

Abstracts

of the scientific papers of assist. prof. **Veselin Todorov Mihaylov**, PhD

for participation in competition for academic position “Associate professor”,
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Abstracts of publications from group „B.4“

[B.4.1] **V. Mihaylov**, Z. Ivanov, H. Mersinkov, S. Stoyanov and R. Wrobel, *Influence of the control signal on parameters of low impedance injectors for SI engines*, IOP Conference Series: Materials Science and Engineering, vol.1031, 012018 (2021), eISSN: 1757-899X, DOI: <https://doi.org/10.1088/1757-899X/1031/1/012018> ;

There is high variety of injectors for spark ignited (SI) engines, especially those fitted with additional aftermarket LPG/CNG fuel system. The tendency is for using injectors with lower electrical resistance, because of the faster opening time. But this rise some difficulties, one of which is the higher current, that pass through injector’s coil. One of the most used method to counter fight that is using special control signal.

The aim of the study is to investigate how the control pulse affects various parameters of low-resistance injectors - opening time, closing time, current and temperature.

Performed studies have shown that the use of PWM of the control signal has the following advantages: reduces the current flowing through the injector winding; the heating of the injector is reduced; the closing time of the anchor is reduced, as this method of control does not affect the opening time. The conclusions can be summarized as:

1. Electromagnetic injectors with a resistance below 5Ω cannot be controlled by a constant pulse due to the high temperatures that develop in the area of their coil.
2. PWM modulation of the control pulse is an effective method for reducing the current, and hence the temperature of the winding.
3. With the PWM modulation of the control pulse, a better speed of the injector itself is achieved, as the modulation of the pulse affects only the closing time of the valve needle, reducing this time by up to 12%.
4. It is necessary to use a controlled flyback diode in the control circuit, otherwise the closing time of the injector will be unnecessarily long.

[B.4.2] **V. Mihaylov**, Z. Ivanov, S. Belchev and D. Petkov, *Experimental evaluation of the effectiveness of a diesel fuel additive*, IOP Conference Series: Materials Science and Engineering, vol.1031, 012017 (2021), eISSN: 1757-899X, DOI: <https://doi.org/10.1088/1757-899X/1031/1/012017> ;

One of the ways to reduce carbon emissions is by lowering the energy consumption of vehicles. Electrical or hybrid cars can help for lower emissions from transport in nearby future, but a big step can be achieved now if there is a way to reduce fuel consumption in current fleet. The use of fuels with improved characteristics or use of fuel additives, which can affect fuel physical and

combustion properties, are promising measures in this direction. Due to advances in chemistry science and the research done in this area, it is of practical interest what the achievable benefits are nowadays. The aim of this research is to study how a popular present day commercial additive affects the fuel consumption and environmental performance of a high-speed diesel engine. In this paper are shown the results from performed studies on a direct injected diesel engine when working with additive, aimed to improve its energy consumption and hence its reduction in carbon emissions. The results show improvement in some of the harmful emissions, but no improvement of engine's efficiency.

The engine was tested at steady state. The results of the study show that the use of this fuel additive does not affect fuel consumption and therefore cannot increase the efficiency of the engine. Its effect is mainly expressed in relation to some of the harmful components emitted by the engine. At medium engine speeds the used additive has a positive effect on smoke at low and medium loads, on HC in the whole load range, and on carbon monoxide CO emissions - at high engine loads. At full throttle characteristics there is a definite positive influence on CO emissions. With regard to nitrogen oxides NO_x there is practically no effect in both characteristics. As a side effect can be noted a slight reduction in torque and power around 1÷2 percent.

[B.4.3] P. Grzybowski, P. Iljaszewicz, P. Kardasz, L. Sitnik, R. Wróbel, R. Dimitrov, V. Mihaylov and W. Macek, *A study of possibility the air conditioning system in a car to become a bioaerosol generator*, *AIP Conference Proceedings* 2439, 020017 (2021), eISSN: 1551-7616, DOI: <https://doi.org/10.1063/5.0070923> ;

Specific odor emitted sometimes from the air conditioning system in the cars is often a symptom of microbiological contamination within the ventilation ducts. A group of 42 cars with installed air conditioning systems was checked in terms of bioaerosol delivered into the cabin through the ventilated air. The bioaerosol in question comprised mesophilic and psychrophilic bacteria and fungi. Ratios of bioaerosol concentration in the inner and outer air were calculated. For the cars under tests, the inner bioaerosol concentrations were generally smaller than those from the outside air, except for few cases, mostly for mesophilic bacteria. The achieved results do not show any specific correlation between the inner to outer concentration ratios and actual air temperature and air humidity for all types of measured bioaerosols. Also, the age of the cars itself was not possible to correlate with the changes of the bioaerosols concentrations within the inner air. The highest observed bioaerosol concentration ratio achieved value of 8,50 for mesophilic bacteria. The zero concentrations in the cabin entering air was found 8 times for mesophilic bacteria, 2 times for psychrophilic bacteria and 3 times for fungi. It was concluded that the actual bioaerosol concentration in the air coming out from the air conditioning channels depended on the given car history. This comprised of exploitation conditions, outer air conditions with the met level of airborne particles, their nature, probably also air channels and filter construction and frequency of the earlier performed servicing of the air conditioning system. All these factors together during all the vehicle exploitation time period, influence and form the bio composition of the particulates in the air entering the car cabin.

