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CO-FIRING OF GAS COAL DUST FINE PARTICLES AND SYNTHETIC PEAT GAS. PART 2. NUMERICAL STUDIES ON THERMOCHEMICAL PROCESSING OF PEAT IN A FIXED BED

Purpose. To investigate the gasification process of peat in gas generators with a fixed bed at a pressure of 1.5 MPa and create the initial conditions at the entrance to the waste burners required for combustion of the binary mixture.

Methodology. The objects of research were peat granules of Volyn peat. To calculate the process of gasification of peat gas, the constructed model of thermochemical processing of solid fuel, described in the first part of the work by the authors was used.

Findings. It is shown that in the area close to the upper boundary of the fixed bed, where the process of gasification of peat is stationary, there is a jump in the temperature of peat particles from 300 to 772 °C, in which the tar is practically not released, and thus the obtained pyrolysis gas contains CO_2, H_2O, H_2 and CO. The structural and physicochemical characteristics of gas generators are obtained and the initial conditions at the entrance to the discharge burners of the chamber furnace of the steam generator TPP-210A are formed.

Originality. It is shown that when the velocity of peat particles decreases, a slag bed is formed between the zone of maximum heat release and the grate, which consists of cooled ash particles, which protect the grate from overheating. With such an organization of the process it is possible to achieve the stationary process of gasification with mechanical incompletely burned material equal to zero.

Practical value. It is shown that with the help of the model of thermochemical processing of solid fuels it is possible to adjust the height of the dry distillation zone by changing the velocity of the dispersed phase and the rate of heterogeneous and homogeneous chemical reactions by changing the proportion of O_2 or H_2O air enrichment.

Keywords: *fixed bed, coal, peat, thermal conductivity, steam — air gasification, conductive and radiative heat exchange*

Introduction. Co-firing of two solid fuels in the common combustion space has a significant advantage over the combustion of a single designed solid fuel. The main advantage of co-firing is the diversification of fuel supply, which makes it possible to choose fuel suppliers, which, in turn, reduces the cost of fuel and allows replacing scarce fuel. Another advantage of this method of combustion is the ability to involve off-balance fuels, such as biomass or peat [1, 2].

There are three main ways to organize the process of co-combustion of two solid fuels in the common fuel combustion space of the pulverized coal boilers. The first method involves pre-mixing at the fuel depot or during transportation before grinding. This method is the simplest from a technological point of view and minimizes investment. However, it is only suitable for coal with similar grinding characteristics or for a small proportion of additional solid fuel. Adding plant biomass or peat to the coal leads to worsening of the mix grinding.

The second method involves the separate feeding of two fuels into the boiler. This method requires a large investment, but allows varying the ratio of fuels in a wider range. A separate feeding allows grinding each type of fuel to the optimal size, which improves combustion efficiency.

The third method is preliminary gasification of one solid fuel (biomass or peat) and its purification, followed by combustion of generator gas in the boiler furnace. This method requires largest investment, but is the most efficient and environmentally friendly way of co-firing.

An example of the introduction of preliminary gasification of biomass is the Kymijarvi CHP (Finland), where wood industry waste is gasified in a circulating fluidized bed gasifier with air blowing. The capacity of the gasifier reaches 70 MW. The obtained generator gas is burned in the furnace of a pulverized coal boiler [3].

Given the prospects and advantages of the technology of preliminary gasification of peat granules, a significant potential of fuel peat in Ukraine, an original scheme of co-firing was developed in the furnace of TPP-210A boiler of gas coal and synthetic peat gas generated at stationary gasification of Volyn peat particles under pressure of 1.5 MPa. One of the main elements of this scheme is a gasifier. Therefore, at the first stage, it is necessary to study the process of gasification of peat granules in a gas generator for different options, which is the basis for optimizing the combustion of binary mixtures.

Literature review. The first part of this work [4] describes in detail the gasification process based on the developed two-dimensional system of parabolic and hyperbolic equations of aerodynamics, heat and mass transfer and chemical reaction of a gas-dispersed medium in a fixed bed. The model allows obtaining detailed information about geometric, aerodynamic, thermal and physicochemical parameters of gasification in a fixed bed. There is also presented a mathematical description of the combustion process of fine dust of coal and generator peat gas based on the program ANSYS FLUENT (model Non-Premixed Combustion). Using the developed model, we numerically investigated the process of thermochemical processing of peat particles in an oxygen-enriched steam-air mixture in a fixed bed at a pressure of 1.5 MPa for option 1. The obtained results will be used in joint combustion of 36,720 kg/h synthetic peat gas (20 % by energy of fuel) and 48,996 kg/h of fine dust of coal supplied to the main burners *5* of the furnace of the TPP-210A steam generator *7* (Fig. 1 [4]). A detailed description of the process of burning a binary mixture will be presented in the third part of this paper.

Unresolved aspects of the problem. The process of peat gasification in a steam-air mixture enriched with oxygen in a fixed bed has not been studied so far (Options 2–4).

Purpose. To investigate the influence of the velocity of peat particles on the nature of the temperature distribution of phases and concentrations of gas components, stability (stabilization) and stationary process of thermochemical processing of peat.

Methods. Modeling of the process of gasification of solid fuel in a steam-air mixture in a fixed bed is described in detail in the first part of this work [4].

