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Investigation of work parameters of SI engine dedicated to energetics aggregates with pneumatic injection system

W Marek[1] and K Śliwiński[1]

[1]Cracow University of Technology, Institute of Automobiles and Combustion Engines, al. Jana Pawła II 37, 31-864 Krakow, Poland

E-mail: wmarek@pk.edu.pl

Abstract. The article presents the possibilities of alternative fuel combustion in the engine four-stroke spark ignition engines. Power of the motor was carried out pneumatic fuel injection system using a hot gas developed by Prof. Stanislaw Jarnuszkiewicz. Presented made the position of the measuring system with the power and results. The engine experimental at the time of the study was powered by a blend of alcohol and gasoline. The main aim of the study was the question of control fuel dosage, taking into account the energy needs of forcing the engine load. During the tests carried load characteristics control the motor using the power control quality. Another issue was the elimination of penetration of fuel to the engine lubrication system, a problem occurred in the initial study on the issue of the pneumatic fuel injection using the hot exhaust gases. In summary we present the findings of this phase of the study.

1. Introduction

More recently can noted the growing interest of large industrial corporations and specialized government agencies issue of improving the efficiency of energy supply diversification. It is expected, therefore, that in the next few years will increase interest in the widest possible and universal, to use of internal combustion engines for energy purposes. The carrier of chemical energy in the working process of these engines, will be the fuels of varying fractional and group composition, and with diversified character of the phase. Therefore, it is clear that at the current stage of development of industrial civilization, piston internal combustion engine will remain for a long time the main drive source in many sectors of the economy.

This publication is another in the series [1], which will be presented the results of studies to indicating areas of possible uses, proposed by Professor Jarnuszkiewicz, the concepts of pneumatic injection by means of hot exhaust gases. In this publication will be presented one of the ways to use of waste liquid fuels, in an internal combustion engine, for the conversion of chemical energy to useful work for the production of electricity and useful heat energy in the process of recovery of waste heat from the exhaust system and engine cooling system [7]. As an example of broad and widespread use of waste fuels, can be given advanced projects in this area in the Nordic countries, despite the well-developed infrastructure of the existing energy supply from power plants.

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2. Purpose and methodology of research

The main objective which was to achieve in the case of a multi-fuel engine, was the issue of controlling the dosage of fuel in the spark-ignition engines, taking into account of the energy requirements of the engine load inducement system. It not without significance was also the problem of minimizing toxic exhaust emissions, but it was treated more as a limitation, not a decision criterion. In the research work we identified another limitation, associated with the passage of the liquid phase of fuel dosing, to the lubricating oil. Was studied and recorded the impact of the fuel used for the engine, onto parameters such as torque and power, fuel consumption, the total efficiency of the engine, excess air coefficient, and exhaust gas temperature. Scheme of the engine load, was realized as the regulatory load characteristic of the engine, and was done at a fixed rotational speed of the engine shaft, using the qualitative power control.

3. Test bed investigation of the SI engine

Research of engine fed with a mixture of alcohol and the gasoline separately, were carried out on a special test bed in the Laboratory of Combustion Engines, Cracow University of Technology, whose essential elements are as follows:
– two-cylinder, four-stroke spark ignition engine,
– engine brake generator MEZ,
– AVL fuel mass flow meter , AVL Type 4210,
– The measuring systems for determining: exhaust gas temperature, ambient pressure and humidity of the intake air by the engine, the excess air ratio.

As a research object was prepared a two-cylinder four-stroke spark-ignition engine 126 000 A1, equipped in the pneumatic-fuel injection system using the hot exhaust gases, according to the concept of Professor Jarnuszkiewicz, which in the factory configuration, was carburetor equipped.

