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RESEARCH OF THE INFLUENCE OF PHYSICAL AND CHEMICAL PROPERTIES OF COAL ON THE GASIFICATION PROCESS USING THE EXAMPLE OF ANGREN BROWN COAL

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Abstract: *The influence of the properties of Angren brown on the process of layered gasification was studied. The dependence of the calorific value of the resulting gas on the quality characteristics of coal when using air as a gasifying agent has been established. Methods are shown for increasing the calorific value of gas obtained during the gasification process when using coal with different moisture content and different fractional composition. The features of technological processes in the reaction zones of a laboratory gas generator have been studied. Based on generally accepted methods, the volume fractions of flammable components, as well as the non-flammable part of the generator gas, were determined. The slag formation temperature for Angren brown coal was experimentally determined. The qualitative characteristics of the resulting generator gas were compared with the gas from the underground gasification of coal of Yerostigaz JSC.*

Keywords: *Gasification, brown coal, air blast, coal moisture content, coal ash content, particle size distribution.*

Annotatsiya: *Angren qo‘ng‘ir ko‘mirining xususiyatlari qatlamli gazifikatsiyalash jarayoniga ta’siri aniqlandi. Havoni gazlashtiruvchi vosita sifatida ishlatishda hosil bo‘lgan gazning kaloriya qiymatining ko‘mirning sifat xususiyatlariga bog‘liqligi ko‘rsatildi. Namligi va fraksional tarkibi turli xil bo‘lgan ko‘mirdan foydalanganda, ko‘mirni gazifikatsiyalash jarayonida olingan gazning energetik qiymatini oshirish usullari ko‘rsatilgan. Laboratoriya gazogeneratoridagi reaksion maydonlarida kechadigan texnologik jarayonlarning xossalari o‘rganildi. Umumiy qabul qilingan usullar asosida generator gazining yonuvchi hamda yonmaydigan tarkibiy qismlarining hajmiy ulushlari aniqlandi. Angren qo‘ng‘ir ko‘mirining suyuq holatga o‘tish harorati tajribalar orqali aniqlandi. Olingan generator gazi va Yerostigaz AJ dan olinadigan gazning sifat ko‘rsatkichlari taqqoslandi.*

Kalit so‘zlar: *Gazifikatsiya, qo‘ng‘ir ko‘mir, havo ta’minoti, granulometrik tarkib, ko‘mirning namligi, ko‘mir kulligi.*

Аннотация: *Изучено влияние свойств Ангренского бурого на процесс слоевой газификации. Установлена зависимость калорийности получаемого газа от качественных характеристик угля при использовании воздуха в качестве газифицирующего агента. Показаны способы повышения калорийности газа, получаемого в процессе газификации при использовании угля с различной влажностью и различным фракционным составом. Изучены особенности технологических процессов в реакционных зонах лабораторного газогенератора. На основании общепринятых методик определены объемные доли горючих компонентов, а также негорючая часть генераторного газа. Экспериментально определена температура шлакообразования для Ангренского бурого угля. Сопоставлены качественные характеристики полученного генераторного газа с газом подземной газификации угля АО «Yerostigaz».*

Ключевые слова: *Газификация, бурый уголь, воздушное дутье, влажность угля, зольность угля, гранулометрический состав.*

Introduction

Angren brown coal is the main fuel used in boiler units of the New-Angren and Angren thermal power plants [1]. High ash content and high moisture content of coal are the main factors reducing the efficiency of fuel combustion in these power plants [2]. Solving the problems of increasing the efficiency of coal combustion and reducing harmful atmospheric emissions through the use of coal enrichment technologies are very capital-intensive [3-4]. Another promising area for the efficient use of coal is the use of coal gasification technology [5-7]. Gas generating plants are simple in design and

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reliable in operation, which is a distinctive quality compared to direct coal combustion plants [8-9].

Coal gasification is one of the promising methods of using solid fuel in the energy sector. During gasification, almost the entire organic mass of the fuel is converted into gas, which can be burned in the combustion chambers of combined cycle gas turbine units or in boiler furnaces [10-11].

Increased attention to research into the laws of the gasification process is associated with an increase in the growth of demand for solid fuel. Various processes of coal gasification were studied in detail in [12-13]. Despite a lot of work done, there is practically no data on the process of layered gasification of Angren brown coal. In addition, the lack of practical data on the influence of the quality of Angren coal on the process of layered coal gasification requires the determination of experimental data for the development of gasification technologies.

