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MANAGING THE PROCESS OF UNDERGROUND COAL GASIFICATION

Purpose. The research purpose is to determine the efficiency parameter of the coal gasification process based on the analysis of the composition of combustible gases (H_2, CH_4, CO) and the producer gas calorific value, depending on the methods of supplying the blast mixtures to the gasifier oxidative zone.

Methodology. A laboratory setup is used to perform experimental research into underground coal seam gasification. Its constituent segments are a stand, branches for supplying blast and gas-outlet mixtures, as well as a flow control system. This setup makes it possible to model the coal seam occurrence according to the mining-geological conditions of its occurrence. When determining the gasification process efficiency, two methods of supplying the blast mixture are tested: through a blast injection well and combined method (blast injection well + controlled pipeline). The generated producer gas calorific value has been determined analytically according to the "additivity rule", taking into account the concentration of each combustible gas and its calorific value.

Findings. The underground gasifier efficiency when changing the method of supplying the air mixture has been substantiated. Based on qualitative data on the concentration of combustible gasifier gases at the outlet of a modeled underground gasifier, conditions for increasing their concentration have been characterized and time intervals have been determined, through which their decrease occurs with increasing outgassed space.

Originality. It has been revealed that the use of combined blast method in an underground gasifier causes a double supply of oxidizing agent to the gasification zone. This intensifies the gasification process by expanding the gasification reaction zones both along the length of the gasification column and along the seam thickness. Also, the combined method of supplying the blast mixture is characterized by improved thermal stability and gas formation parameters.

Practical value. The research results make it possible to quickly make technological decisions for changing the operating modes of the underground gasifier, as well as determine the optimal method for supplying air mixtures, which improves the quality and calorific value of the producer gas. When changing the blast supply method to a combined method, the average concentration of H_2, CH_4 and CO combustible gases increases by 3.85 %, and the calorific value increases by an average of 0.53 MJ/m^3.

Keywords: *underground gasification, coal seam, combustion face, experimental research, producer gas, controlled pipeline*

Introduction. In the modern world, energy security is an important basis for the national economy development [1]. According to state statistics, hard coal accounts for 22.4 % of the structure of Ukraine's own primary energy production. On the way of Ukraine's integration into the European Union, the Ukrainian energy sector should develop according to European legislation, comply with one climate policy and become more climate-oriented. Reducing carbon emissions is a key measure to combating global climate change [2].

Huge emissions of CO_2, CH_4, N_2O and fly ash generated during coal mining and combustion are one of the main reasons for greenhouse gas accumulation in the atmosphere [3]. Therefore, reducing carbon emissions from the coal industry is a necessary step to control global warming. At the same time, it should be noted the negative impact of coal mining on the environment, especially the formation of large waste dump areas [4], and soil contamination within the boundaries of mining allotments [5, 6].

It cannot be denied that the reduction of fossil energy is a tendency towards the development of green energy [7], and other types of alternative fuels and methods for generating electricity [8, 9]. However, it is now necessary to take advantage of the coal industry and turn fossil energy into resources. According to the Paris Agreement, global coal production capacity must be reduced by 80 %. Renewable energy sources are not yet sufficiently sustainable. Therefore, large amounts of coal energy are required to ensure a stable energy supply [10]. Regarding the issues of post-war reconstruction of Ukraine, the work [11] notes that energy independence and achieving the Green Deal could cost Ukraine $150 billion.

While developing its advantages, the coal industry should actively combine with alternative energy sources [12]. It is necessary to implement projects for integrating wind, water and solar energy when obtaining traditional energy from fossil fuels [13, 14]. Thus, it is not difficult to assume that the coal industry will face unprecedented challenges in the near future.

