of the bus reaches the reference line, until the back end of the bus does not pass line BB'.

It was measured the maximal value of noise for both vehicle side, so the measurement repeated twice and the highest measured value is rounded to the decibel, as required by the standard, tables 4 and 5.

Under drive conditions, the noise emission of CNG bus is lower significantly compared to the tolerable limit value of 80 dB(A). The noise emission of CNG bus under drive at speed V=50 km·h^{-1} is lower for 6 dB(A), compared to the similar measurements with diesel bus. The results marked as (*) in the Table 6, represent the values obtained by measuring the noise emission of the CNG bus during switched on cooling fan in second gear speed.

Table 4 *Measured diesel bus noise values at drive conditions, dB(A)*

Bus side	Measurement	30 km·h^{-1}	40 km·h^{-1}	50 km·h^{-1}
Left	1.	76.6	76.6	77.7
	2.	76.3	77	78
Right	1.	74.5	73.5	77
	2.	75.9	74.4	76.9
Results ...		**77**	**77**	**78**

Table 5 *Measured CNG bus noise values at drive conditions, dB(A)*

Bus side	Measurement	30 km·h^{-1}	40 km·h^{-1}	50 km·h^{-1}
Left	1.	75.8*	71	70.1
	2.	76.3*	72.4	70.3
Right	1.	69.4	70.7	71.8
	2.	71.2	71.8	70.9
Results ...		**76**	**72**	**72**

CONCLUSIONS

The noise incurred and generated by city traffic has a negative impact to a large extent to life quality. In the Republic of Serbia as well as in other parts worldwide, the traffic generated noise is becoming a very serious issue, especially in large industrial cities.

Reconstructing buses from diesel fuel drive to CNG applications contributes to noise decline to a large extent. It was also proved during the conducted tests and noise measuring according to methods defined by adequate and referential standards.

When at idle, the bus noise with CNG drive is lower for 7-13 dB(A) compared to the alternative with diesel engine, whereas at 1800 min^{-1} at high idle, decline of 22 dB(A) was registered.

The noise of CNG drive buses in motion, at speed limit of 30 $km \cdot h^{-1}$, 40 $km \cdot h^{-1}$, and 50 $km \cdot h^{-1}$ is lower for 1-6 dB(A) compared to the same type bus version with diesel fuel drive.

In public transportation of passengers in the city of Kragujevac there are 50 buses which daily make about 250 km as an average, for 315 working days per year. By applying the CNG buses instead of the existing ones with diesel engine, a considerable decline in noise emission would be achieved.

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