Results. When the velocity of peat particles decreases from $u_{p0} = -0.000365$ (option 1 [4]) to $u_{p0} = -0.000354$ m/s in the time interval $\tau = 600-1900$ s between the grate and the zone of maximum heat release a protective bed is formed consisting of cooled inert ash particles with a temperature of $t_{ash} = 306-463$ °C, whose height increases over time from 3 to 632 mm (curves 4 and 7 in Fig. 1, a). From the data in Fig. 1 it follows that in option 2 the working process is non-stationary (in contrast to option 1 [4]), which is also evidenced by the distribution of the volume fractions of gas components through the height of the fixed bed (Figs. 2, 3, a, b). Stability (stabilization) and stationary process of thermochemical processing of peat can be achieved by reducing the speed of peat particles from
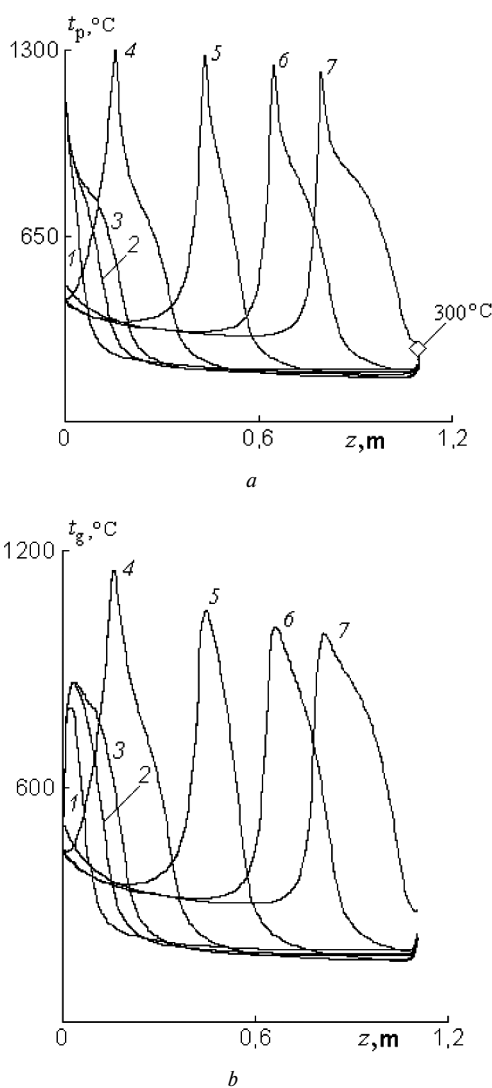

Fig. 1. The temperature distribution of the particles of Volyn peat (a) and gas (b) by the height of the fixed bed depending on the duration time for option 2:

1 — 100 s; 2 — 200 s; 3 — 300 s; 4 — 600 s; 5 — 1,000 s; 6 — 1,500 s; 7 — 1,900 s
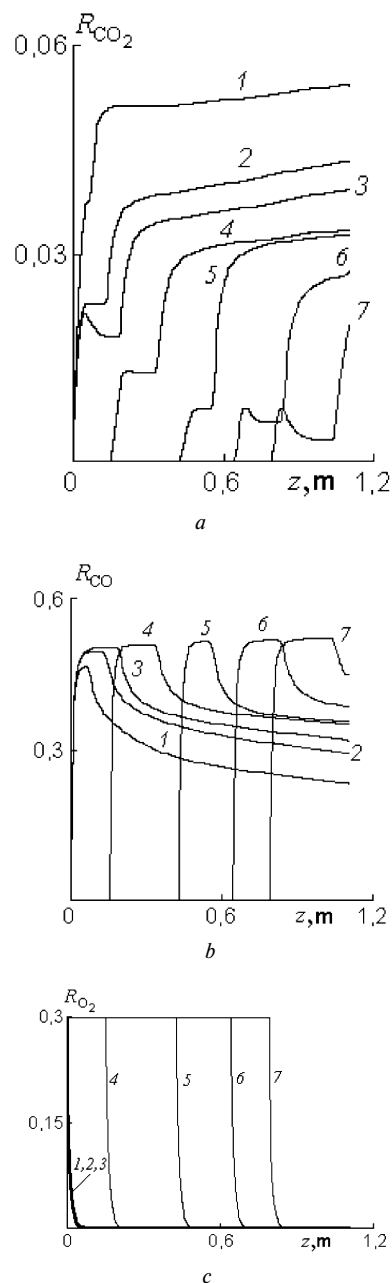

Fig. 2. The distribution of the volume fractions of gas components CO_2 (a), CO (b) and O_2 (c) by the height of the fixed bed versus time for option 2:

1 — 100 s; 2 — 200 s; 3 — 300 s; 4 — 600 s; 5 — 1,000 s; 6 — 1,500 s; 7 — 1,900 s

$u_{p0} = -0.000354$ to $u_{p0} = -0.0003$ m/s (option 3). In this case, it is possible to achieve stability and stationary process, as seen in Figs. 4–6 (curves 6–8) in the time interval 1500 s $\leq \tau$.

At the outlet of the reactor, the following composition of the generator gas is obtained for option 3 (in terms of dry weight): $R_{CO} = 44.01$; $R_{H_2} = 11.01$; $R_{H_2O} = 3.06$; $R_{CO_2} = 2.84$; $R_{O_2} = 1.83$; $R_{N_2} = 37.24$ % at $\tau = 2000$ s (here R is the volume fraction of the gas mixture component). In this case, the slag gasket covers most of the height of the reactor — 1.0725 m, and the reaction zone only — 33.9 mm. Therefore, at the outlet of the reactor in the gas mixture there are small amounts: $R_{H_2O} = 2.84$ and $R_{O_2} = 1.83$ %, which indicates an insufficient height of the active zone. Mechanical unburnt fuel in the third option $q_{4,3} = 0$ (Fig. 7, c).

