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THE TESTS OF DEVELOPMENT OF POLIETHYLEN AND RESIDUE BY VACUM DESTILATION OF USED OILS

PRÓBY ZAGOSPODAROWANIA ODPADÓW Z POLIETYLENU I POZOSTAŁOŚCI PO DESTYLACJI PRÓŻNIOWEJ OLEJÓW ZUŻYTYCH

Abstract

The results of research on effect of addition of polymer-polyethylene, and addition of waste oils vacuum residue to coal charge was studied in laboratory experiments. Charges containing coal only and coal blended with 1 and 4% of polymer and coal blended with 1 and 4% of waste oils vacuum residue were carbonized in a laboratory plant. In all cases the carbonization process proceeded without difficulties yielding seared coke. The investigation results exhibited that: the addition of 1 and 4% polyethylene and the addition of 1 and 4% waste oils vacuum residue to the coal charge did not deteriorate the physical and chemical properties of the obtained coke as well as its reactivity and structural strength, determined according to the Syskov's method.

Keywords: waste utilization, coking

Streszczenie

Przedstawiono wyniki badań wpływu dodatku polimerowego do wsadu węglowego oraz wpływu dodatku pozostałości po destylacji próżniowej olejów zużytych do wsadu węglowego na właściwości otrzymanego koksu. Ich celem było wykazanie, że dodatek w postaci polimeru-polietylenu i dodatek w postaci pozostałości po destylacji olejów zużytych, może być wprowadzony do wsadu węglowego w takiej ilości, która nie spowoduje żadnych negatywnych skutków w procesie otrzymywania koksu. Procesowi koksowania poddano sam węgiel oraz węgiel z dodatkiem polimeru-polietylenu i węgiel z dodatkiem pozostałości po destylacji próżniowej olejów zużytych w ilości 1 i 4% masy węgla. Wsady węglowe były koksowane w doświadczalnym piecu laboratoryjnym. Na podstawie wykonanych badań laboratoryjnych stwierdzono, że wprowadzenie do wsadu węglowego dodatku polimerowego-polietylenu oraz dodatku pozostałości po destylacji próżniowej olejów zużytych nie powodowało pogorszenia jakości koksu pod względem jego właściwości fizykochemicznych, wytrzymałości strukturalnej, oznaczanej według metody Syskova oraz reakcyjności koksu. Wykonane badania laboratoryjne potwierdziły możliwość wykorzystania odpadów z tworzyw sztucznych i pozostałości po destylacji próżniowej olejów zużytych.

Słowa kluczowe: utylizacja odpadów, koksowanie

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1. Introduction

At present, more and more frequently pyrolysis process is used to utilize wastes. Classic example of a pyrolitic process is coking process of a hard coal. Introduction of the waste into the coking mixture-charge to the coking process, is considered a universal method of waste utilization. Production capacity of coke oven batteries enables to dispose of scraps on a big scale, even with small quantities of waste as an additive to the coking charge, and the plants of gas depuration and separation of other coking products, always used in coking plants, facilitate the utilization of waste.

Using hard coal coking process to utilize waste, and use of the waste as an additive to the classic coking coal charge depends on some fundamental requirements. Such an additive should have properties close to the properties of the coal used in the process of coking, and should not disturb the process of classic mixture coking, and the properties of coking products should be in accordance with standard requirements.

In Poland, to limit the quantity of plastic waste a bill regarding plastic waste was passed, on 27th April 2001 (Official Gazette No. 62, head 628, 2001), specifying the rules of dealing with plastic waste in a way ensuring good protection of human life and health, according to the principle of preventing the waste formation, or limiting the waste formation, or limiting the quantity of waste and its detrimental influence on the environment, and also its recovery or utilization. There are several methods of plastic waste disposal: thermal combustion, gasification, hydrocracking and pyrolysis [1]. These methods require high investment costs connected with separation and condensation of process volatile products. The only economically well founded method of polymer waste disposal is to use it in existing processes, e.g. as an additive to coal mixture in coke plant, as coke production is a classical example of pyrolysis, and the utilization of polymer waste could confer to a coke plant the status of the factory acting for the benefit of the natural environment. Polymer pyrolysis does not differ in character from coal coking; as a result of heating chemical bonds crack and resulting radicals recombine between them forming gas and liquid products, and coke. Polymers are rich in hydrogen and as a result of pyrolysis process they give more gaseous products than coke.

Technical literature information shows that some waste added to the coal mixture favourably influence the coke quality and productivity of coke oven batteries [2–8]. Addition of the coke pitch and heavy residua from crude oil distillation, favourably influenced coke forming properties of the coal. These additives due to the relatively low melting point penetrate between coal grains causing, among other features, widening of its plasticity range. It was found that addition of 2% of coke pitch to the coal mixture, could substitute, taking into consideration coke forming properties, 4% of coking coal. As a result of a coking process of the charge mixture consisting of coking coals having average coke forming properties and 5–10% of coke pitch, coke useful for metallurgical purposes was obtained.