Underground coal gasification is an advantage and addition to traditional coal mining technologies. It is a key technology for implementing low-carbon programs for mining and processing coal reserves [15]. In recent years, underground coal gasification has been developing at a very fast pace and has shown great potential. Over the past five years, a number of laboratory and field experiments have been conducted to study gasification mechanisms, optimize operating parameters, determine the process efficiency and methods of their control [16]. At the same time, the coal gasification processes in underground conditions have not been fully studied, and due to the rapid development of scientific and technological progress, they constantly require improvements. Underground coal gasification is a complex physical-chemical process consisting of a series of continuous phases. The gasification process occurs at the gas-solid interface. Coal gasification is based on either incomplete fuel combustion (with a lack of oxygen) or complete fuel combustion followed by the reaction of carbon with carbon dioxide and water vapor to generate combustible producer gases (CO, H_2, CH_4). The essence of underground coal gasification technology is as follows (Fig. 1).

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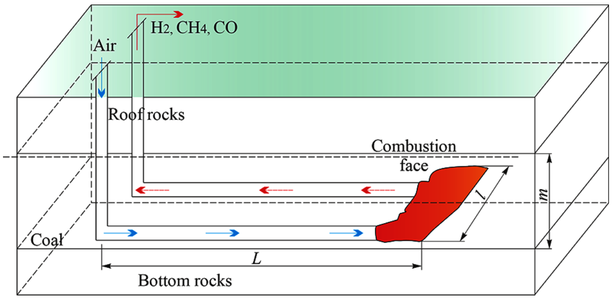

Fig. 1. Mechanism for conducting underground coal gasification process:

m – coal seam thickness, m; l – combustion face length, m; L – gasification column length, m

Two wells are drilled from the earth's surface to the intersection with the coal seam: the blast injection well and the gas-outlet well. The horizontal part of the wells is drilled through the coal seam. After that, a reaction channel is formed between the wells using one of the well-known methods of directional drilling, hydraulic or pneumatic fracturing, etc. A blast mixture, which is represented by air, oxygen-enriched air or a steam-air mixture is supplied into one of the wells. And through another well, producer gas is removed. The coal gasification process occurs between the specified wells with the formation of reaction zones of an underground gasifier, which are characterized by variable temperature field parameters.

Before implementing the UCG technology, it is first necessary to study the mining-geological structure of the rock mass containing the coal seam, predict the growth rate of the cavity in the rock mass, assess the technical capabilities and impact of the process on the environment, determine the economic feasibility and safety aspects for successful exploitation and reduction of technology complexity. At the same time, the mining-geological conditions of the occurrence of coal seams precisely determine the technological and technical solutions for conducting gasification processes. It should be noted that underground coal gasification technology is characterized by a low efficiency value, which is conditioned by the low producer gas calorific value.

Analysis of recent research and publications. To date, many studies on underground gasification are focused on increasing the efficiency of conducting the gasification process, in particular by increasing hydrogen concentrations in the producer gas [17] and reducing carbon dioxide emissions [18]. These studies cover the theoretical analysis of gas-formation processes [19, 20], the development of new mathematical and thermodynamic models describing the gasification process, the substantiation and development of which allows for a more productive transition to laboratory or pilot industrial research [16]. Much information is also provided on the possibility of methane receiving from coal towards creating a cleaner energy future [21].

China plays a dominant role in conducting these studies, as the prospect of a carbon-neutral world encourages China to invest heavily in clean coal technologies. Thus, the work [22] assesses the potential of China's coal reserves and the possibility of their mining using gasification technology to produce a substitute for natural gas. Moreover, quite often the possibility of mining coal reserves that are off-balance or have been abandoned is considered. The analysis of test results [23] shows that from the remaining coal reserves it is possible to obtain a gaseous product with a calorific value of 5.02–5.86 MJ/m^3, which contains 5–10 % of H_2, 14–16 % of CO and 5–8 % of CH_4. The resulting gas calorific value is an important indicator for assessing the gasification process efficiency. The main directions for controlling the underground gasification process, which allows increasing efficiency, is to increase the temperature in the underground gasifier channel by reversing the blast flows; increasing the pressure in the underground gasifier; use of pulsating blast; water-inrush management; backfilling of mined-out space, as well as the use of catalysts.