Thus, option 1 [4] is better than the third one. Consider the working process where the mass fraction of water vapor has
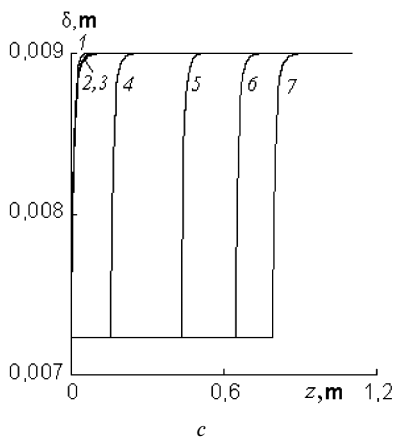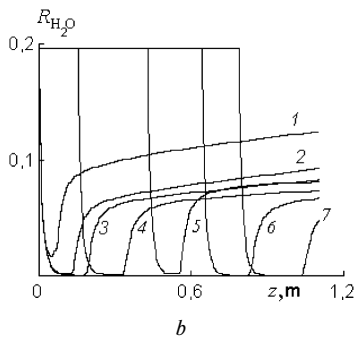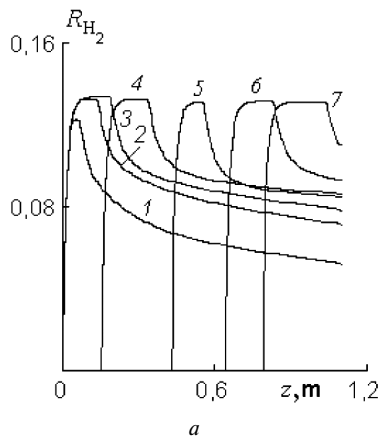
Fig. 3. Distribution of volume particles of gas components H_2 (a) and H_2O (b), particle diameter (c) by the height of the fixed bed depending on the time for option 2:

1 − 100 s; 2 − 200 s; 3 − 300 s; 4 − 600 s; 5 − 1,000 s; 6 − 1,500 s; 7 − 1,900 s
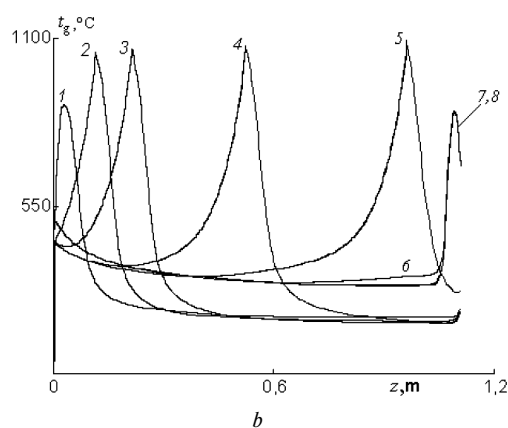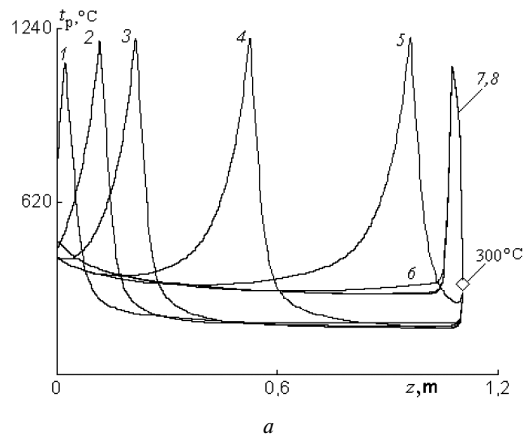

Fig. 4. The temperature distribution of the particles of Volyn peat (a) and gas (b) by the height of the fixed bed depending on the time for option 3:

1 − 100 s; 2 − 200 s; 3 − 300 s; 4 − 600 s; 5 − 1,000 s; 6 − 1,500 s; 7 − 1,900 s; 8 − 2,000 s

been increased from 13 (option 1 [4]) to 23 % (option 4). Similar to the first option, the zone of maximum heat release in option 4 is adjacent to the grate, but $t_{p,\max1}$ = 1114−1126 °C > > $t_{p,\max4}$ = 922 °C (compare with Fig. 2, a [4] and 8, a; here $t_{p,\max1}$, $t_{p,\max4}$ − maximum temperature for options 1 and 4). The composition of the synthetic gas at the outlet of the reactor for option 4 (in terms of dry weight): R_{CO} = 29.55; R_{H_2} =14.23; R_{H_2O} =7.922; R_{CO_2} =6.79; R_{CH_4} =6.275; R_{N_2} = = 17.73; $R_{CH_{1.193}O_{0.4083}}$ =14.43; $R_{C_2H_2}$ =3.063 % at τ = 600 s; and R_{CO} = 41.73; R_{H_2} = 22.65; R_{H_2O} =0.571; R_{CO_2} =6.86; R_{N_2} = = 28.2 % at τ = 3200 s.