Introduction of an additive to a standard coking blend depends on a few requirements. Generally, such an additive should have coke forming properties, not disturbing the process of coke forming of standard coking blend. Coking products from the process with an additive should have a similar quality as products from standard process, and the additive must not disturb the course of the process in existing coking plant apparatus.

The aim of the research work described in the paper were attempts to use polymer waste and the possibilities of utilization of vacuum residuum, as a bitumen addition to the coal charge in the coking process; it means high temperature pyrolysis without access of the air.

2. Results and discussion

Tests sof coking process with the coking blend containing polymer and waste oils vacuum residue.

Standard coking blend and coking blend containing 1% and 4% by mass of polyethylene and coking blend containing 1% and 4% by mass of waste oils vacuum residue were subject to the coking process. Properties of coal charges used for coking in laboratory conditions were as follows: moisture W^r_t = 8 mass %, ash A^d = 6.1 mass %, volatile matter V^{daf} = 34.2 mass %, S^d_t = 0.55 mass %, crucible swelling number SI = 5 and fraction coal < 3 mm = 90%.

Properties of polyethylene additive used in tests (measured as for coal) were as follows: moisture 0.0 mass %, ash 0.4 mass %, volatile matter 99 mass %.

Properties of vacuum residue under investigation were as follows: moisture 0.0 mass %, ash 5.9 mass %, volatile matter (determined according to test methods mandatory for coal testing) 88 mass %, viscosity at 100°C above 80 mm^2/s, S content 1.0 mass % and solid materials 4.0 mass %.

All coke properties with the exception of structural strength, were determined according to the Polish Standards for Testing Materials.

Structural strength of coke was determined according to the Syskov's method modified by Salcewicz and Dżao-Szu-Czang [9, 10].

The testing device consisted of a steel base plate with a vertical tube on it. The inner diameter of the tube was 76 mm at the bottom tapering slightly to 74 mm at the top. The tested sample was put on the bottom of the device and then shattered by dropping on it three times an 1 kg weight from the height of 1 m. The size reduction was the measure of the coke strength. Results were reported in Nm/m^2 *i.e.* as work consumed for an unitary surface increase. In the original Syskov's method a 25 g coke sample sized between 1–25 mm is recommended. In the modified method a sample of narrowed size distribution 6–10 mm was used. Such a modification caused an evident improvement of the reproducibility of the measurements.
The coke reactivity was tested according to the Polish Standard, PN-90/C-04311. In this Standard the coke reactivity is defined as "coke ability to reduce carbon dioxide according to the reaction $CO_2 + C \rightarrow 2CO$" and the reactivity index Rco_2 recorded in cm^3/g . s is "the velocity constant of the reaction of a gas carbon dioxide with a carbon of the coke at testing conditions specified by the above Standard". These testing conditions were: sample weight 7 g, size distribution 1.0–3.15 mm, temperature 1000°C, pressure 760 mmHg and CO_2 flow rate 3 cm^3/s.

Coal charges, with and without polymer and waste oils vacuum residue, were subjected to coking process in the experimental oven.

250 g of coal charge with moisture content W^r_t = 8%. Compacting grade for all samples tested was the same and amounted to 0.95 kg/dm^3 (for a dry charge). In the lower part of the oven the temperature of 1200^{0}C was reached after about 5 hours, and the temperature of 950°C in the upper part of the oven after about 10 hours, and it was the end of the coking process.

Table 1

Properties of coke

Coke	Moisture W^a mass %	Ash A^d mass %	Volatile matter V^{daf} mass %	Structural strength Syskov's method Nm/m^2	Reactivity Rco2 cm^3/g.s
100% coking blend	0.3	9.8	1.5	1070	1.08
1% of polyethylene in coking blend	0.3	9.5	1.5	1068	1.09
4% of polyethylene in coking blend	0.2	9.6	1.6	1036	1.15
1% of waste oils vacuum residue in coking blend	0.4	10.5	1.8	1071	1.07
4% of waste oils vacuum residue in coking blend	0.4	11.1	1.9	1085	1.04

3. Conclusions

All the coking blend used in tests, containing 0, 1 mass % and 4 mass % of polyethylene additive, and containing 0, 1 mass % and 4 mass % of waste oils vacuum residue additive, gave baked coke, and coking process run without disturbance. So, the conclusion is that addition of 1 mass % and 4 mass % of polyethylene and that addition of 1 mass % and 4 mass % of waste oils vacuum residue did not cause negative changes in coke quality and its physico-chemical properties, such as structural strength and coke reactivity. The tests carried out showed that addition of 1 mass % and 4 mass % of polyethylene, and that addition of 1 mass % and 4 mass % of waste oils vacuum residue into coking blend does not influence negatively those properties which are the most important for its use in high furnace process, for example strength and low reactivity.

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