ASSESSMENT OF THE POSSIBILITY OF EXTENDING THE INTERVALS BETWEEN ENGINE OIL CHANGES ON BIOGAS POWERED UNITS

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Abstract
Intervals between subsequent oil changes in combustion engines are usually specified in operating hours and for most units an oil change is carried out after this period. The possibility of a controlled extension of the oil service life until the next oil change on the one hand reduces engine operating costs, but on the other hand may have a negative effect on engine lifetime.
It is also important to reduce the environmental impact resulting from the reduced consumption of engine oil. Checking the quality of oil may allow you to safely extend oil service life without the risk of reducing an engine lifetime. The article presents the results of a study of selected oil parameters at excessive usage times. It was found that for the engines powered by biogas it is possible to extend the oil change interval by 200 hours.

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

INTRODUCTION

Spark-ignition internal combustion engines powered by biogas are not only used in electricity production systems. Despite the use of such solutions, e.g. in buses, this is still the predominant use of internal combustion engines in biogas. Biogas can be produced from biological material. These can include both crops grown specifically for biogas production, organic waste from agricultural production and waste from storage facilities. In addition, sewage, municipal waste and, increasingly, marine algae are used to produce biogas (*Kaszkowiak et al., 2017; Czekała, et al., 2016*). Biogas is produced from renewable sources, which reduces the balance of CO_2 emissions. Due to the diversified raw materials from which biogas is produced, its composition varies (*Bilcan, Le Corre & Delebarre, 2003; Kosiba et al., 2016*). The approximate composition of biogas depending on the substrate from which it is produced is presented in Table 1.

Tab. 1 Selected components of biogas depending on the substrate from which it is produced (*Kwaśny, Banach & Kowalski, 2012*)

Component/substrate	units	Waste from households	Sludge from sewage treatment plant	Waste from agricultural production	Wastes from the agro-food industry
Methane CH_4	[%]	50-60	60-75	60-75	68
Carbon dioxide CO_2	[%]	34-38	19-33	19-33	26
Nitrogen N_2	[%]	0-5	0-1	0-1	-
Hydrogen sulphide H_2S	[ppm]	100-900	1000-4000	3000-10000	100
Oxygen	[%]	0,1-2,0	0,5-1,0	0,5-1,5	1,-1,5

Particularly high differentiation in the composition of biogas can be seen for hydrogen sulphide and methane content. At the present time, the production of biogas as a fuel is becoming particularly profitable, because in addition to waste utilization (as is the case with the use of sewage, municipal waste and waste from the agro-food industry as a substrate), a fuel can be obtained at a relatively low cost. Moreover, the fuel is treated as generated from renewable sources. Furthermore, the fuel is treated as originating from renewable sources. This consequently affects the profitability of using biogas as fuel. It

should be mentioned that biogas used as a fuel is exposed to continuous monitoring of the methane content and volume of impurities.
Specially developed engine oils are most often used to lubricate engines powered by biogas. Biogas as a fuel is characterised by a higher auto-ignition temperature and usually a longer combustion time. This results in more intense heating of the engine oil (*Górniak et al., 2014*). As previous studies have shown, the composition of the biogas feeding the engine also has a significant influence on the condition of the engine oil (*Kaszkowiak et al., 2017*).

MATERIALS AND METHODS

Three spark ignition, supercharged, 380 kW each, type MAN E2842LF322 internal combustion engines were used in the tests. They powered the power generators. The engines were of identical design, powered by biogas. They powered electric generators with a capacity of 340 kW, loaded with an average power of 300 kW. Their load varied only slightly (±5%). They operated at a speed of 1500 rpm [157 rad/s]. The engines were in very good technical condition. The engines had had their engine oil changed before the commencement of the tests. The biogas used to power the engines was purified. The biogas's parameters were monitored systematically with the use of the biogas analyzer BIOTEX MultiPoint. The changes in the content of individual components were slight (less than 1%). The composition of biogas is presented in table 2.

Tab. 2 Composition of biogas powering engines

Component	Content
Methane [%]	65
Hydrogen sulphide [ppm]	17
Carbon dioxide [%]	34,5
Ammonia [ppm]	0

The engine was lubricated with Shell - Mysella S5 S 40, a low ash oil with extended durability, dedicated for engines fuelled with gaseous fuels. Its basic nominal properties are presented in table 3.