[B.4.4] R. Wrobel, L. Sitnik, M. Andrych-Zalewska, L. Loza, R. Dimitrov and V. Mihaylov, *The Changes of Ergonomic Engine Vibroacoustic Response Regarding Their Development, Energies*, 14(14):4215, 2021, ISSN: 1996-1073, DOI: <https://doi.org/10.3390/en14144215> ;

The research presented in this paper focused on the evaluation of the vibroacoustic response characteristics of a gasoline internal combustion engine as a function of the development of subsequent versions of the vehicle (downsizing). Particular attention was paid to the changes in frequency bands that may affect the human body. At the same time, it should be noted that this band (<500 Hz) also carries diagnostic information about the condition of the power unit.

The tests on the internal combustion engine vibroacoustic response characteristics at various measurement locations have succeeded in obtaining frequency values for each of the measured speeds and gear ratios, as well as in recognizing some recurring relationships and distinguishing those that may be significant from the point of view of passenger vehicle driving ergonomics.

For the measurement point on the engine mount:

1. For each measurement pair, the frequency measured on the turbocharged vehicle was lower than that measured on the naturally aspirated vehicle.
2. In each measurement case, a higher gear ratio for a given vehicle speed caused a decrease in the vibration frequency value.

For the measuring point on the steering wheel:

1. Changing the gear ratio for a given vehicle speed has no or very little effect on the vibration frequency values occurring on the steering wheel.
2. The lowest frequency values occur at the speed of 30 km/h, ranging from 7–10 Hz (they remain within the range of resonant vibrations for upper limbs).

For the measuring point on the headrest support:

1. Changing the gear ratio for a given vehicle speed has no or very little effect on the values of the vibration frequencies occurring on the headrest support.
2. The lowest frequency values are 7–10 Hz at 30 km/h (they remain within the range of resonance vibrations for the head).

The vibration values at 50 km/h are mostly 10–16 Hz, and they fall within the resonance vibration range for the head and larynx, trachea and bronchi.

The successive vehicle models equipped with charged engines generate spectra like those of naturally aspirated engines. In the case of charged engines, the magnitudes of the dominant harmonics are smaller, which should have a positive effect on driving comfort.

The charged engines have lower average values in the bands (and therefore lower energy spectral density values). This implies that the introduction of additional highspeed components (turbocharger) has no negative effect on the vibroacoustic response of the engine.

Thus, it can be confirmed that modern engines extend the spectral density of the engine's vibroacoustic response. At the same time, the size of the dominant harmonics is reduced. This means that they can potentially affect the functioning of other human organs than was the case with older models. The reduction of the above-mentioned dominant harmonics should translate into a longer possibility of exposure of the human body to vibrations and thus also a longer time of safe driving.

[B.4.5] G. Sierzputowski, R. Wróbel, **V. Mihaylov**, M. Janeczek, M. Majewska-Pulsakowska and S. Jarzqb, *Pilot Studies of Vibrations Induced in Perambulators When Moving on Different Surfaces*, *Applied Sciences*, 11(16):7746, 2021, ISSN: 2076-3417, DOI: <https://doi.org/10.3390/app11167746> ;

The ergonomics of transport is a topic widely described in the literature. One of the fields of ergonomics that researchers are engaged in is vibrometry (both laser and accelerometry) of travel and its translation into NVH (Noise, Vibration and Harshness). However, so far, the influence of baby carriage movement on the generated vibrations has not been described in more detail. The topic seems to be particularly important considering occurrence of vibrations with significant amplitudes, whose frequency range can have a direct bearing on the resonance frequencies of the child's internal organs. The article presents the results of research consisting in the measurement of vibrations to which an infant, lying in two different types of prams, may be exposed when being transported on different surfaces. The author's measurement system, based on accelerometry, was used for the research. The obtained weighted RMS acceleration values not only exceeded human comfort level in all cases (according to ISO standard) but several times were in the range of the highest discomfort ($>2 \text{ m/s}^2$). Furthermore, the observed vibration frequency range ($\approx 0 \div 32 \text{ Hz}$) coincided with the frequencies of free vibration of organs and parts of the child's body.

[B.4.6] Z. Ivanov, **V. Mihaylov**, L. Sitnik and Z. Sroka, *Operation of diesel engine with fuels treated with nanoparticle additives*, *IOP Conference Series: Materials Science and Engineering*, vol.1002, 012022 (2020), eISSN: 1757-899X, DOI: <https://doi.org/10.1088/1757-899X/1002/1/012022> ;

Treatment of materials with nano-sized elements is widely used in the automotive industry. This application is associated both with surface treatment of parts and in the form of various mixtures. The use of nanoparticles as an additive to oils and fuels aims to impact the energy efficiency of the engine in order to improve mechanical losses and its environmental performance. Improving mechanical losses leads to a reduction in energy consumption and hence to a reduction in carbon emissions. Published research in this regard has shown an impact on various physical processes related to engine performance. The aim of the present study is to investigate the impact of carbon nanoparticles dispersed in biodiesel fuel mixtures on the operating parameters of a direct injection diesel engine.

The addition of diamond carbon nanoparticles to biodiesel fuel mixtures leads to a change in the studied parameters of the combustion process of the tested diesel engine. The increased thermal conductivity of these mixtures has a positive effect on the processes of fragmentation and evaporation, which take place at the beginning of the fuel supply to the engine cylinder. These processes have a strong impact on the duration of the physical phase of ignition delay and practically do not affect its chemical phase.

Prolonged operation of the fuel system of the engine with nanoadditives in fuel changes the differential characteristic of fuel injection. This leads to an increase in the relative amount of fuel injected into the engine cylinder during ignition delay, relative to the whole injected fuel per cycle. This change in the fuel supply characteristic has a decisive impact on the maximum values of the rate of increase of pressure in the engine cylinder.

