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IMPACT OF SUPERCHARGING ON THE NOISE LEVEL IN BIOGAS ENGINES

J. Kaszkowiak*, M. Markiewicz-Patalon, S. Borowski***, P. Dorszewski******

Abstract: *In the study, there are compared the results of noise level measurements for the spark-ignition unsupercharged engine and a supercharged biogas engine. The examination was conducted for three values of rotational speed for unloaded and loaded engines. It has been determined, that as far as engines operating without loading, the noise level does not depend on an engine furnishing with a supercharging system. For loaded engines, a higher level of noise was found as compared to an engine not equipped with a turbo-compressor.*

Keywords: Biogas, Combustion engine, Noise, Additional charging.

1. Introduction

Emission of sound is an inseparable effect of combustion engines‘ operation. A continuous development of these units and improvement of their performance, apart from the improvement of functional characteristics, influences the environment among the others by the generated noise. Sounds emitted by combustion engines, may also be used to diagnose their technical condition. The noise transmitted within the selected range of frequencies, may be helpful at the time of establishing of the technical state of selected engine’s elements (Komorowska et al., 2011). Noise also accompanies work processes in machines driven by combustion engines – as an example shredding and cutting – at the time of which, energy generated by a machine’s engine is converted into resistances of a machine’s working elements movement (Bochat et al., 2013). The most commonly occurring source of noise are the transportation and production works. The excessive noise is the cause of health problems of people and animals, and may result in disturbances in the natural habitat’s flora (Bukovjanová et al., 2008). Lowering of combustion engines‘ noxiousness for the natural environment may be obtained on different planes, such as constructional changes limiting the fuel consumption, and adjust the exhaust gases‘ composition (Kaszkowiak et al., 2016). The use of engine oils on the basis of bioadditives may also be used for piston combustion engines to lower the level of noise (Tulik et al., 2013). Gas fuels used for feeding engines of spark ignition result in the decrease of emission of harmful pollutants and lowering of the costs of an unit’s exploitation. Gas fuels, just like ethanol, may be considered substitute substances for combustion engines‘ supplying. They are characterised by high parameters, that is high octane number, high spontaneous ignition temperature, wide flammability limits of their mixtures with air and high calorific value (Lejda et al., 2003). Production of ethanol (Gumienna et al., 2016) and biogas, which may be produced both from specially cultivated plants as well as from ensilage (Kaszkowiak, 2014) is the alternative for fuels obtained from natural ground resources.

Reaching by the year 2020 in the final energy’s consumption of 20 % share of the energy from renewable sources and 10 % share of biofuels in the overall consumption of transport fuels (COM (2006) 848 final), is one of the objectives in the policy of the European Union. The biofuels are, among the others,

* Jerzy Kaszkowiak, PhD.: Faculty of Mechanical Engineering, UTP University of Science and Technology, Poland. Al. Prof. Kaliskiego 7, 85-796 Bydgoszcz, e-mail: kaszk@utp.edu.pl

** Marietta Markiewicz-Patalon, PhD.: Faculty of Mechanical Engineering, UTP University of Science and Technology, Poland. Al. Prof. Kaliskiego 7, 85-796 Bydgoszcz, e-mail: marietta.markiewicz@utp.edu.pl

*** Sylwester Borowski, PhD.: Faculty of Mechanical Engineering, UTP University of Science and Technology, Poland. Al. Prof. Kaliskiego 7, 85-796 Bydgoszcz, e-mail: sylwester.borowski@utp.edu.pl

**** Piotr Dorszewski, DSc.: Faculty of Animal Breeding and Biology, UTP University of Science and Technology, Poland. Al. Prof. Kaliskiego 7, 85-796 Bydgoszcz, e-mail: piotr.dorszewski@utp.edu.pl

bioethanol and biogas. In the future, ¼ of bioenergy may originate from biogas produced from organic matter, for ex. from ensilages, from whole plantsmanure and dunghill, wet food and fodder wastes, and other ones. Biogas is the product of bacterial anaerobic fermentation – methanogenesis, in which a mixture of gases is generated, among which there dominate methane, carbon dioxide and hydrated sulfides (Mrůzek et al., 2011). Methane present in biogas may be subject to conversion into heat, be an engine fuel and later on be used for electric power generation (Kalač, 2011). From 1 ha of herbs, there may be generated enough biogas, to make it possible to drive a passenger car the distance of 40 thou. km. The volume of 25 kg of biogas allows to cover a distance of 500 km (Vagonyte). From 1 ha of corn there may be generated enough bioethanole to drive a passenger car for the distance of 30 thou. km. Biogas is more productive, as there may be covered the distance more than twice as long – 70 thou. km (Michalski, 2007).
Generation of biogas is the form of energy‘s acquisition from the biomass‘s renewable energy for the purposes of effective and productive feeding of combusion engines (Stanek, 2009). Engines fed with gas (biogas including), are most often the engines constructed as high-pressure and adjusted for work with gas fuel. Adaptation consists in: lowering of the compression rate by modernization of a piston or head’s construction to increase the combustion chamber’s capacity, change of the system of the mixture’s ignition from self-ignition into spark ignition and modernization of the feding with gas system. Modification of the engine cooling’s system shall be necessary in many cases.

