TEKA. COMMISSION OF MOTORIZATION AND ENERGETICS IN AGRICULTURE – 2016, Vol. 16, No. 4, 83–86

Determination of the distillation parameters of the milesPLUS® *diesel* fuel comprising a bio-component in the form of methyl esters of corn oil

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Received November 17.2016; accepted December 21.2016

Summary. The aim of the study was to determine the effect of adding bio-components in the form of methyl esters of corn oil to the milesPLUS diesel oil on its fractional composition. The corn biofuel was produced in-house by using an own-design GW-200 reactor. The diesel fuel evaporated at temperatures ranging from 162 to 352°C. The addition of 7, 20 and 40% of a bio-component in principle does not affect the deterioration of the starting point distillation temperatures. They affect the temperature at the end of distillation to a greater extent, resulting in temperatures exceeding 360°C.

Key words: Biodiesel, CME – Corn Methyl Esters, fractional composition, temperature distillation, fuel diesel.

INTRODUCTION

In accordance with the Act on Bio-components and Liquid Fuels (adopted by the Polish Government on 25th August 2006), biofuels may be produced and distributed legally in Poland as of 1st January 2007 [15]. FAME Biodiesel is obtained in the process of transesterification. Its parameters deviate slightly from those of the diesel fuel, however, if the transesterification process is carried out properly, the resulting biofuel can be used as an additive in the form of a diesel bio-component or used as a 100% pure fuel. B100 FAME biodiesel has better parameters compared to the diesel fuel: higher cetane number, better lubricating properties, higher ignition temperature and low sulfur content [2,3,4]. One of the principal parameters used for assessing the suitability of FAME biodiesels for compression-ignition engines is the fractional composition, which is the reason why this very subject was chosen for investigation by the authors of this paper.

The milesPLUS® diesel fuel is the so-called arctic fuel, it was introduced in the Polish Statoil network on 15th December. And a month earlier, at the Statoil stations in Bialystok, Suwalki, Bielsk Podlaski and Lomza. It is characterized by two parameters improved in respect of the so-called standard diesel oil. Due to its modified formula, the temperature of blocking the CFPP cold filter is -32°C, while the standard diesel oil maintains its parameters to -20°C. What is more, the fuel cetane number was increased to 55 units, which has a beneficial effect on ignition in compression ignition engines by shortening the delay period of auto-ignition. Under the current standard for diesel fuel PN-EN 590:2013, the cetane number should not be less than 51 units. This is usually 51-52 units. Increasing the cetane number results in easier ignition and combustion. The milesPLUS® diesel fuel does not include bio-components.

A growing demand for biofuels produced mainly from rape-seed oil makes producers search for new alternative plants, a dicotyledons belonging to brassicas (plants of the cabbage family) being one of them [5,9,10,11]. For the production of FAME are increasingly willing to use the animal fat Biofuel of the AME Biodiesel type (Animal Fat Methyl Esters) was produced in a GW-200 reactor constructed by one of the authors (G.W).

PRODUCTION OF AME BIOFUELS IN THE PROCESS OF TRANSESTERIFICATION FROM PURE FAT AND USED FAT

Calculating the optimum (stoichiometric) amount of reactants needed to carry out the transesterification process usually involves the usage of simplified models [8]. However, in order to determine the appropriate amount of reactants needed to produce FAME, the authors of this paper used a model developed by one of the co-authors, which makes it possible to optimally determine the quantities of methyl alcohol and the catalyst necessary for the process of transesterification – Fig. 1 [6,8]. The following ratio was used for the purpose of transesterification of canola oils: for each 1 dm^3 of oil, a mixture obtained from dissolution of 7.0g of

KOH in 0.15 dm^3 of CH_3OH was used. Transesterification was performed in a single step, with the temperature of the start of the process being 63^{o}C P.a. purity CH_3OH methyl alcohol of a molecular weight of 32.04 g/mol was used for the transesterification process, along with p.a. purity KOH potassium hydroxide with a molecular weight of 56.11 g/mol as the catalyst.

The process of transesterification was carried out in two stages and the obtained degree of oil transition into methyl esters was equal to 98.4% (w/w). The result has proved that the obtained CME biofuel complies with EN 14214 standards of biofuel for a high pressure engine, as regards the ester content in FAME (Fatty Acid Methyl Esters).

DETERMINATION OF THE IMPACT OF THE TYPE OF ANIMAL FAT USED FOR BIOFUEL PRODUCTION ON THE FRACTIONAL COMPOSITION OF AME BIODIESEL

Biofuel of the CME Biodiesel type (Corn Methyl Esters) was produced in a GW-200 reactor constructed by one of the authors (G.W) – Fig. 2. A very important parameter used for the assessment of fuel/biofuel operating properties is their fractional composition. Mentioned parameter is determined on the basis of the temperatures of distillation. The temperature of fuel ignition in an engine largely depends on the temperature of the start of distillation and the amount of fuel vaporized in the initial stage of distillation. The higher content of lightweight fractions is, the better self-igniting properties are, which translates directly into gentler way of starting the engine [7,12,13].