[B.4.7] S. Belchev, Z. Ivanov, T. Uzunov and V. Mihaylov, *Determination of the stages of the injection process for Common Rail injectors using vibration pulses*, IOP Conference Series: Materials Science and Engineering, vol.977, 012023 (2020), eISSN: 1757-899X, DOI: <https://doi.org/10.1088/1757-899X/977/1/012023> ;

The study and modeling of the combustion process of diesel engines require knowledge of the injection characteristics. The information on the exact start, duration and end of the injection is required. For Common Rail injectors with electromagnetic control, the beginning and duration of the electronic control pulse are precisely known. The actual start and duration of the injection are not the same as those of the impulse and they are related to the movement of the nozzle needle. The experimental determination of the movement of the nozzle needle requires specially prepared experimental installations and expensive measuring instruments. In addition, the experimental injector must be prepared with design modifications allowing the incorporation of sensors. The article presents a method for determining the start and duration of injection of Common Rail injectors using the registration and analysis of vibration pulses generated in the injector body. The method is based on the fact that the nozzle needle causes vibrations in the injector body when lifting and seating.

The purpose of the presented work is to show to what extent the recorded vibration pulses in the injector housing can be used to determine the beginning and end of lifting of the nozzle needle.

The proposed method for determination of injection phases gives adequate results and can be used for research purposes. It is characterized by simplicity and ease in building the experimental setup. No design changes are required to the tested injectors.

The duration of the injection is much longer than the duration of the control pulse, the difference between them is in the range of 500-800 μ s and is influenced by the duration of the pulse and the injection pressure.

The determined influences of the injection pressure and the mass of the movable elements in the injector on the injection delay and duration have a logical character and confirm the non-random nature of the times determined by the presented method.

[B.4.8] Z. Ivanov, S. Stoyanov, V. Mihaylov and H. Santos, *Flow characteristics of gas injectors* , IOP Conference Series: Materials Science and Engineering, vol.664, 012021 (2019), eISSN: 1757-899X, DOI: <https://doi.org/10.1088/1757-899X/664/1/012021> ;

The operation of Internal Combustion Engine (ICE) with gaseous fuels is characterized by the specificity of the fuelling process. Nowadays the most common system is the one in which after lowering its pressure the gas fuel is delivered to the engine intake manifold by means of gas injectors. This leads to a difference in the laws of fuel supply relative to the original gasoline injection system that dispenses fuel in liquid phase.

Theoretical research has been done and gas leakage has been found to be critical under engine normal operating conditions, that is, it depends on fuel pressure and not on the environment in which the fuel leaks (intake manifold). An experimental test stand was set-up for testing gas injectors under conditions very close to the real working ones.

Multi-parameter characteristics of a bottom feed type gas injectors are experimentally determined, that show the dependence of the duration of the electrical control signal on the injected fuel per cycle at varying pressure at the intake manifold and constant differential pressure. It can be concluded that at increasing load (increasing intake manifold pressure), the proportional coefficient in the software of the gas control unit, that is used to relate the fuel flow of the gasoline and gas injectors should be corrected in negative direction.

[B.4.9] R. Dimitrov, Z. Ivanov, P. Zlateva and V. Mihaylov, *Optimization of biogas composition in experimental studies, 8th International Conference on Thermal Equipment, Renewable Energy and Rural Development (TE-RE-RD 2019), E3S Web Conf. 112 02007 (2019), eISSN: 2267-1242, DOI: <https://doi.org/10.1051/e3sconf/201911202007> ;*

The article is focused on the potential and application of biogas, as an alternative fuel from Renewable Energy Sources, for use mainly in gas-generator stations. Biogas fuel is basically a mixture of methane and carbon dioxide. Its composition depends on the type of raw material used for its production. Methane concentration in biogas is between 50÷80 %. To be possible engine to work with maximum efficiency with different biogas fuels, it is necessary to modify specific adjustment parameters depending on the concentration of methane in the mixture. This requires the creation of a biogas simulation system for different concentrations of the main components.

The aim is to investigate and determine the optimum and permissible biofuel blend concentrations and their impact on engine performance and fuel consumption. Variation of power and specific fuel consumption with different concentration of biogas mixtures has been investigated at wide-open-throttle operating characteristics.

As the carbon dioxide content is greater in the composition of biogas, the calorific value of the fuel is lower. Optimum results are obtained when methane in biogas is about 75-80%. The use of biogas with lower methane concentrations is possible, but it is necessary to improve the efficiency of the engine (for example: through increase of compression ratio of the engine).

[B.4.10] R. Dimitrov, K. Bogdanov, R. Wrobel, L. Serrano and V. Mihaylov, *Adjustment parameters of an internal combustion engine working with methane, IOP Conference Series: Materials Science and Engineering, vol.664, 012020 (2019), eISSN: 1757-899X, DOI: <https://doi.org/10.1088/1757-899X/664/1/012020> .*

The paper presents a study of the variation of ignition advance when the engine works with methane and a comparison with values when the engine runs on gasoline. It is known that methane has a lower burning velocity than gasoline, and therefore, to obtain a maximal efficiency from the working process (the maximum value of cylinder pressure p_z should be 7-15 degrees after TDC), ignition advance should be increased, as for different operating regimes this angle should be increased with different values.

The purpose of the present study is to determine the necessary increase in the ignition advance of a SI engine retrofitted for methane operation at all speed and load regimes. A gasoline engine has been studied and were measured and analysed the ignition advance at work with gasoline and methane, with optimal air-fuel ratio λ for both fuels. Three-dimensional graphics of ignition advance variation across the rpm and load range were made. The data obtained represent important and necessary information for adjusting and tuning the methane system to obtain maximum efficiency when converting a gasoline engine to work with methane.