In the fourth option, the stationary process of gasification of 28,939 kg/h of the raw peat in three reactors produces 33,794.5 kg/h of crude synthetic gas, which is directed to the gas cleaning chamber *17*, where the condensation of heavy hydrocarbon vapors C_2H_2 in the amount of 1,753 kg/h and purification from discrete phase occur, after which the peat gas is mixed with 5,469.5 kg/h of evaporated moisture from the input fuel *26* and after the discharge of excess pressure in the gas turbine *34* enters the gas burners 8 (Fig. 1 [4]). Mass fractions of peat gas components at the inlet to the furnace are: H_2O = = 0.222; H_2 = 0.0124; CO = 0.3556; CO_2 = 0.1396; CH_4 = 0.059; H_2S = 0.0046; N_2 = 0.2072.

In the furnace of the TPP-210A boiler 7, the joint combustion takes place of 37,511 kg/h of synthetic gas (20 % of fuel energy) and 47,963 kg/h of fine coal powder supplied to vortex burners 5 (Fig. 1 [4]). A detailed description of this process is given in the third part of this paper.

In the time intervals 2,200 < τ < 3,200 s (option 1 [4]) and 2,400 < τ < 3,200 s (option 4), where the gasification process of Volyn peat is stationary, the volume fractions of the combustible part of the generator gas (in terms of dry weight) are: in the first option − CO + H_2 = 66.01 %, in the fourth option − 64.38 %, while the content of CO and H_2 in option 1 is 26.5 % higher and is 71.46 % lower , respectively, than in the fourth option (compare Figs. 3, 4 [4] and 9, 10). Due to the fact that the calorific value of carbon monoxide is higher than the calorific value of hydrogen, the calorific value of the generator gas in the first option is greater than in the fourth option.

In the area close to the upper limit of the fixed bed H_{bed} = = 1.1064 m at stationary working processes in options 1 and 4 the jumps of peat particles temperature are observed, from 300 to 528 °C (option 4) and from 300 to 772 °C (option 1) (curves *10−12* in Fig. 2, a [1]; curves *7−10* in Fig. 8, a). A high level of gas temperatures in this area is achieved due to the removal of the drying zone from the gas generator (*22* in Fig. 1 [4]), resulting in a sharp increase in the rate of thermal decomposition of oxygen-containing compounds [5, 6]
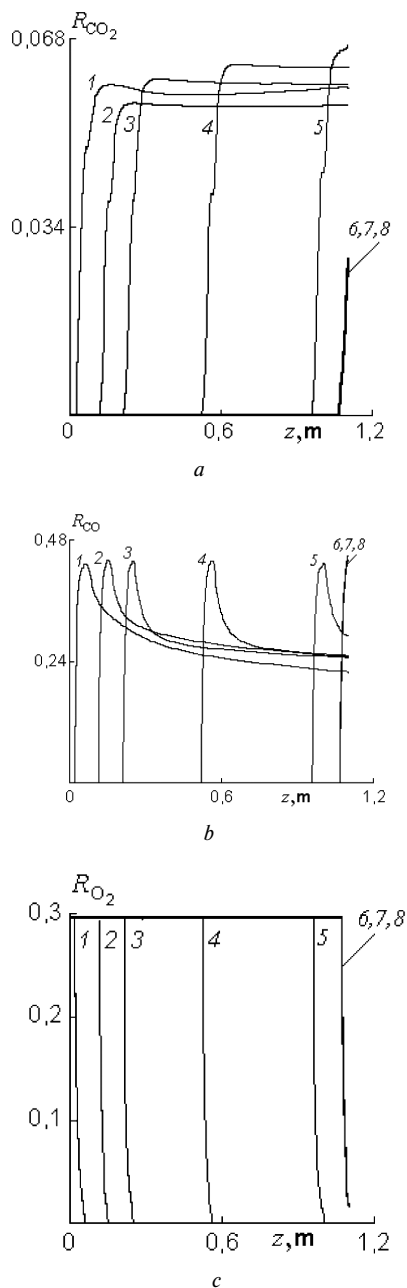
Fig. 5. Distribution of volume fractions of gas components CO_2 (*a*), CO (*b*) and O_2 (*c*) according to the height of the fixed bed depending on the time for option 3:

1 − 100 s; 2 − 200 s; 3 − 300 s; 4 − 600 s; 5 − 1,000 s; 6 − 1,500 s; 7 − 1,900 s; 8 − 2,000 s

$$r_{CH_{1.193}O_{0.4083}} \rightarrow = 4.26 \cdot 10^6 \exp\left[\frac{-70 \cdot 10^3}{L_g T_g}\right] C_{CH_{1.193}O_{0.4083}}, \qquad (1)$$

where L_g is the universal gas constant, kJ/(kmol · K); T_g is gas temperature [7, 8], K; $C_{CH_{1.193}O_{0.4083}}$ is concentration of oxygen-containing compound in the gas phase [9, 10], kmol/m³.