Coal gasification makes it possible to obtain generator gas, the combustion of which significantly reduces the formation of harmful gases and makes it possible to generate thermal and electrical energy in local facilities, which is a very pressing issue [14-16].

Conducting an experiment

The study used brown coal grade B2 from the Angren deposit (table 1) [17]. The experiment was carried out on a laboratory bench [18]. To assess the influence of humidity, coal particle size distribution and air flow on the characteristics of the direct layered gasification process, fractions of 3–10, 10–20 and 20–30 mm were used. Particle sizes are selected to reduce their thermal resistance in order to ensure maximum coal reaction speed. A range of changes in air flow has been selected that provides areas of stable gasification of the fuel under study: 4.5-5.0 m^3/hour.

Table 1

Characteristics of the working mass of Angren brown coal grade B2

Humidity W^w, %	Ash content A^w,%	Carbon C^w, %	Sulfur $S_p^w + S_o^w$, %	Hydrogen H^w, %	Oxygen O^w, %	Nitrogen N^w,%	Lower calorific value Q_L^w, kcal/kg
34.5	14.4	39.1	1.3	1.9	8.6	0.2	3 210

Depending on humidity, fractional composition of coal and air flow, the following gasification process data were obtained:

– chemical composition and calorific value of generator gas;

– distribution of the concentration of flammable gas components along the height of the gas generator;

– rate of coal mass loss;

– coal slag formation temperature.

In fig. 1. The concentrations of generator gas obtained experimentally are shown, while the particle size distribution of the coal was 10-20 mm. The chemical composition of flammable components, as well as the calorific value of the generator gas, was determined on a gas chromatograph «Chromatec-Krystall 9000» according to the methods given in [19-20].

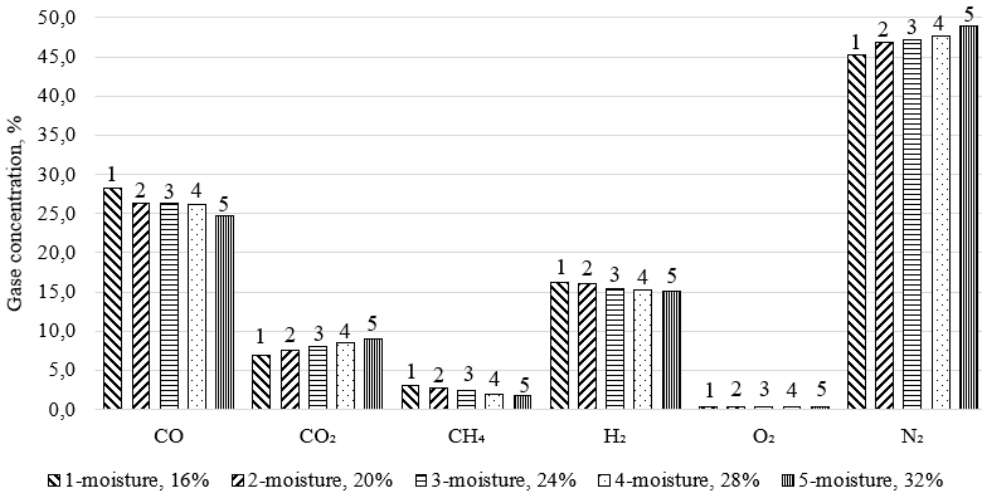

Fig.1. Concentrations of generator gas at an air flow of 4.6 m^3/hour

A series of experiments were carried out for samples with working coal moisture contents of 16%, 20%, 24%, 28% and 32%. It has been determined that when using coal with different granulometric sizes at the same consumption of gasifying agent, the resulting caloric content of the generator gas will be greater for samples with smaller sizes [21-22]. With a working humidity of coal of 16%, a fractional composition of 10-20 mm and an air flow rate of 4.4-4.8 m^3/hour, the best indicators were observed in terms of calorie content and yield of the resulting gas (fig. 2).