Making use of the renevable energy sources in power engineering is the constantly developing field and may, to a considerable degree, contribute to making use of natural resources‘ limitation (Ziółkowski et al., 2009).

2. Materials and methods

There have been tested two combustion engines with spark ignition designed for biogas feeding. Both the engines had the identical construction. Constructed as 12- cylinder, vee-type engines of cubic capacity amounting to 12000 cm^3. The engine’s power rating without charging amounted to 330 kW, while the charged engine equipped with a turbo-compressor of constant geometry had the power of 380 kW. The rated speed of both the engines amounted to 157 $rad\ s^{-1}$ (1500 rpm). Both the engines powered the same power-generators. Supply of both the engines was conducted from the same biogas tank. Parameters of biogas are presented in Tab. 1.

Tab. 1: Parameters of biogas supplying engines at the time of tests.

Biogas components	Average content
Methane	65.25 %
Hydrogen sulfide	12 ppm
Carbon dioxide	35 %
Ammonia	0 ppm

That experiment was planned as a two-factor one of 3 levels of the first factor (engine’s loading) and on 2 levels of the second factor [supercharging (1) and its absence (2)]. The experiment’s factors and their values are presented in Tab. 2.

Tab. 2: The experiment’s factors and their values.

Loading of the engine (factor A)	Supercharging (factor B)	
	Yes	No
	0 kW	0 kW
	180kW	180 kW
	280 kW	280 kW

The engines, together with aggregates, are in identical, closed rooms. The engines are fully efficient, have the run (about 1000 hours of operation), similar period from the last replacement of the engine oil (about 120 hours), are lubricated with the same engine oil. Prior to the measurements' commencement, each engine was heated up till it reached the ordinary operation's temperature (cooling liquid's temperature about 85 ^{0}C). The examinations were conducted for both the engines at the rotational speed of 157 rad s^{-1} (1500 rpm), for each engine working without loading and with a loading respectively 180 kW and 280kW. The noise level was measured with the integrating sound meter HD 2010 UC, in the distance of 1m from the side engine's surface. The time of the test's performing amounted to 5 minutes for an engine operating without loading and next loadings. The reading was repeated 5 times after each 60 seconds of operation. The rotational speed was measured with a laser revolution counter Voltcraft DT-10L with measurement precision ±0.5 %, according to the manufacturer's data, comparing it with the speed displayed by the factory engine's revolution counter. The power absorbed from the engine was established on the basis of the generator's electric power.

The obtained results of measurements were subject to the statistical analysis for a two-factor experiment, with testing of significance of the differences with the Tukey test on the level of 0.05. The FR-ANALWAR programme on the basis of Excel was used for the analysis.

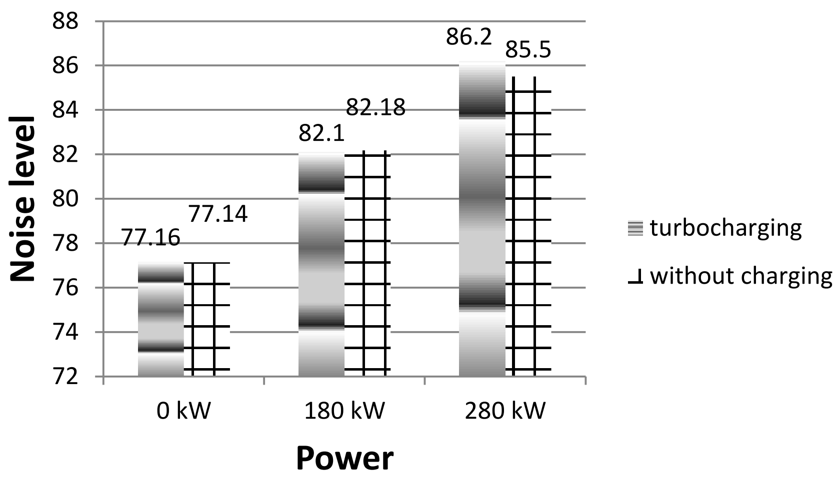

Fig. 1: Mean values of the level of noise.