Therefore, the values of the rates of release of volatile substances and their thermal decomposition are close, so that the value $R_{CH_{1.193}O_{0.4083}} \rightarrow 0$ (see the first and last terms of the right-hand side of equation (17) [4]). However, the gradients of the heating rates of peat granules in options 1 and 4 in the same time interval differ significantly. In the first option, the heating rate of the dispersed phase is 2.1 times higher than in the fourth one. High-speed heating of the dispersed phase in option 1 resembles the process of high-speed bertinization [11, 12], in which the tar is practically not released, and thus obtained py-
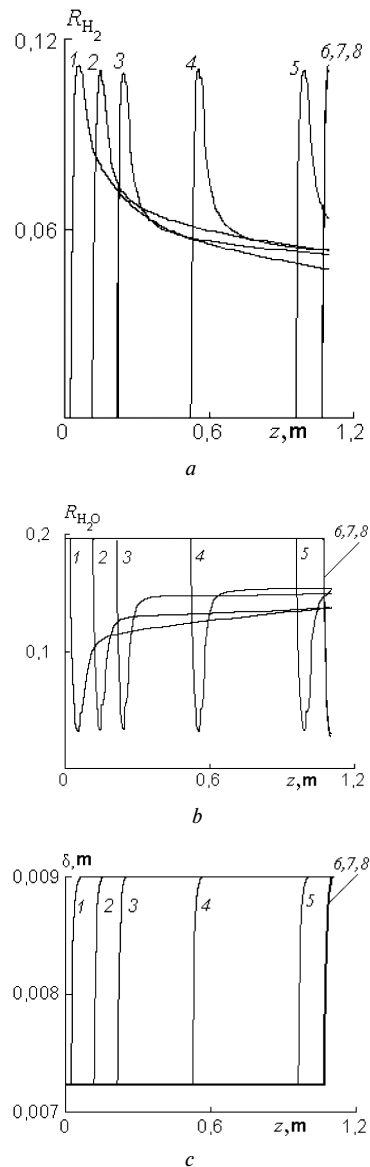

Fig. 6. Distribution of volume fractions of gas components H_2 (*a) and H_2O (b*), particle diameter (*c*) by the height of the fixed bed depending on the time for option 3:

1 − 100 s; 2 − 200 s; 3 − 300 s; 4 − 600 s; 5 − 1,000 s; 6 − 1,500 s; 7 − 1,900 s; 8 − 2,000 s

rolysis gas contains CO_2, H_2O, H_2 and CO [13, 14]. From the analysis of the results of calculation it follows that in both cases the lower limit of the dry distillation zone over time in the intervals is $\tau < 2200$ (option 1) and $\tau < 2400$ s (option 4), where the gasification process of Volyn peat is non-stationary, shifts up along the axis z due to release of volatile substances from the primary fill of peat granules This is clearly seen in Figs. 9, *b*, 10, *a, b*. At time $\tau = 400$ s, the height of the dry distillation zone is $\Delta z = 836$ mm, and at $\tau = 1600$ s is $\Delta z = 238$ mm.

In the pyrolysis zone there is an increase in the curves $R_{H_2O}(\tau, z)$ (curves *1−6* in Fig. 10, *b*), $R_{CH_4}(\tau, z)$, $R_{C_2H_2}(\tau, z)$ due to the decomposition of the oxygen-containing compound $CH_{1.193}O_{0.4083}$, and a decrease in the dependences $R_{CO}(\tau, z)$ and $R_{H_2}(\tau, z)$ (curves *1−6* in Figs. 9, *b*, 10, *a*). The nature of the distribution curves of the gas components CO, H_2 and H_2O in the pyrolysis zone can be explained on as following. In this area, mixing of the volatile substances takes place, and the concentrations of pyrolysis gas components CH_4 and H_2O there significantly exceed the concentrations of CO and H_2 (first reaction (2) [4]), and that in generator gas coming from the gasification zone, with a high content of CO,
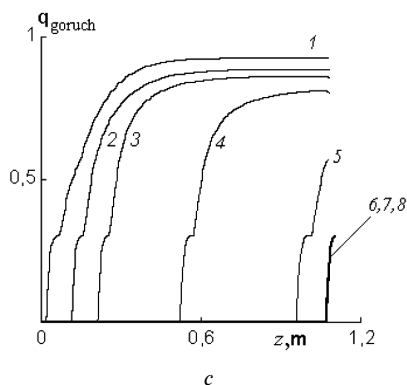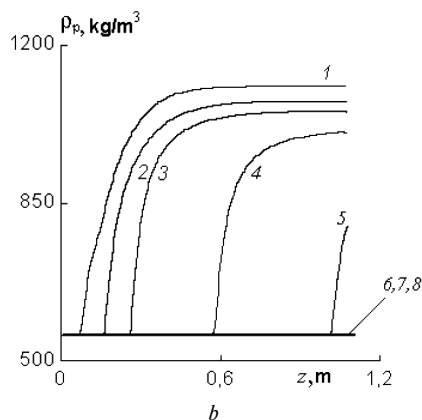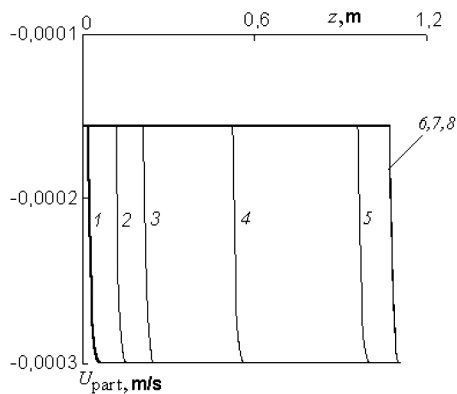
Fig. 7. Distribution of velocities of Volyn peat particles (a), their density (b) and combustible substances (c) in crushed peat through the height of the fixed bed depending on the time for option 3:

1 − 100 s; 2 − 200 s; 3 − 300 s; 4 − 600 s; 5 − 1,000 s; 6 − 1,500 s; 7 − 1,900 s; 8 − 2,000 s