Abstracts of publications from group „Г.7“

[Г.7.1] Z. Ivanov and V. Mihaylov, *Transient operation of a direct injection diesel engine*, IOP Conference Series: Materials Science and Engineering, vol.614, 012008 (2019), eISSN: 1757-899X, DOI: <https://doi.org/10.1088/1757-899X/614/1/012008> ;

Driving in urban areas is dominated by transient modes of operation. In such environment automotive engines operate with varying loads, frequent gear shifts and depending on the duration of the transition process, can be approximated with engine speed characteristics with partially open throttle.

The purpose of the present study is to examine the operation of the engine in transient modes and to determine the variation in fuel consumption and emissions of harmful components in exhaust gases. The main task of this report is to investigate the dependencies of changing cyclic quantity of fuel injected and the emissions of harmful components for a direct injection diesel engine.

The direct injection engine tests have shown the presence of phases of the transient modes in terms of fuel consumption and the content of harmful components in the exhaust gases. These phases are more pronounced in transient processes at engine operating modes in the low and medium load range. During the first phase at low speeds there is a rapid increase in the injected fuel per cycle as the engine tries to increase the kinetic energy of the vehicle and the rotating parts of the transmission. Together with increased fuel consumption, carbon dioxide and nitrogen oxide emissions are also increased. Next there is a drop in fuel delivery, which results from the reduced rate of rise of the rotation speed and gradually reaching the set load of the dynamometer. The third phase is related to the settlement of engine parameters to steady mode. By changing the mode in the area of high loads, the transient mode is characterized by the operation of the engine with wide-open-throttle speed characteristics.

In the first phase of the transient process, nitrogen oxides have a local maximum only at low loads. In such mode, after reaching the established parameters, as a result of reduced fuel delivery, the amount of nitrogen oxides also decrease. In all other modes, their amount is continuously increased as a result of improved thermodynamic combustion conditions in the engine cylinder.

By increasing the duration of the transition mode and creating conditions for the engine to work with part-open-throttle speed characteristics, there is a potential for reducing fuel consumption when driving in urban areas and reducing emissions of toxic components in exhaust gases.

[Г.7.2] S. Stoyanov and V. Mihaylov, *A study on characteristics of vacuum solenoid valves*, IOP Conference Series: Materials Science and Engineering, vol.1002, 012033 (2020), eISSN: 1757-899X, DOI: <https://doi.org/10.1088/1757-899X/1002/1/012033> ;

Vacuum solenoid valves have been widely used in internal combustion engine engines. They are used to regulate various processes in the car's systems by controlling actuators – for example, variable geometry of the turbocharger, exhaust gas recirculation (EGR) valves, various bypass or throttle valves. The vacuum solenoid valves are controlled by the electronic control unit (ECU) by means of a constant frequency and pulse width modulation of the controlling signal. In operation, these valves change their characteristics over time, which leads to a change in the control of the actuators, and hence to the overall operation of the engine and systems related to the environmental performance of the vehicle. Often there is no feedback on the actual value compared to the demand and their correct diagnosis is difficult.

The purpose of this study is to determine dependence of pressure characteristics from possible deviations of some parameters (vacuum system, power supply) during normal usage of the vehicle, which can be useful in diagnosis. For this purpose, a stand was made for testing the parameters of valves. To determine the operating conditions of the solenoid valves, measurements were made on some vehicles at typical driving conditions. It has been found that for this type of solenoid valves, made by Pierburg, control signal with constant frequency of 250 Hz and variable fill factor of 10 to 99% is used. The pressure maintained in the vehicle system provided by the vacuum pump of the brake system is around 50 mbar(a), and in the case of intensive frequent use of the brakes can reach up to 400 mbar(a) for a brief period of time.

Experimental research has been done and multi-parameter characteristics of a type of electromagnetic pneumatic valves are determined. These characteristics can help greatly in the diagnostics process of valves, due to the lack of feedback signal. It can be concluded that the system pressure doesn't play an important role on the regulated pressure. In case the demand value is 50 mbar(a) or more above the vacuum pump pressure, the valve will be capable to maintain the regulated pressure with error less than 2 percent. The valve is much more sensitive to the supply voltage. A difference of 2V at the valve will lead to significant error in maintaining the set value, which can reach up to -32% at 90% duty cycle of the control signal.

[Г.7.3] S. Stoyanov, V. Mihaylov and Z. Ivanov, *Characteristics of vacuum solenoid valves in case of various malfunctions*, IOP Conference Series: Materials Science and Engineering, vol.977, 012026 (2020), eISSN: 1757-899X, DOI: <https://doi.org/10.1088/1757-899X/977/1/012026> ;

Vacuum solenoid valves are used to control actuators, in most cases connected with the emission system. In general, the diagnosis of modern cars is difficult due to the large number of elements and the fact that usually they gradually change their characteristics but remain operational. This is especially important for elements without feedback. The purpose of this research is to determine characteristics of faulty valves, which could be useful in diagnostics process. The results show change of valve characteristics at some of the most common problems during long term operation of the vehicle.

The purpose of this study is to determine the changes in the characteristics of vacuum solenoid valves after they have been replaced in car workshops due to a failure in the system they operate. For this purpose, several damaged valves were tested, and their characteristics were determined and compared with the characteristics of a new valve.

Experimental research has been done and characteristics of several faulty electromagnetic pneumatic valves are determined. These characteristics can help in the diagnostics process of valves, due to the lack of feedback signal.

From this experimental research can be concluded that:

1. As the valve ages, as well as when the venting to the atmosphere is clogged, the tendency of change is to increase the regulated vacuum.
2. Damage (puncture) to the rubber membrane leads to decrease of regulated vacuum.
3. A flyback diode is essential for correct operation of the valve. In case of malfunction in it the deviation from demand value can reach up to 80 %.
4. For accurate diagnostics of this type of valves it is advised to use specialized equipment and additional testing than that proposed by OEM service recommendations.

