INVESTIGATIONS OF THE IGNITION AND COMBUSTION PROCESSES IN THE SINGLE COMPRESSION ENGINE

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Abstract

An aim of work was analysing of combustion and ignition processes in chambers with small volume at the use of different sorts of fuels, fuel liquid and air mixtures and fuel gas ones. For experiments, the machine of single compression the cubic capacity of 400 mm^3 approx and average piston speeds 4 m/s was used. Investigated physical processes allowed better recognizing processes occurring in miniature- real engines. For the feeding of the machine of single compression, homogeneous mixtures of hydrogen with air, propane with air and mixtures methyl and ethyl alcohol in the stoichiometric relation with air were used. Adequately earlier prepared mixtures warranted the repeatability conditions of the experiment.

Experiments effected with the machine of single compression showed small increases of pressure from combustion process. The occurrence this can be explained with significant heat conduction to walls during comparatively long compressing and combustion. In carried research with the machine of single compression with very large ratio surface combustion chamber to its volume, one obtained comparatively low value of the maximum compression pressure. The researches showed that on processes of compression, combustion and ignition, the greater influence had geometry of combustion chamber, average piston speed than sorts applied fuels.

Keywords: *combustion engines, reciprocating engines, micro power generator, vallar microengine, combustion processes*

1. Introduction

Technological progress and development of new manufacturing processes of the precise machine parts created the possibilities for miniaturization of mechanical and electromechanical equipment. The miniature mechanical equipment creates application on similar miniature power plants, which would characterize itself by the high specific energy (they ought to be small, light, durable and reliable). These units have various applications, not only in the miniature mechanical systems, but they can be also utilized to the powering of various electronic equipment. In all their applications these units must be light in weight.

For the purpose of recognition of the basic processes occurring in micro engine, the machine of the single charge compression was used.

2. Single compression machine

In experiments the single compression machine was utilized, with the 6 mm piston diameter, 12 mm stroke and average piston speed 4 m/s that responds to rotational speed of 10000 rpm approximately (Fig. 1). The test stand enabled realization and investigation of the individual work cycle. Measuring system with the computer registration and acquisition of data enabled the simultaneous measurements of pressure and temperature. Machine was supplied with mixture the fuel and air prepared earlier, assuring repeatability of the experiment conditions. As the gas fuel mixtures of air with propane were used (4% propane and 96% air) and air with hydrogen (16%

hydrogen and 84% air). As the liquid fuel the mixture of methyl and ethyl alcohol with air was used. Just before investigations alcohol was vaporized, bringing the whole fuel volume in the container to the gas state.

a) b)

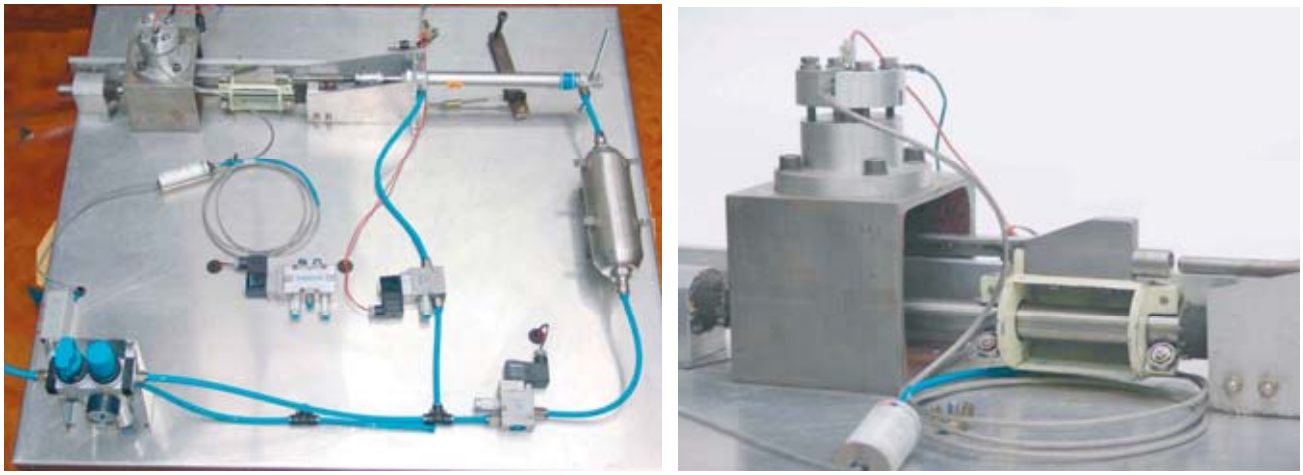

Fig. 1. a) General view of test stand; b) View of single compression machine

For the purpose of the charge ignition in the single compression machine the catalytic igniter was used. Its spiral wire was heated to the temperature of 800°C. The shape and volume of combustion chamber was varied for assignation of their influence on the processes of the mixture combustion.