N_2 and H_2. Therefore, when these gas streams are mixing, a decrease in the values of R_{CO} and R_{H_2}, and increase in the values of R_{CH_4}, R_{CO_2}, R_{H_2O} and $R_{C_2H_2}$ are observed. A significant narrowing of the height of the dry distillation zone at a stable stationary working process contributes to a significant reduction in the residence time of peat and gas in the pyrolysis zone. With such a big temperature jump (option 1) and a significant narrowing of the dry distillation zone, slow reactions such as carbonization (decomposition of $C_6H_{10}O_5$ into C and H_2O) do not occur. Using the model [4], it is possible to adjust the height of the dry distillation zone by changing ratio of two velocities: particle velocity and chemical response caused by changing of the proportion of air enrichment with oxygen and water vapor. This follows from equation (9) [4] (the second terms in the left and right parts of equation (9)). This flexible organization of the working process allows adjusting the tem-
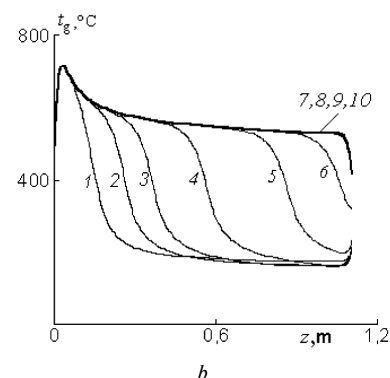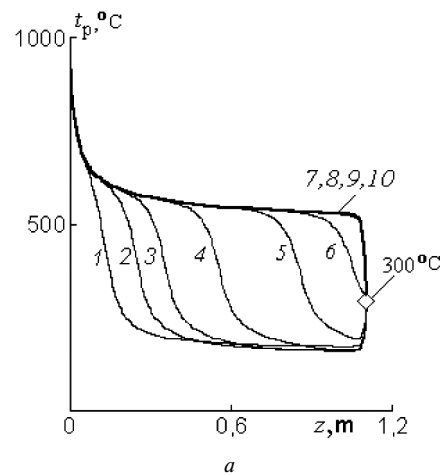

Fig. 8. The temperature distribution of the particles of Volyn peat (a) and gas (b) by the height of the fixed bed depending on the time for option 4:

1 − 200 s; 2 − 400 s; 3 − 600 s; 4 − 1,000 s; 5 − 1,600 s; 6 − 2,000 s; 7 − 2,400 s; 8 − 2,800 s; 9 − 3,000 s; 10 − 3,200 s

perature of the phases at the outlet of the gas generator, and thus regulating the process of thermolysis. This is one of the main practical applications of this model.

In option 4, the intense yield of volatile substances with a constant diameter and velocity of peat particles promotes reduction of the density of particles from 1,176 to 556.5 kg/m³. In the oxidation and reduction zones, where carbon conversion reaches maximum values, there is a sharp decrease in the diameter of peat granules from 9 to 7.3 mm (Fig. 10, *c*) and their speed from −0.000365 to −0.00019 m/s due to the big values of the rates of heterogeneous chemical reactions $C + O_2 = CO_2$, $C + 0.5O_2 = CO$, $C + CO_2 = 2CO$ and $C + H_2O = CO + H_2$ resulting from the high temperatures of the dispersed phase (Fig. 8, *a*). The mechanical unburnt matter at the outlet of the gas generator equals 0.6 %.

Here we present some results of calculations of the process of thermochemical processing of 43,295 kg/h of raw Volyn peat in three reactors with a fixed bed at a pressure of 1.5 MPa. In this case, in each gas generator under the grate with a diameter of 4.215 m, it is necessary to feed a steam-air mixture enriched with oxygen with the following composition: $B_{H_2O} = 997.5$; $B_{O_2} = 2,686$; $B_{N_2} = 3,990$ kg/h (here B_{H_2O}, B_{O_2}, B_{N_2} are the steam, oxidant and nitrogen consumption). After purification in the chamber *17* from heavy hydrocarbons C_2H_2 and small peat particles, the synthetic gas *6*, which came out of the gasifiers, is mixed with the evaporated moisture of the source peat *26* and after relieving excess pressure in the gas turbine *34* enters the gas burners *8* (Fig. 1 [4]).