Thus, in the work [23], it has been determined that reversal of blast flows ensures uniform combustion face advance and increases the producer gas calorific value to 4.62–5.79 MJ/m^3. At the same time, when the oxidative zone increases to 10.2 m, the underground gasification process proceeds in a stable mode.

The intensity of heterogeneous processes increases when a blast is injected into the underground gasifier in the range of 0.2–0.3 MPa. Excessive pressure in the underground gasifier and the presence of moisture in the coal create favorable conditions for producing methane gas [24]. Increasing the pressure in the gasifier promotes the flow of reactions of direct carbon hydration ($C + 2H_2 = CH_4 + 75.3$ kJ/mol) and carbon monoxide reduction ($CO + 3H_2 = CH_4 + H_2O + 205$ kJ/mol). At the same time, the methane content CH_4 and H_2O increases, and concentration of CO and H_2 decreases.

From the experience of operating experimental and laboratory gasifiers, it has been revealed that the ash content of coal has a negative impact on the course of the gasification process. The melted ash crust, which forms on the combustion face plane, prevents contact of gaseous reagents with the solid fuel carbon [25, 26]. Therefore, the use of pulsating blast makes it possible to neutralize the ash crust influence and ensure the resulting gas quality control.

The presence of water-inrush into the underground gasifier leads to a decreased temperature in the reaction zone, which slows down the rate of chemical reactions, especially endothermic ones. This, in general, results in a decrease in the producer gas calorific value, and if there is a significant water-inrush, the combustion face may die out. Therefore, measures must be taken to reduce the water level.

The underground gasification process is accompanied by subsidence of the immediate and main roof rocks. This leads to the formation of through gas-conducting fractures in the coal seam roof, the subsequent formation of which causes underground gasifier depressurization [27]. Therefore, in order to avoid this situation, it is necessary to backfill the mined-out space [28]. When organizing the technological process of gasification of coal seams with backfilling the mined-out space, constant contact of the blast flows with the reaction surface of the seam and the necessary thermal conditions are provided, ensuring the process intensification in the gasifier reaction zones [29].

The gasification process efficiency can be increased by adding catalysts into the blast mixture composition. The most common catalysts for the coal gasification process are compounds of alkali, alkaline earth and some transition metals: Ruthenium (Ru), Cobalt (Co), Ferrum (Fe) and nickel (Ni) [30], as well as potassium carbonates: K_2CO_3, Na_2CO_3, $CaCO_3$ [31]. The introduction of catalysts significantly increases the process efficiency while reducing the temperature, maintaining a high process rate and regulating the product composition.

Identification of unresolved part of the general problem. Despite extensive research on the efficiency and intensification of the underground coal gasification process at the place of coal occurrence, the results obtained are aimed at analytical studies of the material-heat gasification balance parameters, construction and development of mathematical and numerical models, as well as determination of dependences of changes in hydrodynamic-geofiltration regimes around the underground gasifier. At the same time, possible technological and technical solutions aimed at increasing the gasification process efficiency, in particular, when changing the method of supplying the blast, have not been taken into account. In this regard, there is a need to conduct additional research.

The purpose of this research is to substantiate the coal gasification process efficiency based on determined parameters of the yield of combustible gases and their calorific value.

To achieve the purpose set, this paper analyzes methods for improving the coal gasification process efficiency; the dependences of changes in the CH_4, H_2 and CO concentrations in the producer gas are identified; its calorific value is determined using two methods of supplying the blast mixture: through blast injection well and combined (blast injection well + controlled pipeline) methods.

Research methods. Research into coal gasification process is conducted on a laboratory setup consisting of four main segments (Fig. 2): research stand (I), branch for supplying blast (II), gas-outlet (III) mixtures and flow control system (IV).