Abstracts of publications from group „Г.8“

[Г.8.1] *Иванов З., В. Михайлов, А. Колев, Изследователска система за определяне екологичните характеристики на автомобилни двигатели, XVIII Научно-техническа конференция с международно участие ЕКО-Варна, стр.502-510, изд. ТУ-Варна, 2012, ISBN - 954 - 20 – 00030;*

RESEARCH SYSTEM FOR DETERMINATION OF ECOLOGICAL CHARACTERISTICS OF AUTOMOBILE ENGINES: This research system can measure the main components of exhaust gases –CO, CO₂, HC, NO_x, O₂. It has contemporary technical characteristics and class, satisfying modern European standards.

Key words: Automobiles, Environmental characteristics, Exhaust gases, Internal combustion engines..

[Г.8.2] *Иванов З., В. Михайлов, Вибрационно състояние на газови електромагнитни вентили, XVIII Научно-техническа конференция с международно участие ЕКО-Варна, стр. 511-518, изд. ТУ-Варна, 2012, ISBN - 954 - 20 – 00030;*

VIBRATIONAL STATE OF GAS INJECTION VALVES FOR SPARK-IGNITED (SI) ENGINES: In this paper are shown the results from done laboratory experiments for determination of vibrational state of gas injection valves for spark-ignited (SI) engines. A method is proposed for determination of phases of opening and closing of electromagnetic valves, according to vibrational signals. This research gives opportunity for making of methods for diagnosing the elements of fuel injection systems and determination of the real duration of fuel injection, as well as unevenness of fuel delivery to different cylinders.

Key words: Vibrations, electromagnetic valves, gas injection, internal combustion engine.

[Г.8.3] *Димитров Д., В. Михайлов, Б. Костов, Р. Димитров, Моделиране на пробни образци за изпитване на умора при честота 20kHz, Научни известия на НТСМ, година XX, Брой 1(133), стр. 155-159, 2012, ISSN 1310-3946;*

MODELING OF SPECIMENS FOR FATIGUE LIFE TEST AT FREQUENCY 20 kHz: The main faults in machinery and equipment are due to wear or fatigue. Fatigue tests are long and expensive. In recent years, a lot of researchers are actively working on the development of ultrasonic methods, which are capable of intensifying the duration of the fatigue test. At a frequency of 20 kHz test time of 10⁷ cycles is 8-9min. Testing equipment consists of high frequency generator, piezoceramic transducer, wave amplifier (sonotrode) and specimen from tested material. To generate sufficiently high stresses in the specimen system must be operated in resonance. Specimen as part of this chain must have length equal to half the length of the sound wave, respectively, the ends are moving nodes (zero deformation) and the middle node of deformation (maximum stress). In this paper we have discussed several options for the design of specimen based on analytical solutions. The results were confirmed by FEM numerical modeling.

Key words: ultrasonic fatigue, FEM modeling, natural frequencies (Eigen frequencies), sintered steels.

[Г.8.4] *D. Dimitrov, V. Mihailov and B. Kostov, Modeling of Ultrasonic Fatigue-Life Testing Machine, Proceedings of COMSOL conference, Milan, Italy 2012, ISBN 978-0-9839688-7-0;*

Usually fatigue-life tests of materials are long, time-consuming and expensive. With the development of high power piezoceramic actuators nowadays it is possible to provide at very high cycles 10^{10} fatigue tests for reasonable times, at high frequency. The ultrasonic fatigue machine consists of piezoceramic transducer, booster, horn and specimen made of tested material. System works in axial resonant regime. The most used working frequency is 20 kHz due to some limitation of minimal specimen length.

The response of ultrasonic system is modeled, using the software COMSOL Multiphysics and its Structural Mechanic and Piezoelectric interfaces, which give an opportunity to solve electrical and structural equations.

First eigenfrequencies of the system are determined, second displacement amplitudes and stress distribution in frequency domain. The determined eigenfrequency shows good coupling with experimental results, but it has to be mentioned that the precise measurement of material constants (especially Young's modulus) is needed. The harmonic frequency analysis gives the opportunity to predict displacement amplitudes and stresses in the tested specimen. Specimens from different materials with/without different stress concentrators can be designed and checked.

[Г.8.5] *Димитров Д., В. Михайлов, Б. Костов, Проектиране на сонотрод на ултразвуков стенд за изпитване на умора, Сборник доклади трети международен научен конгрес "50 ГОДИНИ ТУ – ВАРНА", том 4, стр. 26-31, изд. ТУ-Варна, 2012, ISBN 978-954-20-0553-7;*

SONOTRODE DESIGN OF ULTRASONIC DEVICE FOR FATIGUE TESTING: In the present article some of the problems in the design and manufacture of ultrasonic sonotrodes (horns) for ultrasonic fatigue test at frequency of 20 kHz, are discussed. Sonotrodes are unique for each different application component, designed to enhance the amplitude of the vibrations, generated by ultrasonic transducers. Materials with low acoustic impedance and sufficient fatigue strength are suitable for sonotrodes. The design process involves choosing a shape to ensure the required gain. Precise measurement of the density and Young's modulus of the material, specifying the geometric dimensions with a FEM simulation are necessary to avoid additional tuning of the machined sonotrode by the "trial and error" method.

Keywords: ultrasound, sonotrode, ultrasonic horn, FEM simulation, Eigen frequency.

