# INFLUENCE OF COMPOSITION OF BIOGAS ON SELECTED ENGINE OIL VALUES

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***Abstract***
*The period between the changes of the engine oil constitutes one of the costs of their exploitation. In the article there is presented the analysis of the selected properties of the engine oil depending on time of operation and composition of biogas. It has been found, that for equally loaded combustion engine, the periods of the engine oil use to a high degree depend on the fuel's quality.*

***Key words:*** *combustion engine, biogas, engine oil.*

## INTRODUCTION

For the combustion engines, it is the diesel oil and and gasoline that all the time constitute the most popular driving units in the mobile device. Looking for alternative energy carriers results in the fact, that more and more often there are used gasolines of renewable origin. One of them is biogas, which can be made both of the specially cultivated plants, as well as different types of organic (Czekała et al. 2016). These may be both agricuktural wastes ( to być zarówno odpady rolnicze (liquid manure, dung) as well as wastes from food processing plants, odpady z pochodzące z zakładów przetwórstwa spożywczego, maintenance storages or markets (Guangqing L., et al. 2009). The other possibility is particularly valuable, as apart from the wastes utilization it does not require designing for cultivation of energy crops areas which could be used for food production (Bilcan, A., Le Corre, O. & Delebarre, A. 2003). Moreover, availability of cultivated plants is connected with seasonality and changeable supply while the wastes are available in a balanced manner for the whole year (kosiba et al. 2016). More and more often, for production of biogas there are also used biological products of sea origin – algae (Mussgnug et al. 2010). Depending on substrates from which biogas is made of, it may differ in chemical composition, volume and type of impurities. The range of changes in the biogas‘ composition depending on the type of the used substrate is presented in table 1.

**Tab 1.** Approximate composition of biogas depending on the source of origin (own study)

| *Gas/source of origin* | *Agrarian biogas plant (corn, beets)* | *Sewage treatment plant* | *Municipal wastes* |
|---|---|---|---|
| *Methane* | *45-75%* | *64-75%* | *45-55%* |
| $CO_2$ | *25-55%* | *20-35%* | *25-30%* |
| *CO* | *≤0,2%* | *≤0,2%* | *≤0,2%* |
| $H_2S$ | *10-30000 ppm* | *≤8000 ppm* | *≤8000 ppm* |
| $N_2$ | *0,01-5%* | *3-4%* | *10-25%* |
| $O_2$ | *0,01-2%* | *0,5%* | *1-5%* |

Biogas is characterised by the compositions changeability, what results both from heterogeneous substrate used for its production as well as treatment's effectiveness. The pollution of biogas, both mechanical as well as the presence undesirable chemical substances influences both the quality of the engine's operation (power, turning moment) as well as its permanence. Prior to be used for the combustion engines‘ feeding, biogas is purified (Annika F. et al 2004). Also the economical costs of biogas generation are of an higher and higer importance. As a consequence, it influences cost-effectiveness of the use of biogas as fuel (Zbytek Z. et al. 2016). In the entities generating biogas and using it for combustion engines‘ feeding, the engine oil is most often subject to constant control, and the decision on its replenishment or change is taken on the basis of the results of analyses and not the time of operation. In the conducted studies there were attempts to determine to what degree pollutions included in biogas impact its properties.

## MATERIALS AND METHODS

Four combustion engines with spark ignition, with pressure charging, of the power 380 kW each were tested. They propelled electric power generators of the power of 340 kW, loading of which changed to a very low degree (±5%). The engines were in a very good technical condition. Prior to the tests, there were operated for not longer than 2 years. Before starting of the cycle of the tests, in all the engines the engine oil, air and oil filters were changed. The engine oil was controlled every 500 hours of operation. There were tested the folowing: viscosity of the oil (at 100 $^{0}$C), the acid value (TAN), the contents of silicon and iron in oik. Biogas with which the engines were supplied, was made of wastes from the municipal wastes treatment plant. Its composition was controlled with the biogas analyser BIOTEX MultiPoint. Biogas, prior to its supplying to the engine, was cleaned from both mechanical as well as chemical impurities. The tests were conducted up to 3000 hours of each engine’s operation. The average composition of the gas obtained following its cleaning (mean values for the period of tests) is presented in the tabel 2. The composition of biogas supplying engines that were tested, had very good parameters, in particular high contents of methane and low contents of suplhur. For the purposes of the tests, the mean contents of the biogas componenets was calculated for each period (500 hours). Because of earlier experiments as well as available results of other authors‘ tests, particularly big attention was paid to the contents of the sulphur compounds in biogas (Anika et al. 2004). The composition of biogas for individual periods is presented in the table 3. In the course of the studies there occurred a short-term increase of the contents of hydrogen sulphide in biogas (in the period of 500-1000 hours of the conducted tests). Following completion of the period of tests, once again the engine oil was changed in all the engines.

Tab. 2. Mean values of the selected compounds in biogas in the period of the conducted tests

| *Biogas component* | *Mean contents prior to purification* | *Mean contents following purification* |
|---|---|---|
| *Methane* | *65,25%* | *65,25%* |
| *Hydrogen sulphide* | *59 ppm* | *17 ppm* |
| *Carbon dioxide* | *35%* | *35%* |
| *Ammonia* | *0 ppm* | *0 ppm* |

Tab.3. Mean contents of the selected compounds in biogas in individual periods of tests

| *Biogas component* | *Methane [%]* | *Hydrogen sulphide [ppm]* |
|---|---|---|
| *0-500 hours* | *65,22* | *12,00[a]* |
| *500-1000 hours* | *65,23* | *41,00[b]* |
| *1000-1500 hours* | *65,26* | *14,00[a]* |
| *1500-2000 hours* | *65,27* | *11,00[a]* |
| *2000-2500 hours* | *65,23* | *12,00[a]* |
| *2500-3000 hours* | *65,28* | *11,00[a]* |

The tested oil paramters and the contents of hydrogen sulphide in biogas were subject to the statistical analysis with the use of the Tukey’s test at the significance level 0,05.