In the furnace of the TPP-210A boiler *7* a joint combustion takes place of 54,936 kg/h of peat gas (30 % of fuel energy) and 42,876 kg/h of coal powder supplied to vortex burners *5*
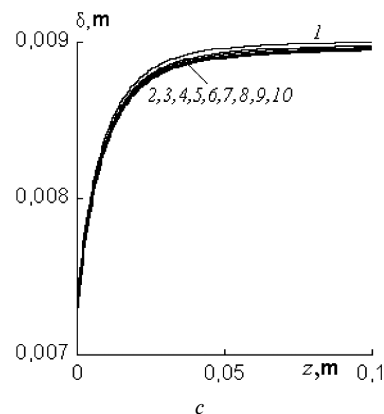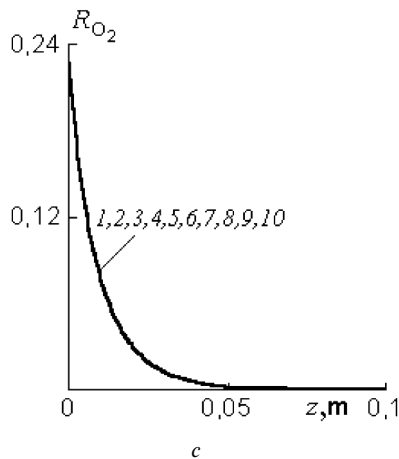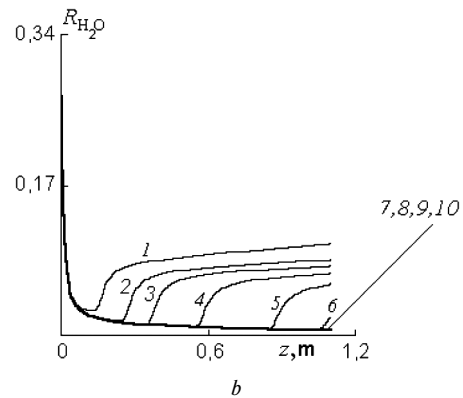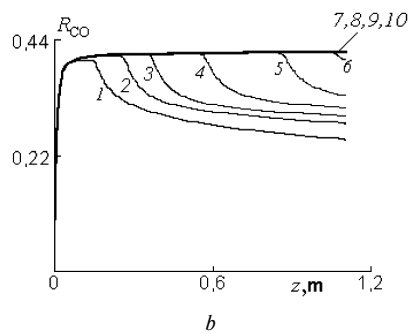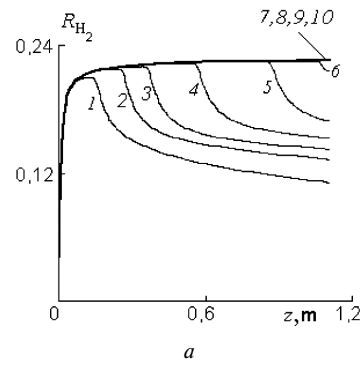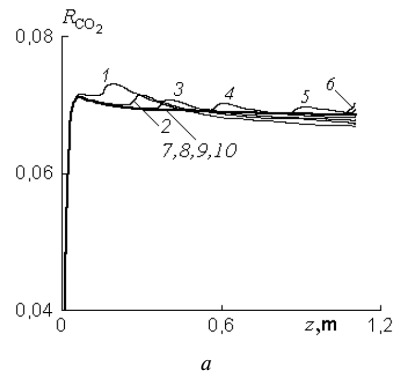
Fig. 9. Distribution of volume fractions of gas components CO_2 (a), CO (b) and O_2 (c) by the height of the fixed bed depending on the time for option 4:

1 − 200 s; 2 − 400 s; 3 − 600 s; 4 − 1,000 s; 5 − 1,600 s; 6 − 2,000 s; 7 − 2,400 s; 8 − 2,800 s; 9 − 3,000 s; 10 − 3,200 s

Fig. 10. Distribution of volume fractions of gas components H_2 (a) and H_2O (b), and particle diameter (c) of Volyn peat by the height of the fixed bed depending on the time for option 4:

1 − 200 s; 2 − 400 s; 3 − 600 s; 4 − 1,000 s; 5 − 1,600 s; 6 − 2,000 s; 7 − 2,400 s; 8 − 2,800 s; 9 − 3,000 s; 10 − 3,200 s

(Fig. 1 [4]) of the combustion chamber. The mass fractions of gas components of peat gas at the inlet to the furnace are the same as in the first option [4]. A detailed description of the combustion process of the binary mixture under consideration is presented in the third part of this work.

Previously, calculation options was described when peat gas cleaned of tar and dust particles is mixed with evaporated moisture from the raw peat *26* and then after the turbine *34* fed to gas burners *8* (Fig. 1 [4]). As was noted in the first part of the work, the disadvantages of this approach are the reduced heat from the combustion of peat gas due to the presence of water vapor and possible condensation of H_2O in the gas turbine, which promotes an erosion of its blades. To eliminate these shortcomings, it is necessary to discharge evaporated moisture *26* and spent drying agent *38* past the boiler through the pipeline *32* (Fig. 1 [4]). In this case, in the cleaning chamber *17* the purification of crude peat gas from tar, dust and H_2O is provided. After passing the gas turbine, 43,258 kg/h (30 % of fuel energy) of the dried purified peat gas is supplied to the gas burners *8* of the TPP-210A boiler *7* (Fig. 1 [4]) for co-firing

with 42,886.8 kg/h of gas coal powder. The mass fractions of the components of this gas at the inlet to the furnace are as follows: $H_2 = 0.00934$; $CO = 0.523$; $CO_2 = 0.087$; $CH_4 = 0.0785$; $H_2S = 0.0061$; $N_2 = 0.2956$.

Conclusions. In the second part of the work, using the model of solid fuels gasification described in [4], numerical studies on the process are performed of the thermochemical processing of peat in three reactors with a fixed bed at a pressure of 1.5 MPa (options 2–4). The following results were obtained:

a) in option 4, in the interval of $2,400 < \tau < 3,200$ s the zone of maximum heat release is adjacent to the grate, thus forming a stable (stabilized) stationary process of the peat thermochemical processing with mechanical unburnt matter of $q_{4,4} = 0.6$ %;

b) by reducing the velocity of peat particles from −0.000365 to −0.0003 m/s (option 3) in the time interval of $1,500$ s $\leq \tau$, it is possible to achieve a stable and stationary gasification process with mechanical unburnt matter $q_4 = 0$. Here the largest

portion of the height of the reactor is occupied with a slag bed 1.0725 m in height, while the reaction zone is only 33.9 mm thick. By this reason, at the outlet of the reactor in the gas mixture there is a small amount of $R_{H_2O} = 3.06$ and $R_{O_2} = 1.83\%$ available, which indicates the insufficiency of the height of active zone. Therefore, option 1 [4] is better than the third one;