[Г.8.6] *Димитров Д., В. Михайлов, Р. Димитров, А. Стоянова, Н. Спасов, Съвременни тенденции при използването на синтеровани компоненти в автомобилната промишленост, Сборник доклади трети международен научен конгрес "50 ГОДИНИ ТУ – ВАРНА", том 4, стр. 32-39, изд. ТУ-Варна, 2012, ISBN 978-954-20-0553-7;*

MODERN TRENDS IN THE USE OF SINTERED COMPONENTS IN THE AUTOMOTIVE INDUSTRY: The development of the modern powder metallurgy (PM) began in the early 50s of twentieth century. The basic PM technology involves obtaining components by pressing and sintering metal powders. The main advantages are the almost complete utilization of the raw materials and the low energy consumption, and the main disadvantage is the presence of residual porosity in the products. The PM components should be cost competitive in comparison to those

manufactured by the conventional technologies: extrusion, investment casting, machining. This cost-effectiveness can be achieved when the components are produced in large series. The automobile industry offers such conditions as it is a main consumer of these products. As a result of the development of the PM technology, if in the 1970 there were 5 -7 kg sintered products in an automobile, in the contemporary automobiles they are about 20 kg and the tendency is to replace more and more loaded components, mainly in the engine and the transmission. This is possible due to the improvement of the pressing equipment and the pressing technologies – achieving higher density; improvement of the sintering technology – a possibility to use less expensive and effective alloying components; improvement of heat treatment technology – combining sintering and quenching in one thermal cycle (sinter hardening), etc.

Keywords: powder metallurgy, automotive industry, connecting rod

[Г.8.7] *Иванов З., В. Михайлов, Х. Мерсинков, Шумови характеристики на газови електромагнитни вентили, XIX Научно-техническа конференция с международно участие „ЕКО ВАРНА 2013“, том XIX, стр.213-222, изд. ТУ – Варна, 2013, ISBN 954-20-00030;*

NOISE CHARACTERISTICS OF ELECTROMAGNETIC VALVES FOR LPG/CNG INJECTION: Noise characteristics of gas solenoid valves from fuel system of internal combustion engine (ICE) for LPG/CNG fuel injection are determined. Spectral analysis is made on signal of sound pressure, emitted from solenoid valves during operation with changing speed. Values obtained can be corrected by A-filter. A new method is proposed for data processing of the noise measurement based on the digital processing of the sound pressure measured directly, allowing the study of the harmonic components in the spectrum of noise from a virtually limitless order.

Key words: noise, electromagnetic valves, internal combustion engine.

[Г.8.8] *P. Haller, R. Wrobel, R. Dimitrov and V. Mihaylov, Introducing new engine performance lab at the department of Motor Vehicles and Combustion Engines of Wroclaw University of Technology, PTNSS CONGRESS–2013, p. 549-555, publ. PTNSS combustion engines, Poland, 2013, ISSN 0138-0346;*

The Engine Test Stand is a measuring position providing wide range of features, enabling data acquisition, used to determine specific engine performance characteristics. Chassis dynamometers are more convenient and easier to operate (engine removal from a car is not required). At the same time, precision and accuracy as well as reproducibility of measurements remain high.

Measurement lab at The Motor Vehicles and Combustion Engines Institute at Wroclaw University of Technology enables sophisticated diagnosis of all types of passenger cars and motorcycles.

The station in our lab is capable of conducting the exhaust gas emission analysis of leaded petrol engines under specific load or with no load at all. In case of passenger cars equipped with a catalytic converter and lambda sensor, it is not only crucial to adjust the emission levels but also determine the lambda sensor values and oxygen content in the exhaust stream. What's more important, the measurement process can be followed online which facilitates team work and delivers substantial speed-up.

[Г.8.9] *Иванов З., В. Михайлов, Х. Мерсинков, Оптичен метод за изследване хода на котвата на газови електромагнитни вентили, XX Научно-техническа конференция с международно участие ЕКО-Варна, стр.415-422, изд. ТУ-Варна, 2014, ISSN 2367-6299;*

OPTICAL METHOD FOR MEASUREMENT NEEDLE LIFT OF ELECTROMAGNETIC VALVES FOR LPG/CNG INJECTION: In this paper are described the results of the development of a system for determining the needle lift of electromagnetic valves used in LPG/CNG injection systems. Established optical system operate in the infrared spectrum of light and consist of autonomous source and receiver. With the addition of equipment for registration of fast changing processes, the system detects high frequency vibrations in the mechanism.

A method for pre and post-processing of the experimental data is developed. Use of a specific mathematical apparatus allows the methodology to be adapted for use also in diesel and petrol injection systems

Key words: Needle lift, LPG/CNG injection valves, electromagnetic valves, gas injection, internal combustion engine.

[Г.8.10] *M. Reksa, M. Andrych and V. Mihaylov, The impact analysis of hydroxide mixture addition on the combustion process in the diesel engine, XXII International scientific-technical conference trans&MOTAUTO '14, сmp.21-23, publ. Scientific-technical union of mechanical engineering, 2014, ISSN: 1310 – 3946;*

This paper presents the analysis which is based on the parameters of the real device for producing a mixture of hydroxyl (HHO) and similar parameters to the real 2.0 SDI VW Golf MK V engine. Theoretical analysis has been made to principles of cooperation the engine with HHO's generator. The effects of the gas on the engine and operating economy were established. The analysis was divided into quantitative and qualitative. Quantitative analysis was contained the theoretical and economic calculation of the thermodynamic cycle taking into account the HHO gas. Qualitative analysis was concerned to the quality of combustion in the engine and the impact generator HHO to the quality of the combustion.