Tab. 3 Selected properties of the new Shell – Mysella S5 S 40 oil

Properties	Unit	Value
Kinematic viscosity 100^0C	[mm^2/s]	13,5
Density (15^0C)	[kg/m^3]	890
Flash point	[^{0}C]	230
Ash content	[%wt]	0,48
Alkaline number TBN	[mg KOH/g]	4,5
Acid number TAN	[mg KOH/g]	4,0

The oil change frequency recommended by the manufacturer for the tested engines is 500 operating hours. However, it is suggested that oil parameters should be continuously monitored and, should they deteriorate, an earlier oil change should be carried out. Such a period between oil changes affects the maintenance of the good condition of the engine, but it should be noted that the condition of the oil also affects fuel consumption (*Macian et al., 2015*). The oil condition was monitored in the tests after every 100 hours of operation. Oil change criteria were as follows: silicon increase above 70 ppm, iron increase above 10ppm, potassium increase above 4 ppm, TBN above 5.50 and TAN below 5.00 or viscosity increase above 14.5 or decrease below 13 mm^2/s. Exceeding the permissible value of one of the monitored components is considered as a necessity to change the oil. The tested oil parameters were statistically analysed using the Tukey test at the significance level of 0.05. These values are recommended by the oil producer. The average values of the obtained results are presented in table 4.

Tab. 4 The average values of the selected oil parameters in relation to the operating time

Operating time [h]	100	200	300	400	500	600	700
Si content [ppm]	55[a]	64[b]	64[b]	65[b]	64[b]	67[c]	70[d]
Fe content [ppm]	5[a]	7[b]	7[b]	9[bc]	9[bc]	10[c]	13[d]
K content [ppm]	0[a]	0[a]	1[b]	1[b]	1[b]	2[c]	2[c]
TBN [mgKOH/g]	4,5[a]	4,7[b]	4,7[b]	4,6[ab]	5,0[c]	5,4[d]	5,7[e]
TAN [mgKOH/g]	2,08[b]	2,01[ab]	2,03[b]	2,4[c]	1,85[a]	2,12[b]	2,38[c]
Viscosity [cSt]	13,9[a]	13,8[a]	13,9[a]	14,1[b]	14,0[ab]	14,2[b]	14,5[c]

RESULTS AND DISCUSSION

The content of silicon, iron and potassium in the oil showed an initial slight increase (silicon after 100h, iron after 200h and potassium after 300h of operation) and then remained at a slightly varying level until 500 hours of operation. From 600 hours onwards, a statistically significant increase in both silicon, iron and potassium contents was observed. However, only the iron content exceeded the limit values at 700 hours of work. The course of the changes in the content of the above-mentioned elements is presented in figure 1.

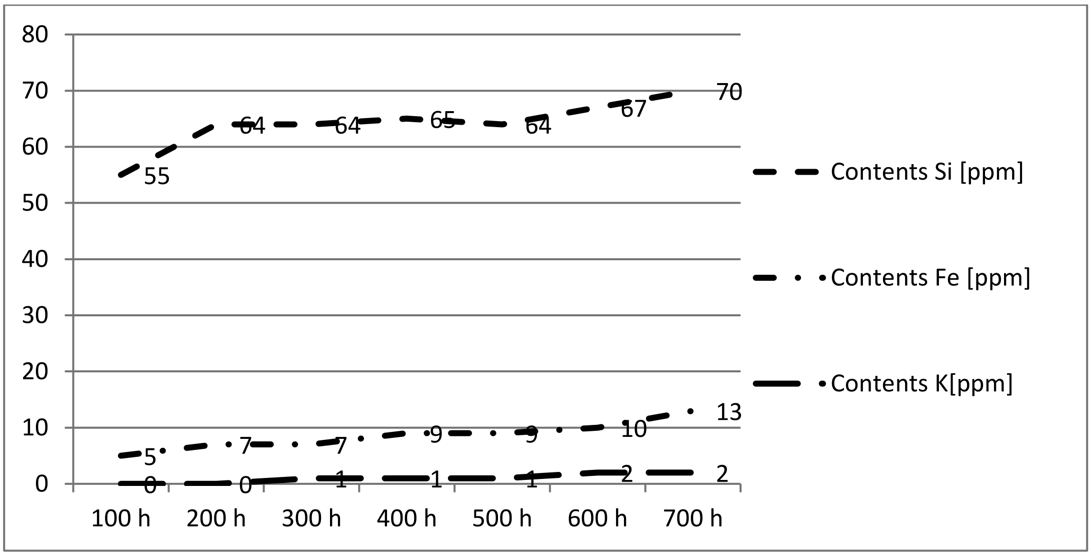

Fig. 1 Changes in silicon, iron and potassium content of oil as a function of operating time.

The changes in the acid and base numbers followed a similar pattern and remained stable after an initial increase up to 500 hours of operation. The acid value did not reach the limit value over the entire test range. The alkaline number only exceeded the limit value after 700 hours of operation. Similar results were obtained by (*Knopik et al., 2016*).The changes in the acid and alkaline values are shown in figure 2.