An important part of the setup is the gasification stand *1*, which reproduces the mining-geological conditions of the coal seam occurrence. The setup makes it possible to model the process of underground coal gasification on the surface in an artificial coal seam with dimensions to the dip of 1.0 and along the strike of 1.2. The combustion face area is 0.2 m^2. This stand is made in sections, which makes it possible to model an underground gasifier using two methods of a coal seam mining: well – gasifier, pillar mining system. From the frontal part there are openings for supplying blast and removing the producer gas.

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The blast supply branch (II) consists of the main *2* and auxiliary *3* compressors, a flow-rate meter *4* and pipelines *5*.

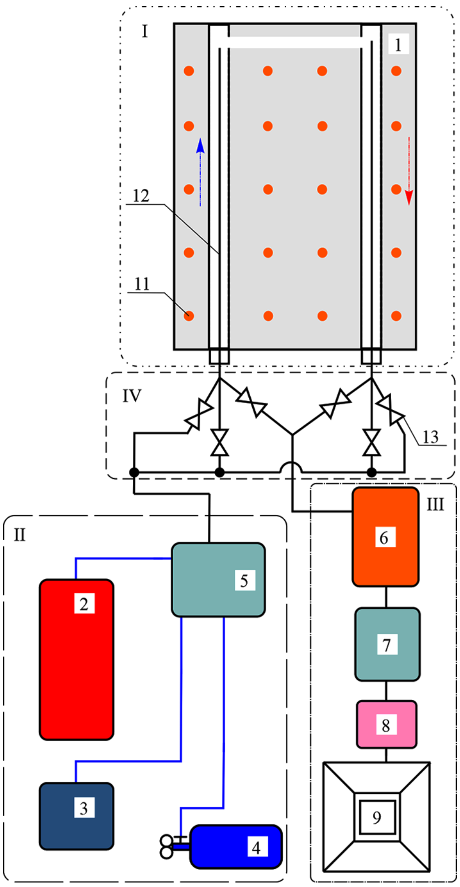

Fig. 2. Process flow scheme of the setup for studying gasification processes:

1 – stand; 2 – main compressor; 3 – auxiliary compressor; 4, 7 – flow-rate meters; 5 – blast pipeline; 6 – cooling tank; 8 – gas analyzer; 9 – smoke exhauster; 10 – gas-outlet line; 11 – controlled pipeline; 12 – blast injection well; 13 – gas-outlet well; 14 – thermocouples; 15 – valves

The branch for supplying blast also includes the controlled pipeline *11,* which provides the ability to directly supply blast to the gasifier reaction zone. The controlled pipeline is inserted through a threaded hole in the stand wall along a modeled blast injection well *12* of the coal seam model.

The gas-outlet branch (III) consists of the cooling tank *6*, flow-rate meter *7*, gas analyzer *8*, smoke exhauster *9* and gas-outlet line *10.*

The flow control system (IV) includes valves *15* to direct blast and gas-outlet flows in the required direction.

The rock-coal mass formation is conducted in two stages in compliance with similarity criteria [32]. At the first stage, the coal seam is modeled, and at the second stage, the coal-overlaying formation is modeled. As an equivalent material, pieces of coal measuring 200 × 150 × 100 mm are used, which in terms of qualitative composition correspond to the studied area and the coal seam parameters ($W^r = 5.8$ %, $W^a = 6.9$ %, $A^c = 12.0$ %, $S^d = 1.6$ %, $V^{daf} = 24.2$ %, $C^{daf} = 80.3$ %, $H^{daf} = 5.5$ %, $O^{daf} = 7.2$ %, $N^r = 5.0$ %, $Q^r = 234$ MJ/kg, $\gamma = 1.24$ t/m^3). In the seam, there is space left for simulating blast injection well and gas-outlet well with a diameter of $d = 0.08$ m and a reaction channel. The reaction channel is formed from coal pieces with a fraction of 0.025–0.068 mm, simulating hydraulic fracturing of the seam between the blast injection and gas-outlet wells.

