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POSSIBILITIES OF CO-INCINERATION OF GLYCERIN PHASE WITH FUEL OIL IN BURNER INJECTOR

MOŻLIWOŚCI WSPÓŁSPALANIA FAZY GLICERYNOWEJ Z OLEJEM OPAŁOWYM W PALNIKU INŻEKTOROWYM

Abstract: Existing regulations (the need to achieve National Indicative Targets in the next years) force increased consumption and production of biofuels and biocomponents. In Poland, the production of esters is particularly important. Last year in Poland, the production of esters reached 650 000 Mg. It can be estimated that the production of esters triggered, at the same time, the production of more than 100 000 Mg of glycerol phase. Existing methods of using glycerol fraction usually require to carry out a multi-stage and relatively complex process of its purification. The paper presents the results of the process of co-incineration of glycerin phase with fuel oil. The burner injector was used in the research which allowed to preheat the combusted fuel mixture. As part of the study, the compounds which were burnt included the mass fraction of glycerol phase not exceeding 40%. The study was carried out in a research laboratory allowing for temperature measurements along the flame length. The paper presents the results obtained during the co-incineration of the compounds in comparison with the analogous data obtained during the incineration of fuel oil.

Keywords: glycerin phase, atmospheric burner, co-incineration of glycerin phase with fuel oil

Introduction

The growing global need for energy and the increasing environmental awareness of the societies in developed countries fosters the use of renewable energy. Due to the climatic and geological conditions in Poland, solar and geothermal energy will not constitute a significant percentage of overall energy output. There possibilities of harnessing hydrological sources are also scarce. Wind energy can be feasibly generated only in some areas of Poland, and this type of energy is recently met with increasing resistance. For these reasons, biomass is an important source of renewable energy in Poland that can be tapped in the short term. One of the easiest ways to take advantage of biomass in Poland is its firing or cofiring. The applicable EU regulations stipulate that liquid fuels shall contain an addition of biocomponents. For example: the Polish National Index Target for this year stipulates that among the total amount of fuels introduced to the market there shall be at least 7.1% biocomponents and biofuels (in terms of calorific value). In recent years, the implementation of the applicable regulations resulted in a substantial increase in the production of bioethanol and esters in Poland. In Poland, 5 percent of bioethanol is added to gasoline, and 7 percent esters is added to diesel fuel. There are also fuels on the market with a higher content of biocomponents, e.g.: B20, B80, B100 fuels with ester content of 20, 80 and 100% respectively, and E85 fuel with 85 percent of bioethanol.

Approximately 170 000 Mg of bioethanol and nearly 700 000 Mg of esters were manufactured in 2013 in Poland [1]. Glycerine phase is a by-product in the production of

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the latter. Glycerine phase generation amounts to a dozen to twenty percent of the mass of the manufactured esters. As the amount of manufactured esters grows, the issue of handling the increasing amounts of glycerine phase becomes more and more urgent. It is estimated that in 2014 the manufacture of esters resulted in the generation of approximately 80-130 Gg (80 000-130 000 Mg) of glycerine phase. It is worth noting that much greater production volumes of methyl esters were forecasted several years ago. It was anticipated that the production capacity of esters in Poland would reach the level of 1.5 million Mg, which would result in the generation of 200 000-300 000 Mg of glycerine phase. These plans were not realised in full due to, among others, the discussion on the role of 1st generation biofuels and fuels in a sustainable economy [2-5]. The uncertainties brought forward by this discussion discouraged new investments in the manufacture of biocomponents from agricultural raw materials. The possible outcome of this ongoing discussion involves the growing role of waste materials in the manufacture of biocomponents and biofuels. The reason for this is that fuels made from waste materials are classified as 2nd generation fuels.

The glycerine phase which is a by-product of the manufacture of methyl esters (or, less often: ethyl esters) of fatty acids is a mixture of various substances: glycerine (up to 70%), methanol (ethanol), free fatty acids, water, soaps and a number of other compounds and solid contaminants. The composition of glycerine phase depends on the raw materials used in the manufacture of esters, and the applied technology of production. A variety of raw materials can be used to manufacture esters, e.g.: vegetable oils and animal fats, as well as waste fats of vegetable and animal origin (e.g. used frying oils).

There are several possibilities of managing the glycerine phase [6, 7]. Their significant part is based on obtaining pure glycerine first [8, 9]. Pure glycerine is used in cosmetics, pharmaceutical, food and chemical industries. After separating methanol, the glycerine phase can be used as a fertilizer component or as a feed additive. The glycerine phase can be also a raw material for process gas production (e.g. in gassing and hydrogenation processes). One of the simpler methods of the glycerine phase management is its co-combustion performed in professional power industry facilities [10, 11].