In this configuration, the engine was characterized by the following working indicators [2]: rated power on petrol 17.7 kW/4500 1/min., the maximum torque of 42 Nm/ 3000 1/min, the minimum specific fuel consumption of 300 g/kWh. Embodiment of multi-fuel supply system of such an engine, require the design and building a pneumatic injection system and the supply fuel system, which the configuration similar to a conventional, low pressure injection supply system [3] [4]. Pneumatic injection system has been designed based on the concept of Professor Jarnuszkiewicz, described in an article on his achievements, in connection with the jubilee of Conference Konmot 2016 [1]. The functional model of designed and mounted on engine, prototype system of pneumatic injection, was shown in Figure 1.

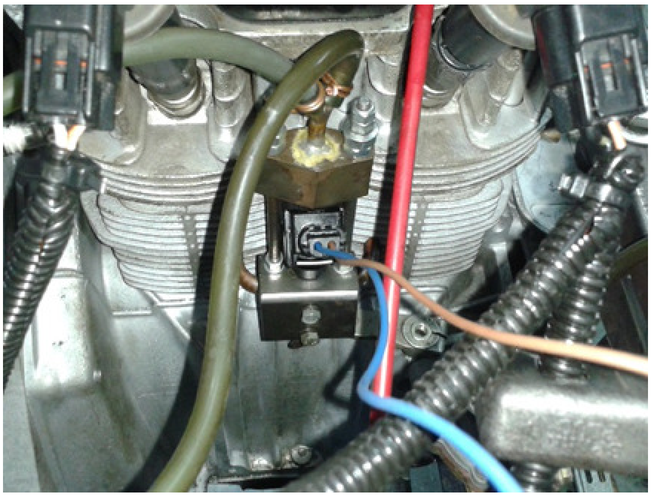

Figure 1. The view of the functional model of the pneumatic injection using hot exhaust gases for liquid fuels.

To control: the value of fuel dose and phase of its dosing, the angle of ignition timing, degree of throttle opening and the composition of the combustible mixture (excess air ratio), and also the value of dose of exhaust gases to blowing the dose of fuel, was designed and used a special motor controller. As the fuel was used waste mixture of iso-butanol and n-butanol alcohol, as a post-processing fuels of the chemical industry - marked ZAK and X. Both waste fuels come from different technology threads and characterized by the same calorific value, but different physical and chemical properties. For comparative purposes, was used motor gasoline.
Due to the prototype nature of fuel supply, and combustion system, the power control range was limited to medium loads.

4. Results and analysis of investigations

For the practical implementation of the research goal, associated with defined above as the multifuel engine supply, was developed a research program of implementing the strategy of diversified supply flow of chemical energy of the dispensed fuel. A reflection of this strategy is an example of the imaging method of regulating engine power, shown in Figure 2, when the engine is fed with a lean mixture.

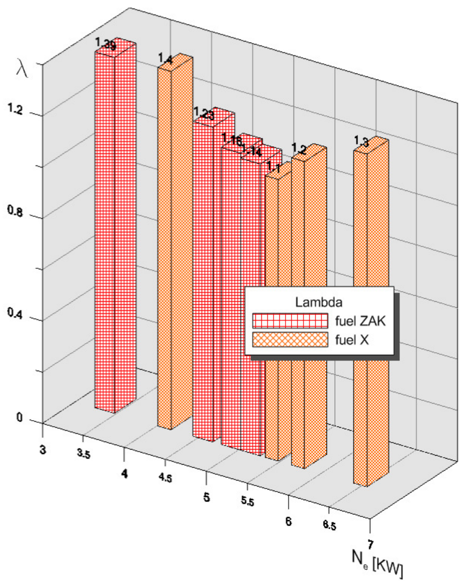

Figure 2. Characteristics of the excess air ratio of test engine, fueled with the post-processing fuels.