Vegetable oils or animal fats have worse distillation properties, and thus worse engine-starting properties, compared to FAME [1,6].

In order to achieve proper starting and combustion properties, it is very important to establish five points. These are: the temperature at the start of distillation, the temperature for distillation of 10% (v/v) fuel, the temperature for evaporation of 65% (v/v) fuel, the temperature for distillation of 95% (v/v) fuel and the temperature at the end of the distillation process.

The research determining the fractional compositions of CME biofuels obtained from pure and used animal fat was carried out in the biofuels laboratory of Centre for Renewable Energy Sources "BioEnergia".

Renewable Energy Sources at a workstation equipped with a AME for determining the composition of the fuels and biofuels with the method of normal distillation – Fig 3.

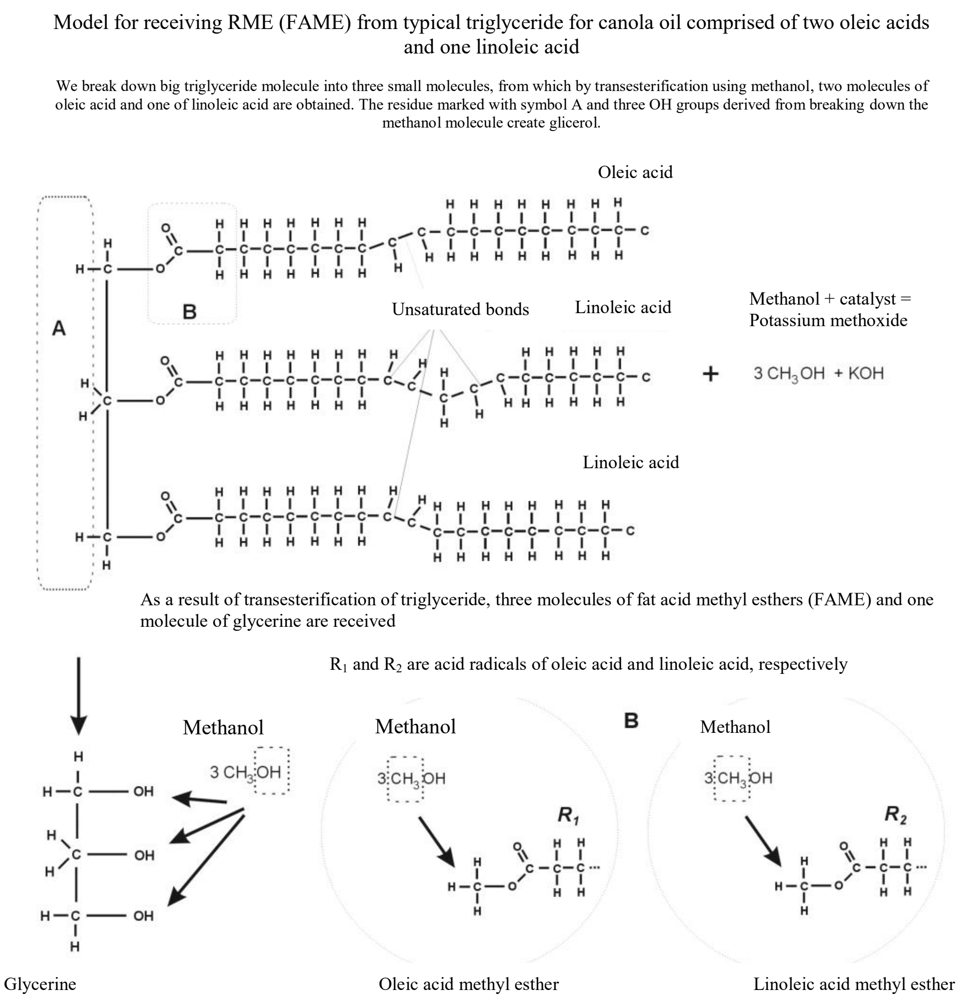

Fig. 1. Diagram of rapeseed oil transesterification [8]

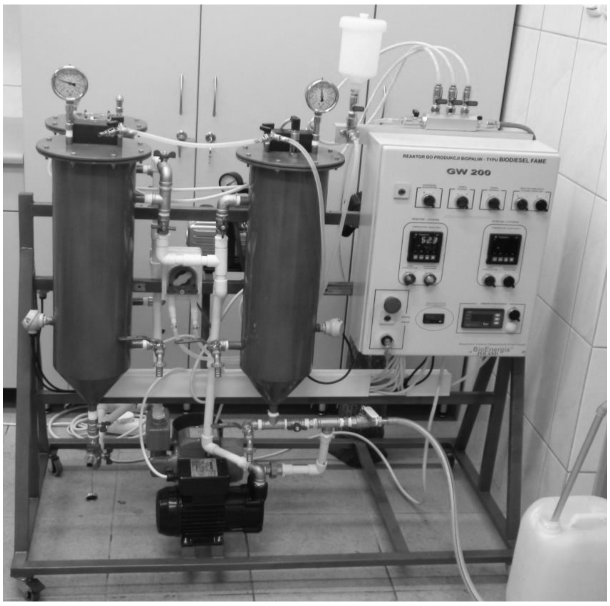

Fig. 2. Reactor GW 200 for production of Biodiesel FAME (CME)