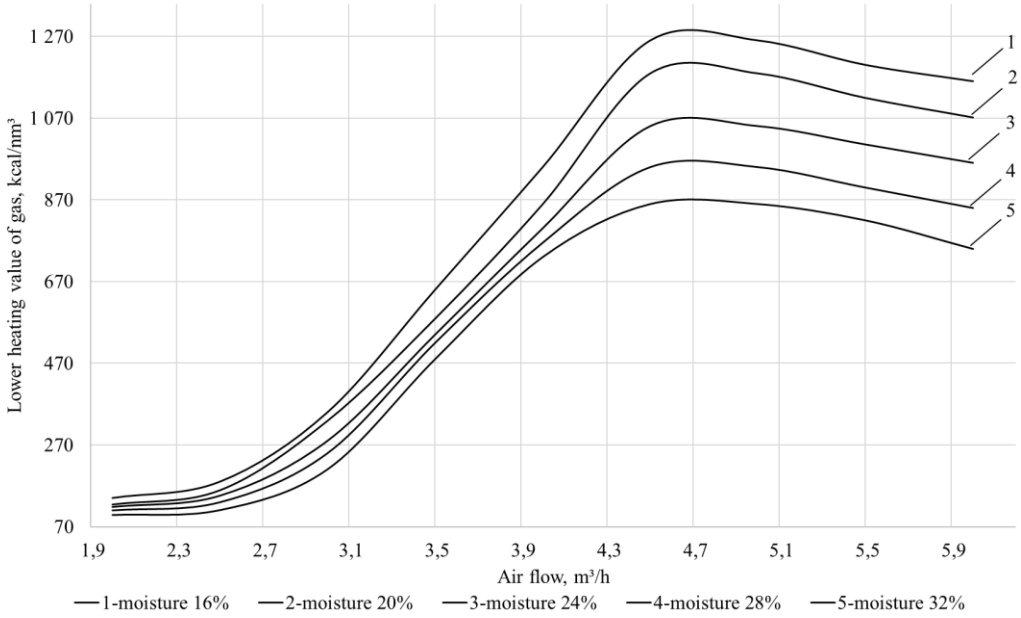

Fig.2. Dependence of the caloric content of gas on the moisture content of coal with an average particle diameter of 10-20 mm

The size of fuel particles is one of the main factors affecting the calorific value of the generator gas (fig. 3). In [23-26] the dependence of the yield of generator gas per unit mass of fuel on the size of fuel particles is described, which is confirmed by experimental results.

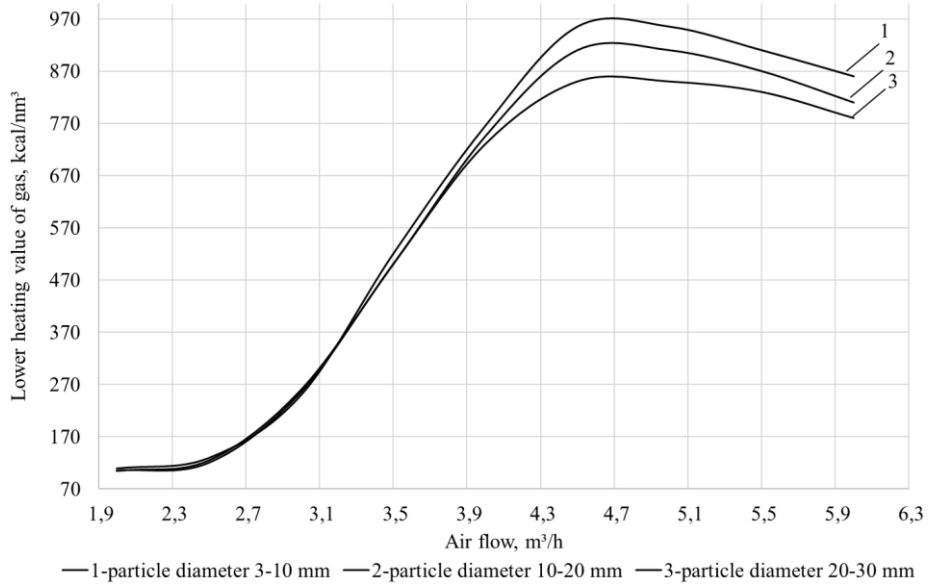

Fig.3. Dependence of gas caloric content on fuel size at an average operating humidity of 28%

A fractional composition of 3-10 mm at the same air flow rate is characterized by a rapid loss of coal mass (fig. 4). This is explained by the removal of moisture and volatilization of combustible components from a smaller surface area of the coal particle [27-28]. The combustion of coke residue from coal at such air flow rates led to slag formation (fig. 5), hence a disruption of the gasification process. Slag formation of the studied samples was observed in the temperature range 900 – 1000 °C.