Thus, there are many applications for the glycerine phase or for the glycerine obtained on its basis. In the case of large manufacturers of biocomponents, utilisation of the glycerine phase is easier. The glycerine phase obtained by individual producers of esters in subsequent production cycles is most frequently characterised by stable properties, and thus, its processing can be carried out in accordance with the same selected technology.

In the case of small producers, the situation is different. They produce esters in various technologies. This production is accompanied by relatively small amounts of the glycerine phase produced. Therefore, it is necessary to find a technology that will make it possible to utilise the glycerine phase produced at small producers in an economically effective and environmentally safe manner. Co-combustion of the glycerine phase with fuel oil could be one of such technologies.

Oil-fuelled boilers are commonly used devices. Conducting the process of co-combustion there would allow for using the chemical energy of the glycerine phase.

Further in the paper, selected results of tests intended to determine technical possibilities of the implementation of such a co-combustion process are presented.

Testing methodology

Testing was conducted on a test stand composed of a cylindrical combustion chamber and a universal burner. The combustion chamber was characterised by internal height of 1.7 m and internal diameter of 0.9 m. The combustion chamber was isolated. A number of instrument nozzles are installed in the combustion chamber structure, which enable performing temperature measurements and taking samples for analysis. Figure 1 presents the test stand used.



Fig. 1. Test stand

The universal burner used in testing was a low-power injector burner by Kroll, type KG 20 (Fig. 2). The burner was equipped with a burner tank with adjustable temperature.

In the injector burner, the fuel is sucked in by the compressed air jet (which is also the primary air) from the burner tank. Then, the fuel is sprayed through a special nozzle. MGA 5 VarioPlus analyser with IR sensors was used to measure the concentration of flue gas components.

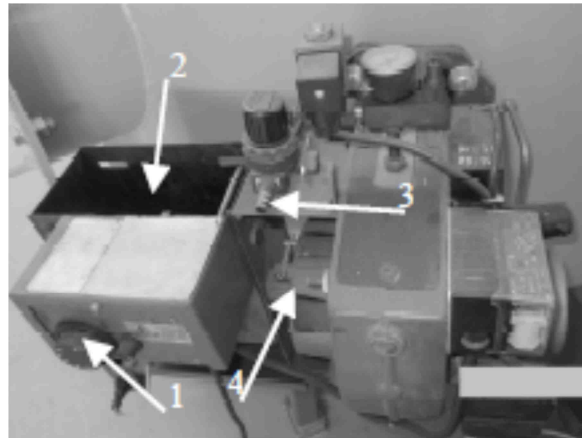


Fig. 2. Burner injector Kroll KG 20. Basic elements of the burner: 1 - adjustable thermostat knob, 2 - burner tank, 3 - primary air supply system, 4 - fan engine

As part of the presented testing, a mixture of light fuel oil and glycerine phase was combusted. Mass fraction of the glycerine phase in the combusted mixture amounted to 20%. Table 1 presents the glycerine phase composition and in Figure 2 it is presented in photographs.

Selected fuel parameters of glycerine phase

Table 1

Item	Unit	Glycerine phase
C	[%]	43.23
H		6.88
N		0.03
S		1.64
Cl		-
O		47.70
Ash		0.14
Water		0.38
Calorific value		[MJ/kg]

The quantities of primary and secondary air supplied to the process were changeable factors in the conducted testing. The primary air jet was adjusted by changing the air pressure. The adjustment was done with the use of a special control knob placed on the burner head. In the presented testing, the primary air pressure amounted to: 0.08, 0.1, 0.12 and 0.14 MPa. The secondary air jet was adjusted by adjusting the size of the slot supplying the air to the secondary air fan. The secondary air jet was adjusted by setting 4 sizes of the slot. These sizes are hereinafter conventionally referred to as: 1, 2, 3 and 4. Where one is the minimum adjustable value of the slot and 4 is its maximum value.

Test results obtained during the mixture combustion were compared to the test results obtained during the combustion of fuel oil.

Test results

Figures 3 and 4 present exemplary results of tests on the impact of the quantity of preliminary and secondary air supplied on the volume of CO concentrations obtained. CO concentration values were converted into comparable values at 3% O₂ content in flue gas. Figure 3 presents results obtained during the combustion of fuel oil and Figure 4 - during the combustion of the 20% mixture.