c) with a mass content of H_2O in the vapor-air mixture of 13 (option 1 [4]) and 23 % (option 4) in areas where the process of thermochemical processing of solid fuel is stationary, the combustible components of the generator gas (in terms of dry weight) are the following: in option 1, $CO + H_2 = 66.01\%$, in the option 4, $CO + H_2 = 64.38\%$, while the content of CO and H_2 in option 1 is 26.5 % higher and is 71.46 % lower, respectively, than in option 4. Since the calorific value of carbon monoxide is higher than the calorific value of hydrogen, the calorific value of the generator gas in the first option is greater than in the fourth one;

d) in option 4, after gasification in stationary mode ($\tau > > 2,400$ s) of 28,939 kg/h raw peat in three gas generators, 33,794.5 kg/h of crude synthetic gas is formed, which after purification from tar and dust is mixed with 5,469.5 kg/h of evaporated moisture of the raw peat *26* and after the discharge of excess pressure in the turbine *34* feed in the amount of 37,511 kg/h to the gas burners of the furnace of TPP-210A boiler. The mass fractions of the components of this gas at the inlet to the furnace are: $H_2O = 0.222$; $H_2 = 0.0124$; $CO = = 0.3556$; $CO_2 = 0.1396$; $CH_4 = 0.059$; $H_2S = 0.0046$; $N_2 = = 0.2072$. This is the initial condition for the co-firing of 37,511 kg/h of synthetic gas (20 % of fuel energy) with 47,963 kg/h of gas coal powder, which will be described in detail in the third part of this work;

e) numerical studies are conducted of the gasification process of 43,295 kg/h of raw Volyn peat in three reactors with a fixed bed at a pressure of 1.5 MPa. At the outlet of the three gas generators after purification from heavy hydrocarbons C_2H_2 and discrete phase, the synthetic gas is mixed with evaporated moisture of the raw peat and enters in the amount of 54,936 kg/h (30 % of fuel energy) the gas burners of the boiler. This is the initial condition for the co-firing mode of 54,936 kg/h of peat gas with 42,876 kg/h of coal powder supplied to the vortex burners of the combustion chamber. The mass fractions of peat gas components at the inlet to the furnace are the same as in the first option [4]. The study of this process is set out in the third part of this paper;

f) the disadvantages of the approach described in paragraphs d) and e) are the reduced heat release from the combustion of peat gas due to presence of water vapor and the possibility of condensation of H_2O in the gas turbine, which promotes erosion of its blades. To eliminate these shortcomings, it is proposed not to mix the evaporated moisture of the fuel and the spent drying agent with peat gas. In addition, in the purification chamber it is necessary to condense the pyrolysis moisture of the raw generator gas and supply 43,258 kg/h (30 % of fuel energy) of dry peat gas in series to the turbine, and then to the gas burners of the TPP-210A boiler for co-firing with 42,886.8 kg/h of gas coal powder. The mass fractions of the components of this gas at the inlet to the furnace are: $H_2 = = 0.00934$; $CO = 0.523$; $CO_2 = 0.087$; $CH_4 = 0.0785$; $H_2S = = 0.0061$; $N_2 = 0.2956$;

g) with the aid of the constructed model [4], it is possible to adjust the height of the pyrolysis zone by changing the ratio of two velocities: the velocity of peat particles and the rate of chemical response by changing the proportion of air enrichment with O_2 and H_2O. This flexible organization of the working process allows adjusting the temperature of the phases at the outlet of the gas generator, and therefore controlling the process of thermolysis. This is one of the main practical applications of using this model.

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Спільне спалювання дрібнодисперсного пилу газового вугілля й синтетичного торф'яного газу. Частина 2. Числові дослідження процесу термохімічної переробки торфу у фіксованому шарі

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Мета. Дослідити процес газифікації торфу в газогенераторах із фіксованим шаром під тиском 1,5 МПа та сформувати початкові умови на вході до скидних пальників, необхідні для спалювання бінарної суміші.

Методика. Об'єктами досліджень були торф'яні гранули волинського торфу. Для розрахунку процесу газифікації торф'яного газу використовувалась побудована модель термохімічної переробки твердого палива, описана в першій частині роботи авторів.

Результати. Показано, що на ділянці, розташованій близько до верхньої межі фіксованого шару, де процес газифікації торфу є стаціонарним, відбувається стрибок температури торф'яних частинок із 300 до 772 °C, за якого смола практично не виділяється, а отриманий таким чином піролізний газ містить CO_2, H_2O, H_2 та CO. Отримані конструктивні та фізико-хімічні характеристики газогенераторів і сформовані початкові умови на вході до скидних пальників камерної топки парогенератора ТПП-210А.

Наукова новизна. Показано, що при зниженні швидкості руху частинок торфу між зоною максимальних тепловиділень і колосниковою решіткою формується шлакова подушка, яка складається з охолоджених золових частинок, що захищають решітку від перегріву. За такої організації процесу вдається досягти стаціонарності процесу газифікації з механічним недопалом, рівним нулю.

Практична значимість. Показано, що за допомогою моделі термохімічної переробки твердого палива з'являється можливість регулювання висоти зони сухої перегонки шляхом зміни швидкості руху дисперсної фази та швидкості протікання гетерогенних і гомогенних хімічних реакцій за рахунок зміни частки збагачення повітря O_2 або H_2O.

Ключові слова: *нерухомий шар, вугілля, торф, теплопровідність, пароповітряна газифікація, кондуктивний і радіаційний теплообмін*