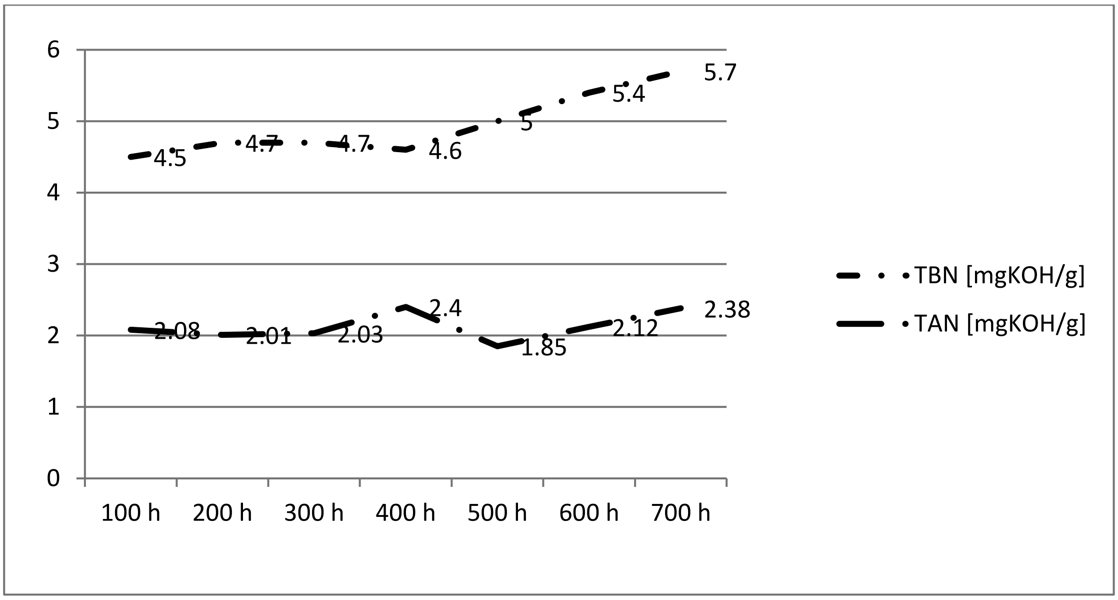

Fig. 2 The course of the changes in the acid and alkaline values as a function of operating time.
The viscosity value measured at 100 °C up to a running time of 500 h did not change in a statistically significant manner. At an operating time of 600 hours, a statistically significant increase in viscosity occurred, and at an operating time of 700 hours, the viscosity reached a limit of 14.5 cSt.

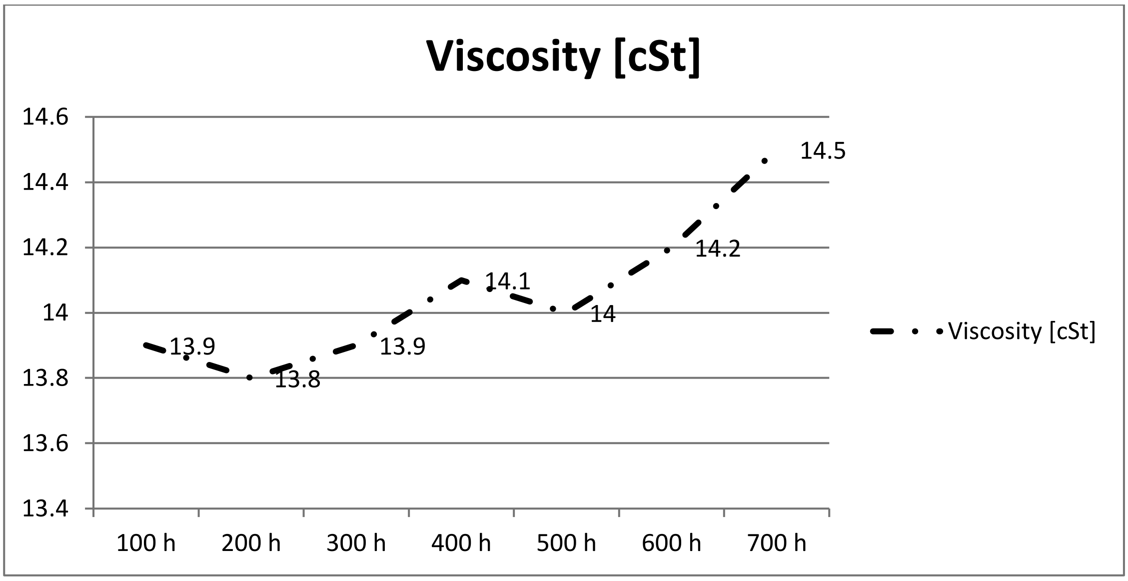

Fig. 3 The course of the changes in the viscosity at 100°C depending on oil operating time.

CONCLUSIONS

On the basis of the conducted tests it can be stated that extending the interval between engine oil changes in biogas-fuelled units is possible. In the cases studied, the factors deciding about the necessity of oil replacement were: alkaline number, iron content and viscosity. On the basis of previous tests, it should be noted that the composition of biogas has a significant impact. At the same time, according to the recommendations of the oil manufacturer, it is necessary to control the condition of the engine oil.

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