In the case marked on the chart as the ZAK, the engine power of 5 kW, was obtained by powered the engine only as so marked fuel.
Further increase in engine power to 6.5 kW, was obtained by application of the fuel, marked as X. This was due to the beneficial effect of fuel X physicochemical properties on the process of creating a combustible mixture, and repeatability of the heat release process. Comparatively, in the case of petrol supply to obtain the same load value, require a gradual enrichment of the mixture, up to the value of the excess air ratio of 0.83 - Figure 3.
Engine operation mode as so configured supply system, for feeding by post-processing fuels, did not cause the phenomenon of penetration of fuel into the lubricating oil. This was related mainly to the perfect process of spraying a liquid phase, when creating the fuel-air mixture. The problems associated with penetration of the waste liquid fuel to the lubricating oil are present in the case of conventional power supply systems of injection, due to insufficient atomization and evaporation of fuel in the intake and in the cylinder [5]. As we know, the process of preparing the fuel for combustion is one of the main factors influencing the efficiency of conversion of chemical energy to work for the engine [6].

The practical realization of this demand to improve the quality of spraying in the case such as that presented here supply system, is associated generally with the need to achieve a compromise between

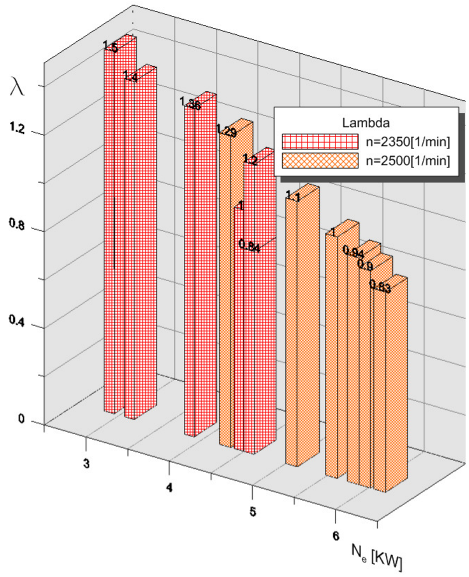

Figure 3. Characteristics of the excess air ratio of test engine, fuelled with petrol.

the cost of apparatus and equipment, and the real possibilities of maneuvering streams of chemical energy of the available fuel types. In other words, it seems rational to carry out each time of discernment concerning the ability to provide the suitable for the assumed of the engine energy parameters, fuel availability, and only then nominate the appropriate types of hardware and fuel dosage control system. Very eloquent, to verification of the scheme of the strategy of qualitative power control as given above (to constantly full throttle), is to visualize the course of the changes of the total efficiency, depending on the load, placed on the Figure 4.

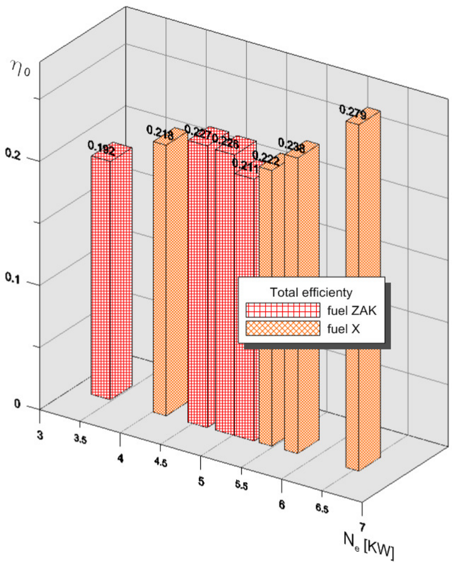

Figure 4. The total efficiency of the test engine fuelled with the post-processing fuels.

With already discussed above reasons, the total efficiency of the engine fueled ZAK, does not exceed 20%. In the case of fuel X supply, can be notice a marked increase in total efficiency of up to approx.

28%, while the occurrence of extension, of disposable load range. Comparatively, in the case of petrol supply, the value of similar total efficiency, was achieved at a lower load - Figure 5.