## RESULTS AND DISCUSSION

The mean results of the tested properties of oil obtained at the time of tests are presented in table 4.

Table 4. Mean results of oil tests

| *Working time [h]* | *Viscosity [cSt(100^0C)]* | *Acid number [mg KOH g^-1]* | *Content of silica [ppm]* | *Contents of iron [ppm]* |
|---|---|---|---|---|
| *0-500* | *14,33[a]* | *3,25[a]* | *64,50[a]* | *4,25[b]* |
| *500-1000* | *14,28[a]* | *3,26[a]* | *66,75[a]* | *4,80[b]* |
| *1000-1500* | *13,85[b]* | *2,45[a]* | *83,75[b]* | *5,50[b]* |
| *1500-2000* | *13,80[b]* | *2,10[b]* | *88,75[b]* | *3,50[a]* |
| *2000-2500* | *13,83[b]* | *2,06[b]* | *57,75[a]* | *3,00[a]* |
| *2500-3000* | *14,15[a]* | *2,16[b]* | *75,70[a]* | *6,25[c]* |

Viscosity, contents of silica and iron in oil did not exceed the admissible values. Only the acid number reached the values considered to be the border ones (Piec 2012). A slight drop in the oil's viscosity after 1000 working hours was observed. After the next 1500 hours of work, the increase of the viscosity values was observed. Viscosity prior to the period of lowering and after the repeated increase, had the values not essentially differing statistically. The drop in viscosity at the time of exploitation of engines powered with liquid fuels most often means diluting of oil as a result of unburnt oil's getting into oil. In case of engines powered with gas fuels, it most often proves chemical reactions taking place in oil and reducing its properties. The rise of viscosity most often proves of a considerable volume of pollutants and the gelation processes. The acid number at 1500 hours of work dropped to the level of 2,45 and was slightly dropping till the end of the research cycle. The values of the acid number for 4, 5 and 6 of the measurement, did not statistically differ and were at the same time statistically lower than for the measurements 1, 2 and 3. The drop of the acid number may in engines powered by the biogas be caused most of all with the increase of the sulpur contents in fuel. It may paradoxically result in the increase of the corrosion wear and tear. The measured contents of silica in the 3 and 4 measurement, had the value essentially statistically lower than for the measurement 1 and 2. The measurements 5 and 6 also had the value not differing statistically from the measurements 1 and 2. The increase of the contents of silica was most probably caused by the increased presence of sulphur in fuel and as a consequence – in oil. The increase of the contents of iron proves the progressing processes of wear and tear (Knopik et al. 2016).

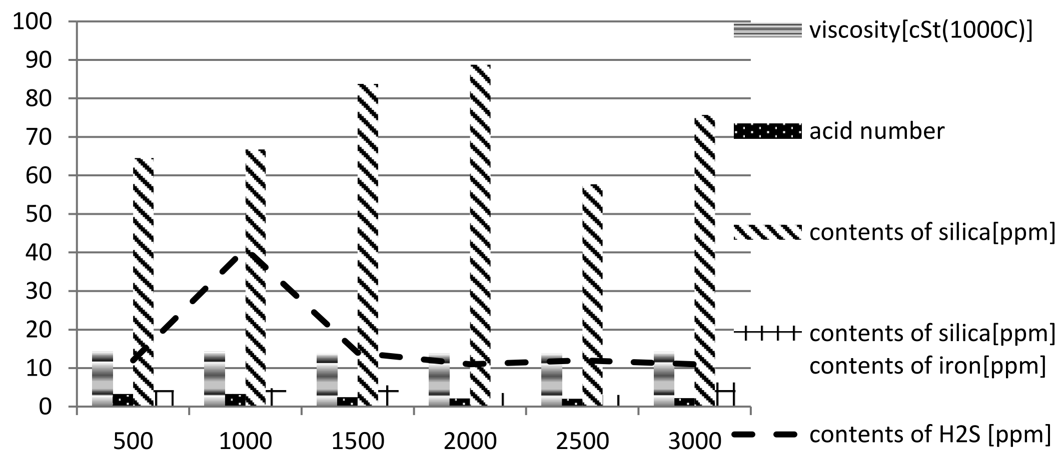


Fig. 1 Diagram of changes of the selected features of oil and biogas

The subsequent drop in the contents of iron in oil is most probably caused by the effective operation of the oil filtering system.
The contents of methane did not essentially statistically change, however the contents of the hydrogen sulfide increased more than three time for the run of 1000 hours. The difference was statistically essential.

## CONCLUSIONS

At the time of the tests‘ conducting it was found, that the examined oil parameters essentially statistically changed following operation for 1000 – 1500 hours. It coincided with the increase of the hydrogen sulfide in biogas. The improvement of the parameters occurring after the subsequent 500 hours in spite of the fact that the level of oil was not supplemented, most probably resulted from effective operation of the oil filtering system

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