Fig. 3. Photo bench equipped with a distiller HAD 620/1 by Herzog

RESULTS

Table 1 summarizes the results of the research determining these distillation properties of biofuels B7, B20 and B40 CME Biodiesel. For comparison purposes, the table shows the results of the research on the distillation temperatures of fuel diesel milesPLUS obtained from company STATOIL. Table 2 summarizes the values of the most important points of the distillation curve the temperatures at the start and end of the distillation process and the percentage (v/v) of distilled fuels at or below 250°C and 350°C.

Table. 1. Comparison of distillation temperatures for three biofuel B7, B20, B40 CME Biodiesel and diesel fuel milesPlus

% [v/v] of distillation	Fuel diesel milesPLUS	B7 CME	B20 CME	B40 CME
0	162	163	165	170
5	176	177	180	184
10	188	191	195	200
15	198	202	207	212
20	212	215	220	226
25	219	222	228	234
30	224	227	233	239
35	232	235	241	246
40	240	243	250	255
45	249	253	259	264
50	258	262	269	273
55	268	272	279	285
60	278	283	290	296
65	285	291	298	304
70	295	304	312	319
75	303	313	320	327
80	312	322	330	338
85	324	335	343	351
90	331	343	351	358
95	341	357	361	364
100	352	362	364	368

Table. 2. Characteristic distillation curve points for fuel diesel and CME biofuels

Up to this temperature, % (v/v) was distilled				
fuel	Start of distillation [°C]	End of distillation [°C]	up to 250°C distils v/v [%]	up to 350°C distils v/v [%]
Fuel diesel milesPLUS	162	352	46	98
B7 CME	163	362	44	92
B20 CME	165	364	40	84
B40 CME	170	368	37	81

CONCLUSIONS

The diesel fuel at the Statoil stations called milesPLUS® was characterized by the distillation range from 162 to 352°C. At the same time, the distillation range is lower than in the case of other analysed diesel fuels at ORLEN and LOTOS stations. This is largely due to the period of refuelling. Winter diesel fuel has a particularly starting point of distillation. This allows for better ignition at low temperatures.

The 7% additive of CME generally did not increase the temperature of distillation. At the beginning of distillation, the temperature range for the fuel increased by only 1 to 3°C. A slightly larger temperature rise was recorded at the end of distillation.

A further increase of the CME bio-component to 20% in a mixture with the milesPLUS diesel fuel resulted in an increase in distillation temperatures. Wherein, with regard to the initial volume of fuel distilling, the difference was insignificant, as compared to pure diesel fuel.

Increasing the content of the CME bio-component to 40% in a mixture with the milesPLUS® diesel fuel resulted in a further increase in distillation temperature. At the same time, as was the case with B7 and B20 biofuels, with respect to the initial volume of fuel distilling, the difference was less for the pure diesel fuel than at the end of the distillation temperature range. The reason for this may be the case that, even though we have a mixture of fuels, the same lighter fractions of diesel fuel evaporate earlier than the heavier ones from the methyl esters of corn oil. It is very suitable for car ignition, since for the ignition of fuel to be performed successfully, at least 10% of the fuel must evaporate.

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WYZNACZENIE PARAMETRÓW DESTYLACYJNYCH OLEJU NAPĘDOWEGO MILESPLUS® *DIESEL* ZAWIERAJĄCEGO BIOKOMPONENT W POSTACI ESTRÓW METYLOWYCH OLEJU KUKURYDZIANEGO

Streszczenie. Celem badań było określenie wpływu dodaniu biokomponentu w postaci estrów metylowych oleju kukurydzianego do oleju napędowego typu milesPLUS® na skład frakcyjny. Biopaliwo kukurydziane wytworzono we własnym zakresie przy użycia własnej konstrukcji reaktora typu GW-200. Olej napędowy parował w zakresie temperatur od 162 do 352°C. Dodatek w postaci 7, 20 i 40% biokomponentu w zasadzie nie wpłynął na pogorszenie temperatur początku destylacji. W *większym stopniu wpływa to* na temperatury końca destylacji, powodując przekroczenie temperatury 360°C.

Słowa kluczowe: Biodiesel, CME – estry metylowe oleju kukurydzianego, skład frakcyjny, temperatury destylacji, olej napędowy.