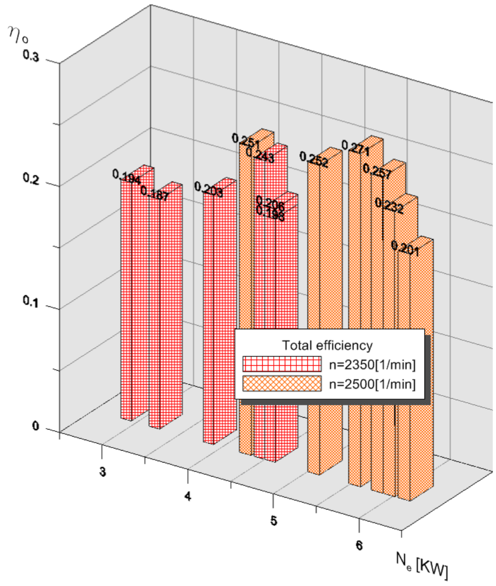

Figure 5. The total efficiency of the test engine fuelled with the petrol.

In the case of supply the engine with the post-processing fuels, may notice a steady increase in the total efficiency for the load increases - Figure 4. However, in the case of petrol supply, this sequence have not so favorable course - Figure 5.
Differences in in the process of creating a combustible mixture, have also caused the difference of the heat release in the cylinder, and the value of temperature of the combustion process. While the combustion of gasoline obtained the maximum exhaust gas temperature of 650 ° C - Figure 6, this during powering the engine with a lean mixture of post-processing fuels, the exhaust gas temperature, was reached a significantly lower value - Figure 7.

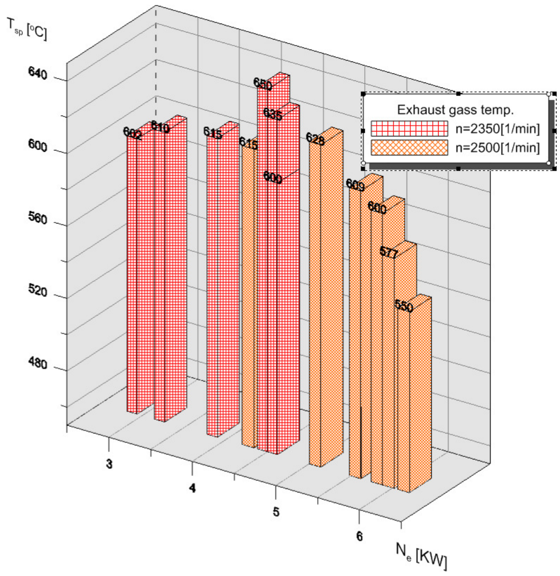

Figure 6. The exhaust gas temperature of test engine, fueled with petrol.

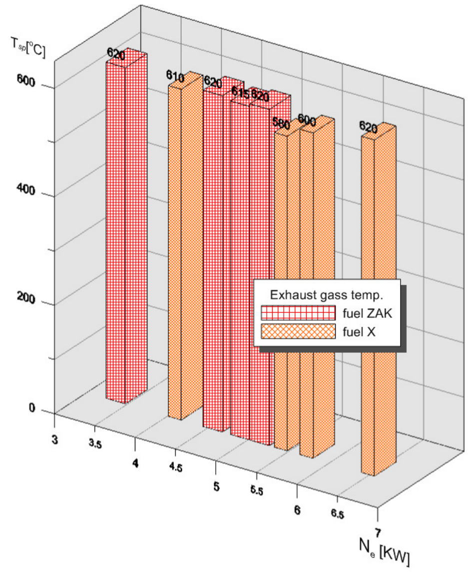

Figure 7. The exhaust gas temperature of test engine fuelled with the post-processing fuels.

5. Summary

The investigation results of the engine 126 000 A1 powered by waste fuels on alcohol base, allow to formulate the following most important conclusions:

1. The supply system designed and manufactured according to the concept of Professor Jarnuszkiewicz, allows to obtain multifuel usefulness, for the spark ignition four-stroke engine,
2. When engine was dual fuel supply, through an appropriate strategy of fuel dosage, was obtained possibility of extending disposable load range when powered by a lean mixture,
3. The results of the research allowed to define the strategy of power and control. It does not revealed the phenomenon of penetration of the liquid alcohol fuel, into a lubricating oil.
4. A preferred course of the total efficiency, and the exhaust gas temperature as a function of the load, demonstrating the effectiveness of the present fuel supply system, in the art of managing the post-processing liquid fuels.

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