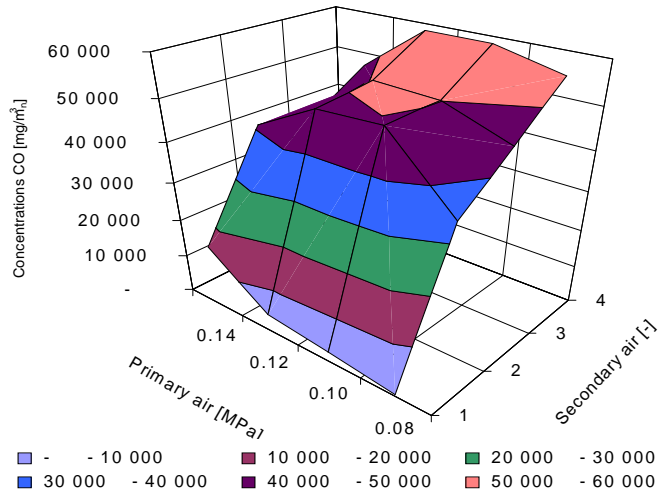


Fig. 3. Impact of primary and secondary air settings on CO concentrations during fuel oil combustion (CO concentrations are converted into 3% O₂ content; m³_n - normal cubic meters)

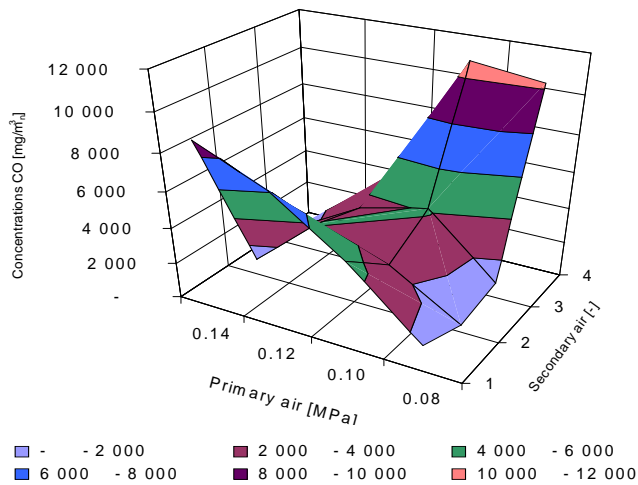


Fig. 4. Impact of primary and secondary air settings on CO concentrations during the combustion of a mixture with 20% of glycerine content (CO concentrations are converted into 3% O₂ content)

As Figure 3 demonstrates, the lowest CO concentration values during oil combustion are obtained when the smallest amounts of primary and secondary air are supplied (i.e. for the setting of 0.08 MPa of primary air and “1” of secondary air).

According to the data presented in Figure 4, the lowest CO concentration values are obtained in the case of two groups of burner settings:

- primary air setting of 0.08 MPa and secondary air of “2” or “3”;
- primary air setting of 0.08 MPa and secondary air of “4”.

Conclusions

Conducted testing proved the possibility of performing the co-combustion process of the glycerine phase with fuel oil in the injector burner. Conducted testing also demonstrated that under ambient temperature of 20°C, the glycerine phase can be smoothly mixed with fuel oil. Pre-heating of the mixture prior to its feeding to the burner is also unnecessary.

During conducted testing, no impact of the glycerine phase content in the combusted fuel on the volume of observed NO_x concentrations was reported. For SO₂ concentrations, a concentration increase was observed resulting from the increased sulphur content in the glycerine phase.

For CO, the adjustment ranges of the primary and secondary air jet volumes were determined, which allow for obtaining the lowest concentration values of this gas during the combustion process.

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MOŻLIWOŚCI WSPÓŁSPALANIA FAZY GLICERYNOWEJ Z OLEJEM OPAŁOWYM W PALNIKU INŻEKTOROWYM

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Abstrakt: Obowiązujące regulacje prawne (konieczność osiągnięcia w kolejnych latach Narodowych Celów Wskaźnikowych) wymuszają zwiększone zużycie oraz produkcję biopaliw i biokomponentów. W Polsce szczególnie istotna jest produkcja estrów, których w ubiegłym roku wytworzono ponad 700 000 Mg. Można szacować, że przy produkcji estrów powstało równocześnie ponad 100 000 Mg fazy glicerynowej. Istniejące metody wykorzystania frakcji glicerynowej wymagają najczęściej przeprowadzenia wieloetapowego, stosunkowo skomplikowanego procesu jej oczyszczania. W pracy przedstawiono wyniki badań procesu współspalania fazy glicerynowej w mieszance z olejem opałowym. W badaniach wykorzystano palnik inżektorowy pozwalający na wstępne podgrzanie spalanej mieszanki paliwowej. W ramach prezentowanych badań spalano mieszanki o udziale masowym frakcji glicerynowej nieprzekraczającym 40%. W badaniach wykorzystano stanowisko badawcze umożliwiające pomiary temperatur wzdłuż długości płomienia. W pracy przedstawiono uzyskane w trakcie spalania mieszanek wyniki na tle analogicznych, otrzymanych w trakcie spalania oleju opałowego.

Słowa kluczowe: faza glicerynowa, palnik inżektorowy, współspalanie fazy glicerynowej z olejem opałowym