3. Measurements results

Utilizing the single compression machine the investigations were carried out using as fuel methyl alcohol, ethyl alcohol and ethyl alcohol with the small addition of oxidant in the form of nitromethane, gas fuels as mixtures: propane with air and hydrogen with air. For each fuel type 30 tests were performed and the average pressure values obtained during these tests are submitted in Tab. 1.

Tab. 1. Average combustion pressure obtained during tests at feeding with different fuels

Item	Fuel type	Mean indicated pressure in tests [bar]
1	Methyl alcohol	6,0
2	Ethyl alcohol	6,3
3	Ethyl alcohol with nitromethane additive	6,5
4	Propane	7,1
5	Hydrogen	6,3

In Table 1 the average pressures of combustion obtained from investigations performed for particular fuels are submitted. Results from performed tests show, that tests with the application of the ethyl alcohol base fuel in single compression machine permitted to obtain some higher

pressures in the comparison with tests with the application of fuel on the methyl alcohol base. The nitromethane additive increased even more the pressure obtained during investigations. The highest value of the combustion pressure for chamber with the same form was received with supplying the machine by propane with air mixture.

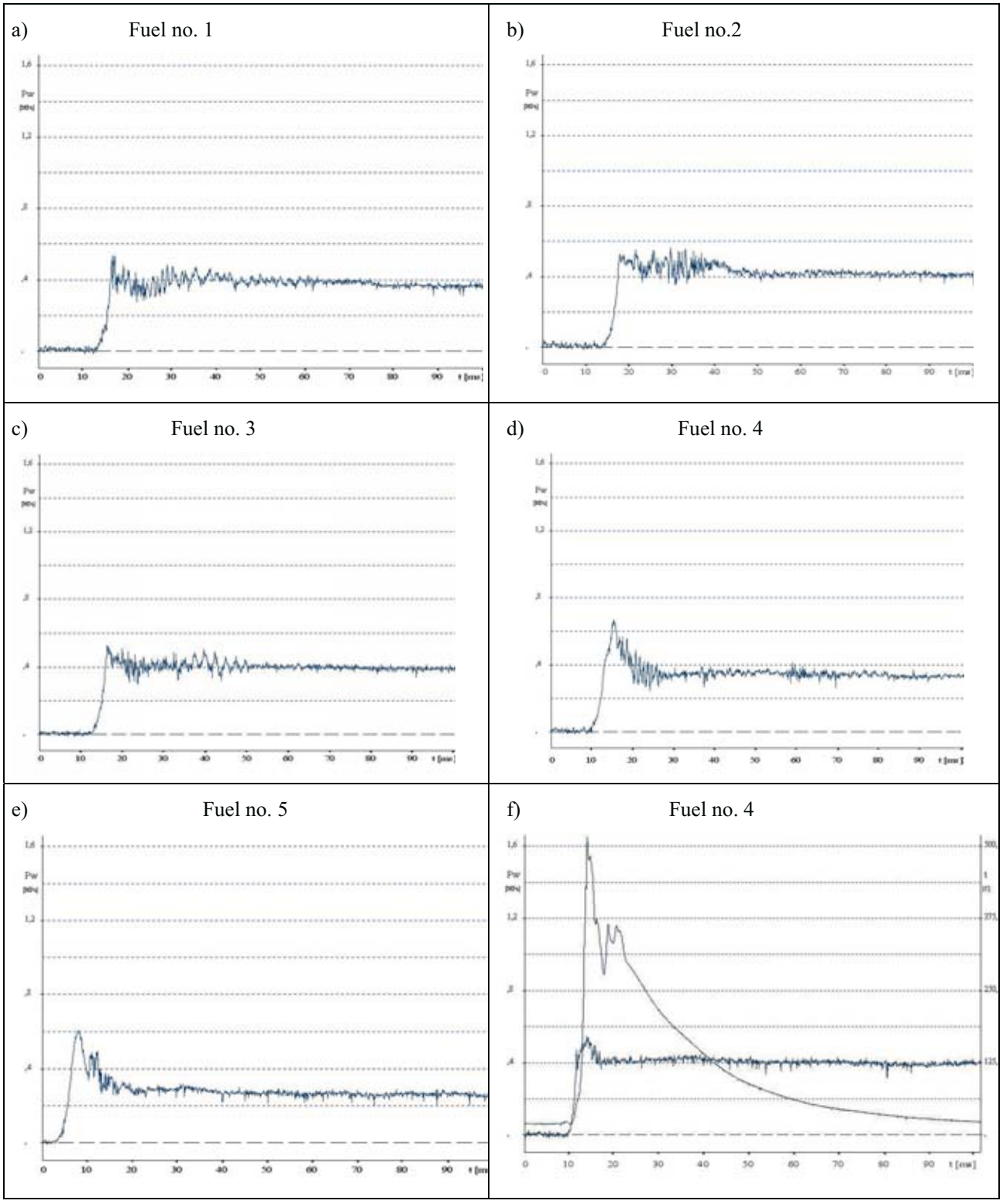

Fig. 2. The example diagrams of combustion pressure courses in the microchamber in the machine of single compression at feeding with fuels: a) with the mixture methyl alcohol with the air; b*) ethyl alcohol with the air;* c*) ethyl alcohol and nitromethane with air;* d*) propane with air* e*) hydrogen with air;* f*) propane with air, and diagram of course of temperature increasing*