The lithological variety of the modeled mass is formed in accordance with the natural conditions of the studied mine field sections. Based on scale factors and the peculiarities of the formation of complex systems, simplifications are introduced into the modeling process in the form of a combination of rock seams with similar metamorphic properties [33]. For the model conditions, the thickness of such seams does not exceed 0.2 m. After the seam has dried, an immediate roof (clay shale) and a main (sandy shale) roof made of mine rock and fireclay solution are placed over the coal seam.

To ensure the system autothermicity, the underground gasifier is thermally insulated. This makes it possible to maintain the gasification process without supplying heat from outside due to exothermic reactions. Refractory bricks serve as a thermally-insulating material, which are laid out in one row along the stand contour to the height of the lithological variety layers.

Variation of pressure in the oxidative zone (exothermic processes) of the reaction channel and outlet of producer gases from the reduction zone (endothermic processes) of the gasifier while ensuring the balance of physical velocities and reaction kinetics, is provided by different methods of blast supply.

The temperature field propagation parameters are studied at individual points of the modeled area, in places of setting stationary temperature sensors of the TEP-109 type – *14.* Sensors are set on the plane of the coal seam contact with the immediate roof.

Using a gas burner, preliminary placed crushed coal is set on fire in the reaction channel through the ignition hole. After ignition, an air mixture (21 % O_2) is supplied through the modeled channel of the blast injection well and a smoke exhauster is started to accelerate the process of burning the reaction channel. The blast supply pressure is 0.11 MPa.

Research into the efficiency of underground coal gasification process through technological solutions is conducted in two successive stages with certain cyclicity. There are a total of ten cycles of conducting research. The first stage of research (cycles 1, 3, 5, 7, 9) includes the supply of air blasts through a modeled blast injection well into the reaction channel zone. At the next stage (2, 4, 6, 8, 10 cycles), an additional blast mixture is supplied to the already formed combustion face through a controlled pipeline (combined mode). During each stage of the research, the concentrations of combustible gases (CO, H_2, CH_4) in the initial mixture are measured. The blast mixture supply pressure through the well is 0.12–0.15 MPa, and through the controlled pipeline – 0.18–0.21 MPa.

The calorific value of gas is an indicator of the quality of underground gasification producer gas, determining its energy value. The producer gas calorific value is calculated according to the "additivity rule", taking into account the concentrations of each combustible gas and its calorific value [34]

$$LHV = \frac{12.622 \cdot CO + 10.788 \cdot H_2 + 35.814 \cdot CH_4}{100},$$

where CO, H_2, CH_4 – gas concentrations, %.

Taking into account the concentrations of individual gases and their calorific values, the total calorific value of the producer gas, which is an important indicator for its effective use, has been calculated.

Results and discussion. H_2, CO, CH_4 and CO_2 are gases produced during the underground gasification process. The main chemical reactions leading to their formation are reactions of carbon combustion (1), reverse carbon combustion reaction (2), carbon oxide formation reaction (3) and methane synthesis (4), kJ/mol

$$C + O_2 \rightarrow CO_2; \quad \Delta H^{\circ}_{298} = -393; \tag{1}$$

$$C + CO_2 \rightarrow 2CO; \quad \Delta H^{\circ}_{298} = +172; \tag{2}$$

$$C + H_2O \rightarrow H_2 + CO; \quad \Delta H^{\circ}_{298} = +131; \tag{3}$$

$$C + 2H_2 \rightarrow CH_4; \quad \Delta H^{\circ}_{298} = -75. \tag{4}$$

Carbon combustion and methane synthesis are exothermic reactions, while the reverse carbon combustion reaction and the carbon monoxide formation reaction are endothermic. Exothermic reactions produce heat while they are running, that is, ΔH (enthalpy change) in these reactions is negative. Endothermic reactions, on the contrary, absorb heat while they are running, that is, ΔH in these reactions is positive.