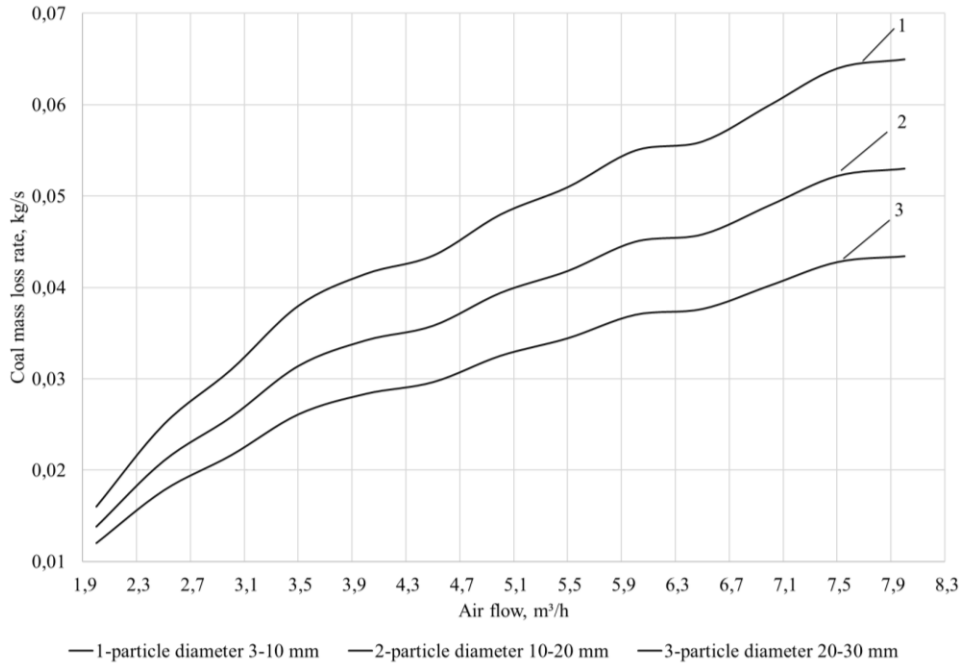

Fig.4. Dependence of coal mass loss on air flow

Fig. 5. Solid slag formed at a temperature in the combustion zone of 900-1000 ° C

The discussion of the results

With an increase in air flow above 5.0 m³/hour, the gasification process gradually turned into the process of complete combustion of coal.

Figure 6 shows the distribution of indicators for the formation of flammable components of the generator gas along the height of the laboratory bench. Coal size is 10-20 mm, coal moisture content is 24%, air flow is 4.4-4.8 m³/hour.

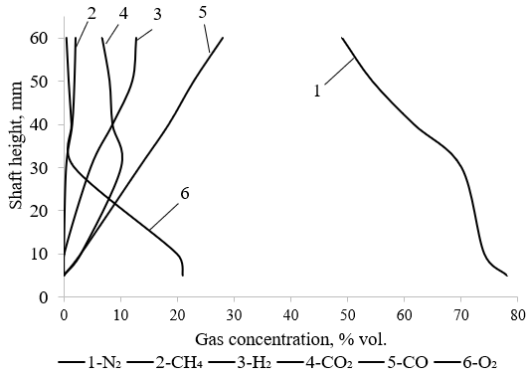

Fig.6. Composition of generator gas at an air flow rate of 4.6 m³/hour

One of the main goals of studying the process of gasification of Angren brown coal is to assess the technical and economic feasibility of obtaining generator gas and using it as an alternative fuel to the gas of underground coal gasification of Yerostigaz JSC [29], which is used for lighting on the boiler equipment of the JSC «Angren TPP». In table 2 shows a comparison of the quality of the obtained gas and the gas from the Yerostigaz JSC.

Table 2

Comparison of quality indicators of generator gases

Producer gas	*CO*, %	*CO₂*, %	*CH₄*, %	*H₂*, %	*O₂*, %	*N₂*, %	Specific gas yield, nm³/kg	Lower calorific value of generator gas, $Q_н^р$, kcal/nm³
JSC «Yerostigaz»	7	23	6	20	1	50	2	800
Experimental installation	26	7	3	16	0.5	47	3.0 - 3.5	950 - 1000

Conclusion

The process of layered gasification with direct air blast for Angren brown coal of grade B2 has been studied. The influence of the qualitative characteristics of coal such as humidity, fractional composition, as well as air flow on the performance of the gasification process is considered. Rational indicators of air consumption have been determined to obtain the highest energy values of the generator gas. The features of technological processes in the reaction zones of a laboratory gas generator have been studied. The use of the results obtained will help improve the efficiency of layered gas generators using Angren brown coal using air blast.

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