[Г.8.11] *Михайлов В., З. Иванов, Фактор на излъчване на шум на автомобилен дизелов двигател, Научни трудове Русенски университет-2015 т.54 с.4, стр.136-140, изд. Русенски Университет , 2015, ISSN 1311-3321;*

RADIATION FACTOR OF AUTOMOBILE DIESEL ENGINE: Radiation factor is main acoustic characteristics of the construction of internal combustion engine. It enables to forecast the acoustic behavior of the engine in different operating modes and in all events affecting the development of working process as a major exciting force. Through experimental research the radiation factor of a diesel engine with direct injection was determined. Levels of vibrational velocity and sound power were determined at different rpm and load regimes in the power range of engine operation. The analysis of the results obtained shows that the structure is optimized in terms of acoustics in the field of low frequencies.

Key words: noise, vibrations, radiation factor, internal combustion engine.

[Г.8.12] Пенчев Б., **В. Михайлов**, *Влияние на директното впръскване на бензин върху екологичните характеристики на двигателите с вътрешно горене, Научни трудове Русенски университет-2015 т.54 с.4, стр.131-135, изд. Русенски Университет , 2015, ISSN 1311-3321;*

EFFECT OF GASOLINE DIRECT INJECTION ON THE ENVIRONMENTAL PERFORMANCE OF INTERNAL COMBUSTION ENGINES: The primary motivation for stratified-charge spark-ignited direct injection engines is to maximize fuel economy by operating the engine with minimal (preferably no) throttling at part load. This requires control of the fuel-air mixing process to create a fuel cloud around the spark plug that is favorable for ignition and complete combustion in every engine cycle. This paper illustrates the ecological aspects of this process. On one hand it turn attention to the problem with gas emission and on the other the noise emissions. It also shows some possible ways for fighting these problems.

Key words: Direct Injection, Lean Burn, Stratified Combustion, High Pressure injection, Engine Noise and Vibration.

[Г.8.13] Иванов З., Г. Чекелов, **В. Михайлов**, *Методи за определяне на усукващата податливост на колянни валове, XXII Научно-техническа конференция с международно участие ЕКО-Варна, стр.426-431, изд. ТУ-Варна, 2015, ISBN-954-20-00030;*

METHODS FOR DETERMINATION OF TORSIONAL COMPLIANCE OF CRANKSHAFTS: In this paper is made a literature overview of the methods for determination of torsional compliance of crankshafts for internal combustion engines. The following are discussed: experimental optical method, test-stand with assembled engine, discrete dynamic model, modal analysis and finite element method.

Key words: crankshaft, compliance, torsional vibrations, internal combustion engine.

[Г.8.14] **Михайлов В.**, Д. Димитров, *Симулационно моделиране на напрегнатото състояние на мотовилка на ДВГ, Известие на Съюза на учените - Варна, стр.108-113, изд. СУБ-Варна, ISSN 1310-5833;*

SIMULATION MODELING OF THE STRESS STATE OF ENGINE CONNECTING ROD: In present article loading of connecting rod of diesel engine is determined by using Solidworks Motion Analysis module. Comparison between analytically calculated forces and Solidworks results shows good agreement. The maximal bias is lower than 10%. Loading from Motion Analysis study at angle of crankshaft 368° is extracted and stress distribution is determined. Maximal equivalent stress value at engine speed 4500 min^{-1} (full loading) is 247MPa and at engine speed 1500 min^{-1} (full loading) is 341MPa.

Key words: connecting rod, stress state, Solidworks.

[Г.8.15] Христов Х., И. Мехмедов, **В. Михайлов**, *Определяне на натоварването във виброизолатор „Perkins Prima 65”, Известие на Съюза на учените - Варна, стр.40-42, изд. СУБ-Варна, ISSN 1310-5833;*

DETERMINATION OF THE LOAD IN ENGINE PERKINS PRIMA 65 VIBROINSULATOR: The automotive comfort depends by the level of noise and vibrations. Different engines need different vibroinsulators with capacity to carry necessary load and to decrease vibrations. With new methodic and actual measurement devices are tested vibroinsulators Perkins Prima 65, when the engine works with 2500 rpm and 100 Nm brake moment. They are determined the forces in a back engine vibroinsulator on longitudinal and vertical axis. The force in the central front vibroinsulator is determined on the long axis only. Graphics are drawn for the force values and damping capacity when the engine stops.

Key words: vibroinsulator, force measurement, damping.

[Г.8.16] *L. Sitnik, R. Wrobel, M. Andrych and V. Mihaylov, NVH application research using accelerometers on a chassis dynamometer, Journal of KONES Powertrain and Transport, Vol.23, No 3 2016, cmp.443-448, publ. Institute of Aviation BK, Warsaw, Poland, 2016, ISSN 1231-4005;*

The work presents results of accelerometric tests conducted during driving cycles on an inertial load chassis dynamometer Maha LPS3000. The object of the research was Mazda 3 1.6 (petrol), built in 2010, mileage 70 thousand km. The tests were related to vibration measurements on a chassis dynamometer using various, forced tractive effort (300, 500 and 700 N). No additional signal processing was used (except for operations necessary to create a spectrum) so as to present the whole vibration spectrum with special emphasis on the resonance frequency of human organs. The article presents vibration amplitude measured at the level of the headrest for three forced tractive efforts: 300, 500 and 700 N. The measurements were made at the speed of 60 km/h in the fourth gear (which corresponds to about 2000 rpm). The obtained results, indicate that the maximum value of harmonics fall in the range 85-95 Hz. Hence, they are resonance frequencies of eyeballs.

In addition to this, one can state that the values of these harmonics are higher for higher values of forced tractive efforts. This would mean that seats should be additionally stabilised (dampened) to limit the influence of dangerous vibration on a human organism.