On the basis of the conducted analyses it was established, that statistically significant differences in the noise level occur between the levels of the factor A (loading) in both the tested engines for all the loading values. No significant statistical differences in the noise level between the tested engines in case of no loading and at the loading of 180 kW were found. Significance of differences in the noise level was found only for the biggest loading of engines, that is 280 kW and amounted to 0.7 dB, a higher noise level was recorded for the supercharged engine.

3. Conclusions

On the basis of the conducted tests, the noise level in biogas powered engines, in the examined case it was found that the decisive factor was the value of an engine's loading. The applied supercharging inadvertently influenced the noise level only at the highest loading. Many factors may have an impact on the noise level. Most of all, application of supercharging influences the course of the fuel combustion's process. Suction murmurs in engines with supercharging (operation of a turbo-compressor, flow of air through the intercooler, higher volume and speed of air flowing through the wiring of the supply system, result in the increase of the noise level. For a man, the sounds of frequency higher than 20 kHz are not heard and it seems, that the sounds of a turbo-compressor most probably influence the level of nose only to a slight degree, especially in case of higher engine's power. However, one should not forget on undoubtful advantages of supercharging, just like for example higher engine's efficiency. Determination of the source of the increased level of noise is the subject matter of further (conducted at present) surveys. There are conducted studies on the level of noise of other engine models, for the purposes of receiving information to what extend the specific technical solutions (construction of an inlet system, construction of a turbo-compressor, the exhaust system) have an impact on the noise level. However, in the conditions of an engine's operation for which the noise level is of high importance, special attention should be paid to the correct dampening.

References

Bochat, A. and Zastempowski, M. (2013) Modeling the dynamics of the vegetable material detachment process from undisturbed areas to improve the design of selected agricultural machines, Transactions of the ASABE, Vol. 56(4).

Bukovjanová, E. and Slavík, R. (2008) Effect of noise on the environment, Tomas Bata University in Zlín. Faculty of Technology.

Gumienna, M., Szwingiel, A., Lasik, M., Szambelan, K., Majchrzycki, D., Adamczyk, J., Nowak, J. and Czarnecki, Z. (2016) Effect of corn grain variety on the bioethanol production efficiency Fuel 164, pp. 386-392.

Kalač, P. (2011) The required characteristics of ensiled crops used as a feedstock for biogas production: a review. J. Agrobiol. 28, pp. 85-96.

Kaszkowiak, J., Kaszkowiak, E. and Markiewicz-Patalon, M. (2016) Analysis of the selected parameters of standard and premium type diesel oils, Trends in agricultural engineering, International Conference, Prague.

Kaszkowiak, J. (2014) Technique of application of additives facilitating silaging of plant materials used for production of biogas, „Journal of Research and Applications in Agricultural Engineering", Vol. 59(1).

Komorowska, I. and Górnicka, D. (2011) Adaptation of engine vibration characteristics for diagnostics of mechanical defects, Silniki Spalinowe, 50(3).

Lajda, K., Jaworski, A. (2003) Problems of gas supply to agricultural engines, Motrol. Automotive and Agricultural Power.

Michalski, T. (2007) Corn - an excellent raw material for the production of biofuels. Maize - new possibilities. Handbook for producers, IV, Biznes Press Sp. z o. o. Warszawa.

Mrůzek, M. and Groda, B. (2011) An analysis of biogas production from grass silage as dependent upon feed quality. Agric. Eng. 7(132), 107-114.

Stanek, J. (2009) Biogas - an alternative gaseous fuels for spark ignition engines, The University of Pardubice Transport Faculty Jana Pernera, Department of Transport Means and Diagnostics.

Tulík, J., Hujo, L., Stančík, B. and Ševčík, P. (2013) Research of new ecological synthetic oil-based fluid, Journal of Central European Agriculture, 14(4), pp. 1384-1393.

Vagonyte, E., Agri-For-Energy 2, Work Packege 4: Biogas & Biomethane, European Biomass Association, http://www.biogaspartner.de/index.php?id=11510&L+1&fs=0\\\%27%3Fiframe%3Dtrue.

Ziółkowski, M. and Balcerski, A. (2009) Internal combustion engines powered by biogas as a prospect of Polish power generation, Scientific Journals, Szczecin.