This course of chemical reactions indicates that oxygen contained in the blast mixture as an oxidizing agent is fully involved in the reactions. Based on this, it can be stated that the presence of oxygen in the initial gasifier mixture indicates the destabilization of the gasification process. The results of monitoring the main producer gas composition are presented in Fig. 3, the analysis of which makes it possible to determine how stable and efficient the gasification process is, as well as to identify possible ways to improve it.

The first cycle of conducting the research according to the first stage includes determining the concentrations of combustible gases when supplying the air blast through the blast injection well. The blast supply pressure is 0.12 MPa. It should be noted that the supply of this blast begins in the second hour of the experiment. Since such a period of air blast supply is sufficient for increasing the temperature field with the formation of reaction zones in the combustion face and ensuring gas-formation reactions. The average concentration of combustible gases during the first cycle of research is 9.9 %: CO – 5.0, CH_4 – 2.6, H_2 – 2.3 %. Low hydrogen levels indicate a lack of moisture in the coal, roof and bottom rocks, but some moisture still enters the modeled gasifier, penetrating into the oxidative zone with the air blast.

The coal gasification process efficiency, when changing the method of supplying the blast mixture, is determined using various supply modes after an hour of experiment duration. Gas concentrations are measured every 15 minutes.

The producer gas product composition immediately changes with the beginning of the second stage (second cycle) of the research. The tendency towards an increase in the average concentration of combustible gases H_2, CO, CH_4 by 3.4 to 13.3 % is observed. This is due to the active effect of the blast mixture on the combustion face plane, in particular on the unreacted coal seam part from the side of its roof. Since the well is laid 0.2*m* (*m* – the coal seam thickness, m) from the seam bottom, this leads to an uneven blast mixture impact on the oxidative zone of the underground gasifier from its bottom to the roof. Thermocouple data indicate a change in the temperature field along the axis of the gasification reaction channel along the coal seam plane in the range of 350–1260 °C. This indicates the formation of different-temperature zones of chemical reactions in the combustion face, in particular, oxidative, reduction and dry distillation, which is confirmed by a number of conducted studies. An oxidative zone is formed on the side of the blast injection well, in which carbon reacts with oxygen. It is characterized by the course of exothermic reactions with a temperature of 790–1260 °C. When the O_2 concentration in the oxidative zone approaches zero, combustion reactions stop, which is the limit of this zone. A significant amount of CO_2 is released in this zone. An increase in temperature indicators from the side of the blast injection well in the oxidative zone also contributes to an increase in CO concentrations in the next reduction zone. The reactions occurring in the reduction zone are endothermic, and the temperature of the coal seam and the gas flow gradually decreases. Its temperature range is 580–890 °C. The reduction zone gradually passes into the dry distillation zone, where gas is generated as a result of coal pyrolysis and the methanation reaction occurs. The temperature is 580–350 °C. It should be noted here that pyrolysis reactions occur in all three zones, since the coal seam gradually warms up along the seam thickness (*m*), combustion face length (*l*) and the extraction panel (*L*) (Fig. 1). The use of blast supply through a controlled pipeline facilitates active contact of the blast flow with the combustion face, in particular in the gasifier oxidative zone. Under such conditions, the blast mixture interacts with carbon heated during the first research cycle. The gasification process efficiency is determined, first of all, by the expansion of the gasification zone, the formation of stable temperature conditions and an increase in the volume of the introduced oxidizing agent.