The small increase of pressure during the combustion in the comparison to the compression pressure results from a high heat transfer through the walls of combustion chamber. For the purpose of exact recognition of the processes occurring in the small chambers, the temperature was measured in the combustion chamber during compression and ignition. On Fig. 2.f the course of rising temperature and pressure during compression and the combustion in micro chamber of single compression machine is shown. The temperature raised from 16°C to above 500°C, however the maximum pressure was 6.5 bar. For designation of mini chamber shape and the influence, the two different chambers with different relationships of chamber surface to its volume were manufactured.

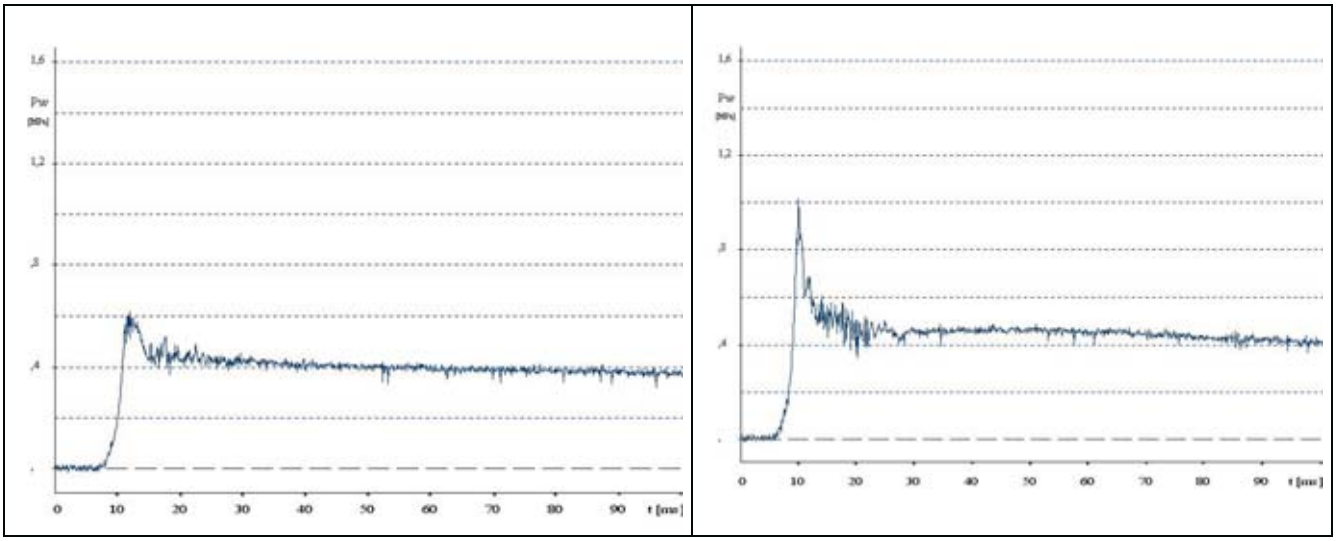

Fig. 3. Example diagrams of the course of compression and combustion pressure of the of propane and air mixture in the machine of single compression in two different microchambers

4. Conclusions

1. The experiments carried out on single compression machine proved the small increase of pressure from the combustion. This occurrence can be explained by significant heat transfer to the walls during relatively long compression and combustion time.
2. The serious problem in these engines is also the large participation of dead volume formed through a different kind of channels in the common combustion volume. The dead volume in the significant manner lowers compression ratio.
3. As a result of the performed experiments was found, that in micro engines with very large ratio of combustion chamber surface to its volume, very intensive heat transfer to the walls occurs.
4. The investigations proved, that on the compression, combustion and ignition processes, the larger influence has combustion chamber geometry, average piston speed than the types of fuels used.

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