[Г.8.17] *Иванов З., В. Михайлов, Г. Чекелов, Параметри на рециркулацията на отработилите газове при автомобилни дизелови двигатели, Научни трудове Русенски университет-2017 т.56 с.4, стр.52-57, изд. Русенски Университет , 2017, ISSN 1311-332;*

EXHAUST GAS RECIRCULATION PARAMETERS IN A DIESEL ENGINE: The limit conditions for the influence of exhaust gas recirculation parameters on various limiting components and environmental characteristics of a diesel engine are studied. The possibilities for reducing the amount of NO_x and the impact on the other toxic components and particulate matter in exhaust gases were determined. The behavior of the carbon emissions from the engine is determined when changing the air charge parameters.

Keywords: diesel engine, exhaust gas recirculation, NO_x, O₂, oxygen concentration, harmful emissions.

[Г.8.18] M. Pasare and V. **Mihaylov**, *The theoretical study of unsymmetrical bending, Annals of the „Constantin Brancusi" University of Targu Jiu, Engineering Series, No. 3/2017, p.52-55, 2017, ISSN 1842-4856;*

The unsymmetrical bending is produced in a beam when the applied loads are not all in the main inertia plane, and the bending moment. The unsymmetrical bending meets the to resistance elements required by forces whose planes pass through the geometric axis, or the forces are in the planes perpendicular to the plane passing through the axis geometry of the beams. For the two main directions of inertia (O_z and O_y), in the case of oblique bending, the moment of bending M_i decomposes in two components oriented along the main inertial directions, resulting M_{iz} , respectively M_{iy} . The resistance condition doesn't turn into a dimensional formula for any section. This section can only be verify; the section is admitted and the resistance condition checked.

[Г.8.19] Иванов З., Р. Димитров, В. **Михайлов**, Д. Петков, *Система за смесване на газове, използвани като гориво за ДВГ, Научни трудове Русенски университет-2018 т.57 с.4, стр.41-45, изд. Русенски Университет, 2018, ISSN 1311-3321;*

SYSTEM FOR REGULATING THE COMPOSITION OF BIOGAS USED AS FUEL FOR INTERNAL COMBUSTION ENGINES: The article shows a study focusing on the use and potential of biogas, as an alternative fuel from Renewable Energy Sources for using in gas-generators. Studies show that the content of particular matters and NOx is significantly reduced due to the mixing scheme used. Given the methane burning - one of the components of biogas, CO2 emissions are lower in the atmosphere. The aim is to study the impact of different biofuel concentrations on the environmental performance of automotive engines, to determine the optimum and permissible biofuel blend concentrations and their impact on engine performance. By modifying the composition of the fuel, it is intended to model a working process by influencing some of its basic parameters such as: maximum cycle temperature, combustion duration, rate of increase of pressure, etc.

Keywords: biogas, Internal Combustion Engines, ecology, environmental characteristics.

[Г.8.20] S. Stoyanov, V. **Mihaylov**, Z. Ivanov and R. Radev, *System for studying the parameters of gas solenoid valves, ANNUAL JOURNAL OF TECHNICAL UNIVERSITY OF VARNA, BULGARIA, 5(2), pp. 112-121, 2021, ISSN 2603-316X, DOI: <https://doi.org/10.29114/ajtuv.vol5.iss2.259> ;*

The aim of the present work is to construct a test stand for determining the characteristics of different fourth generation gas injectors working under various conditions as close as possible to the actual operating ones. For this purpose, the standard fourth generation gas system and liquefied petroleum gas (LPG) as a working fluid were used for the stand. A system has been developed to maintain the gas leakage pressure equal in value to the pressure in the intake manifold of a Spark Ignition (SI) engine. Used LPG is compressed and liquefied for reuse. Additionally, safety measures are taken. The stand provides the right conditions for determining the influence of the nozzle diameter, the length of the connecting pipe between the injector and the intake manifold, the differential pressure upstream and downstream of the injector and other factors that affect these characteristics, which may be different when installing LPG system to an internal combustion engine.

[F.8.21] R. Wrobel, G. Sierzputowski, P. Haller, **V. Mihaylov** and R. Dimitrov, *The vehicle driver safety prediction system*, *Combustion Engines*, 190(3):11-17, 2022, eISSN:2658-1442, <https://doi.org/10.19206/CE-142950> ;

The article presents analysis of road crash accidents. It presents the evolution of safety systems, starting from a description of the currently used vehicle-based systems, with particular emphasis on the prediction of the driver falling asleep. The article also proposes a proprietary system of sleep prediction based on the face detection of drivers. The detection of facial landmarks is presented as a two-step process: an algorithm finds faces in general, and then needs to localize key facial structures within the face region of interest.

[F.8.22] M. Andrych-Zalewska, L. Sitnik, Z. Sroka and **V. Mihaylov**, *Fuel with a higher content of bio components in greenhouse effect aspects*, *Combustion Engines*, 2022, eISSN:2658-1442, <https://doi.org/10.19206/CE-147741> .

Transport is an energy-intensive sector of the economy and it is important where energy comes from and how it is used – now and in the future. The presented research results seem to encourage further work, despite the fact that the work had the character of basic research. The results were achieved in idealized conditions by the fact that the internal combustion engine was tested in static conditions on the test bench and the fuels contained components with strictly defined parameters. These conditions are different from everyday life. However, the obtained results seem to be valuable as they lead to conclusions regarding biofuels, and these conclusions are not directly formulated and published in the literature on the subject. The general conclusion from the research carried out is that the introduction of the so-called biofuels can contribute not to the reduction of CO₂ emissions, but to its faster balancing in the environment. This balancing can be achieved but at the cost of increased fuel consumption. This increase in fuel consumption would probably not occur if the "bio" components in the fuel were synthetic hydrocarbons obtained from biomass. However, proving it requires wider studies, including LCA. Data for this LCA, especially about a fuel consumption, may be coming from long term operation of vehicles.