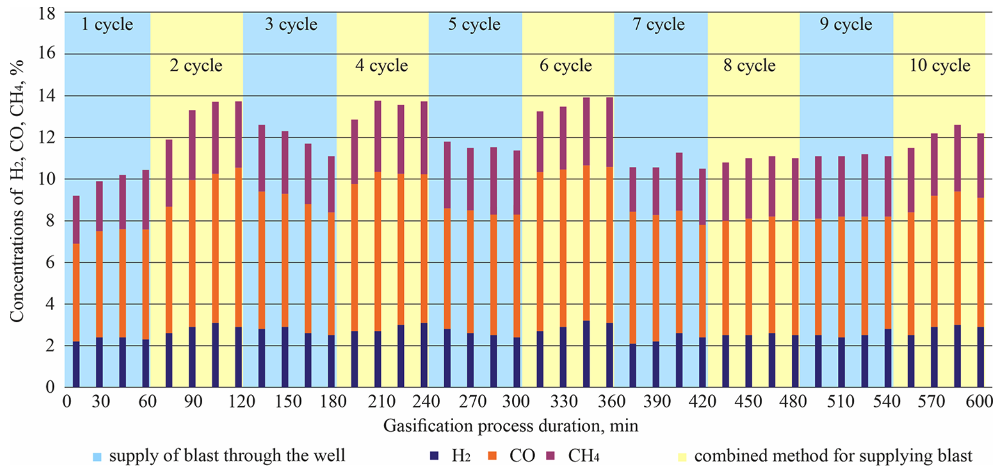

Fig. 3. Dependences of changes in the concentrations of combustible producer gases during the experiments on the method of supplying the blast mixtures

After conducting the second research cycle using the combined blast supply mode, the modeled gasifier is switched to supplying the blast through a blast injection well (third cycle). The concentration of combustible gases increases by 2.1 % compared to the first cycle. This situation is conditioned by the development of the coal seam surface, where chemical reactions occur due to the intensity of the combined blast action on the reaction seam surface, in particular on the seam pores and fractures.

During the third and fifth research cycles, the blast supply spressure remains at the level of 0.12 MPa. During the seventh research cycle, the average concentration of combustible gases decreases by 0.8 and 1.2 %, respectively, compared to the third and fifth cycles. Therefore, at 8 hours and 15 minutes of the experiment duration, the blast supply pressure begins to gradually increase and reaches a value of 0.15 MPa, at which the concentration of combustible gases reaches the average values for the third and fifth research cycle. A tendency towards a decrease in the average concentration of combustible gases is also observed during the eighth research cycle. Therefore, it was also decided to increase the pressure of the blast supplied through the controlled pipeline to concentration values of 12.7 % (fourth cycle) and 13.8 % (sixth cycle). This situation is associated with an increase in the outgassed space, which causes the blast mixture dispersion in the combustion face.

The calorific value variation during the experiment shows the same tendency as the change in concentrations of H_2, CO and CH_4 (Fig. 4). In addition, this demonstrates the gradual increase in the calorific value for each blast supply method.

According to Fig. 4 data, the average calorific value of the gaseous product when supplying the blast through a blast injection well varies from 1.8 to 2.11 MJ/m^3. With the combined method for supplying blast mixture, the gas calorific value increases by 8.0–25 % and varies from 2.2 to 2.43 MJ/m^3. The maximum increase in the change in calorific value can be observed between the first and second research cycles due to the formation of a stable temperature conditions in the coal seam and in the roof and bottom rocks.

Thus, the adopted technological solutions for the methods of supplying the blast mixture are characterized by improved parameters of thermal stability and gas formation.

Subsequent research is planned to develop a new type of controlled pipeline design for supplying blast mixtures directly to the coal seam plane. This design provides for the possibility of changing the angle and supplying of blast mixtures for the most efficient production of high-quality producer gas. At the same time, the design of this pipeline will provide the possibility of conducting the gasification process from the reaction channel of the mine gasifier without forming a berm for the ventilation drift.

Conclusions. On the path of its future development, the energy sector of Ukraine must develop in accordance with European legislation. Therefore, changing technologies for mining the energy raw materials, which cause significant carbon emissions, is one of the key tasks. The technology of underground gasification can be an addition, and in some cases, a

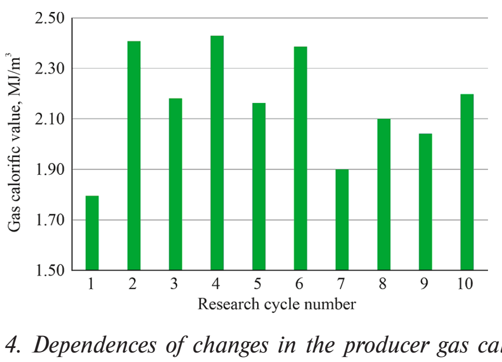

Fig. 4. Dependences of changes in the producer gas calorific value during the experiments on the method of supplying the blast mixtures

replacement for traditional coal mining technologies. In this case, it is necessary to be ready to implement both technological and technical solutions that facilitate efficient process management. The experimental research on coal gasification presented in this paper makes it possible to precisely assess the process efficiency.

The use of combined method for supplying blast in an underground gasifier causes a double supply of oxidizing agent into the gasification zone, which significantly intensifies the gasification process due to the expansion of reaction zones both along the length of the gasification column and along the seam thickness. When changing the blast supply method, the average concentration of CO, CH_4 and H_2 combustible gases increases by 3.85 %, and the calorific value increases by an average of 0.53 MJ/m^3. This makes it possible to adapt the methods of supplying mixtures to the gasifier reaction zones and quickly make technological decisions for changing the operating modes of the underground gasifier.

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Управління процесом підземної газифікації вугілля

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Мета. Встановлення показників ефективності процесу газифікації вугілля на основі аналізу складу горючих газів (H_2, CH_4, CO) і теплотворної здатності генераторного газу залежно від способів подачі дуттьових сумішей у окислювальну зону газогенератора.

Методика. Для виконання експериментальних досліджень з підземної газифікації вугільного пласта була застосована лабораторна установка. Складовими сегментами її є стенд, гілки подачі дуттьових, газовідвідних сумішей і система керування потоками. Дана установка дозволяє змоделювати розташування вугільного пласта відповідно до гірничо-геологічних умов його залягання. При визначенні ефективності ведення процесу газифікації були апробовані два способи подачі дуттьової суміші: по дуттьовій свердловині та комбінований (дуттьова свердловина + керований трубопровід). Теплотворна здатність отриманого генераторного газу визначалась аналітичним шляхом за «правилом адитивності», ураховуючи концентрації кожного горючого газу та теплоту його згорання.

Результати. Обґрунтована ефективність роботи підземного газогенератора при зміні способу подачі повітряної суміші. На основі якісних даних щодо концентрації горючих генераторних газів на виході зі змодельованого підземного газогенератора охарактеризовані умови підвищення їх концентрації та встановлені часові проміжки, через які відбувається їх зниження з ростом вигазованого простору.

Наукова новизна. Встановлено, що застосування комбінованого дуття у підземний газогенератор зумовлює подвійне надходження окисника до зони газифікації. Це інтенсифікує процес газифікації за рахунок розширення реакційних зон газифікації як за довжиною стовпа газифікації, так і за потужністю пласта. Також комбінований спосіб подачі дуттьової суміші характеризується покращенням показників за термостабільністю й газоутворенням.

Практична значимість. Результати дослідження дають можливість оперативно приймати технологічні рішення для зміни режимів роботи підземного газогенератора, а також визначати оптимальний спосіб подачі повітряних сумішей, що підвищує якість і теплотворність генераторного газу. При зміні способу подачі дуття на комбінований середня концентрація горючих газів H_2, CH_4 та CO підвищується на 3,85 %, а теплота згорання у середньому на 0,53 МДж/м^3.

Ключові слова: *підземна газифікація, вугільний пласт, вогневий вибій, експериментальні дослідження, генераторний газ, керований трубопровід*

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