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PREPARATION OF COAL BRIQUETTES BASED ON COAL FINES WITH THE ADDITION OF VINYL CHLORIDE AND POLYETHYLENE TEREPHTHALATE

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ABSTRACT
The object of the study is substandard coals of Kazakhstan and solid organic waste in the form of polymers. The effect of additives of chlorvinyl and polyethylene terephthalate on the energy properties of coal briquettes was researched. When coal fines and chlorvinyl are mixed, the phenomenon of adsorption occurs–spontaneous concentration of chlorvinyl on the surface of coal. According to SEM, gaseous chlorovinyl in the presence of coal is characterized by coarsening of particles into a solid polymer phase with a slight increase in temperature due to adhesion and the formation of larger aggregates. When added to the composition of polyethylene terephthalate briquettes with different concentrations, the calorific value of briquettes increases linearly. Clay was used as a safe binder, preventing coal briquettes from falling apart. The optimization of the composition of coal briquette involved the addition of both clay and polyethylene terephthalate to the composition of briquettes. The presence of these two components will allow to obtain the optimal composition of durable briquettes with a constant calorific value in the range Q = 20-25 kJ / kg.

Keywords: coal briquette, substandard Kazakhstan coal, vinyl chloride, polyethylene terephthalate.

INTRODUCTION
About a quarter of the total coal mined has a fine and dusty fraction [1-4]. This type of fuel is not in demand among consumers because of the low heat output. It is also inconvenient for heating private houses: it wakes up through the grate and therefore has low efficiency, often a large amount of small or pulverized fuel blocks the access of oxygen, which causes the stove to die out [5-8]. For these reasons, a lot of dust and coal of small fractions (up to 6 mm in size) accumulate in warehouses, in fuel sheds in private courtyards. Briquettes made of coal are well tolerated by transportation and storage, have a higher calorific value compared to the starting materials (at least 6,000 kcal / kg), do not emit smoke and gases, burn out completely, without sintering, and decay into ash (ash quality coal briquette no more 10% of the volume, but usually much less) [9-12]. Coal fines from the central regions of Kazakhstan with sizes of 0-5 mm and more without binders are not briquetted into strong pieces, the resulting briquettes spontaneously crumble. Only with grinding to 0.1 mm and pressing pressure up to 25 MPa, it was possible to obtain relatively strong briquettes, however, the obtained briquettes did not have water and heat resistance [13-18]. It is known that the use of unconventional binders is carried out in order to optimize the composition of briquettes and to increase energy characteristics [19-25]. Despite the wide variety of binders, there has recently been a shortage of available, environmentally friendly and relatively cheap binders that provide the creation of briquettes for the chemical and metallurgical industries that have the necessary technological requirements [25, 26]. When selecting binders, it is necessary to take into account their technological properties: the simplicity of preparation for use, the presence of surfactant properties (to reduce the energy of interaction of coal particles and lower briquetting pressure), high adhesion or stickiness to the surface of the dispersed phase, manufacturability (low pressing pressure, low consumption, low energy intensity of briquette production) [26-29].

The object of this research is substandard coals of the central region of Kazakhstan and solid organic waste in the form of polymers. In this work, studies were carried out on the effect of chlorvinyl and polyethylene terephthalate additives on the energy properties of coal briquettes.

EXPERIMENTAL
For the experimental work, solid polymer residues were heated and then machined together with coal. The resulting mixtures were carefully stored with safety precautions in order to protect against oxidation, possible sources of pollution, which may be reagents, atmosphere, and dust.

Earlier, it was found that coal fines from coals of the central regions of Kazakhstan (0-5 mm and more) in the absence of binders cannot be briquetted into strong pieces of acceptable size for use, the prepared briquettes spontaneously crumbled. It was determined that when taking fractions up to 0.1 mm and pressing pressure of about 25 MPa, it was possible to prepare strong briquettes. However, the prepared briquettes did not have the necessary values of water and heat resistance [14, 30-32].
For experiments a laboratory unit for the production of chlorvinyl, consisting of three autoclaves was assembled. In the first autoclave (below) there was calcium carbide, in

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the second autoclave there was a solution of diluted hydrochloric acid, in the third autoclave there was a suspension of coal sludge. To obtain acetylene, a small amount of water was dug into calcium carbide, after which a rapid reaction of acetylene secretion began, and table salt was used to slow down this process. The outgoing flow of acetylene was passed through a solution of hydrogen chloride, then the stages of drying were carried out. Finally, a drained stream of acetylene was fed into an autoclave with coal sludge.

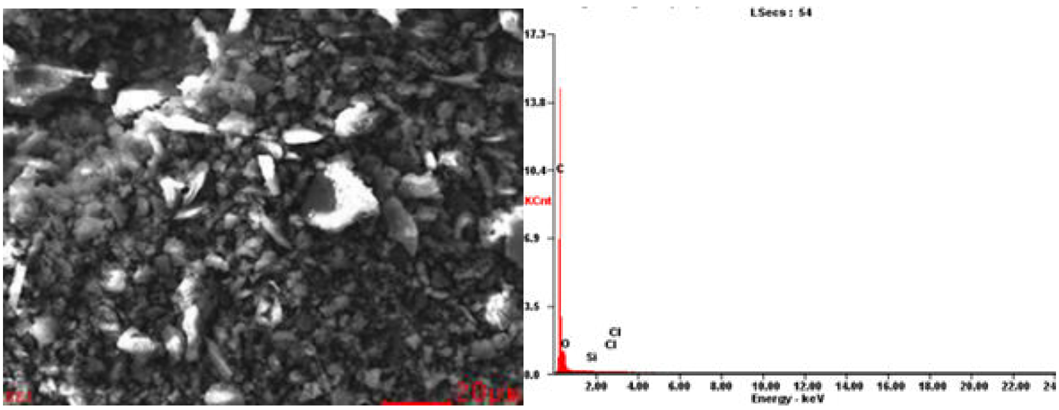
The process of hydrochlorination, with the preliminary stages of obtaining acetylene gas and passing it through a hydrogen chloride solution in the presence of a catalyst can be described by the following reaction:

$C_2H_2 + HCl \rightarrow (HgCl_2) \rightarrow CH_2{=}CHCl$.

The resulting gas was passed through the composition of coal briquettes at a temperature of 150-200°C.

RESULTS AND DISCUSSIONS

It was found that the mixture of all components in the composition of coal briquettes is in a solid state of aggregation. Finished coal briquettes are a coherent dispersed system (Figure-1), in which the dispersed phase cannot move freely in a continuous medium. The hardening of briquettes through polymerization reactions is achieved by the appearance of intermolecular bonds between the solid phase of the coal charge and the binder medium of vinyl chloride, which leads to the formation of a structured polymer matrix. The resulting coherent dispersed system, in contrast to the free-dispersed, has new qualities: strength, elasticity and ductility.



(a) (b)

Figure-1. SEM image (a) and of elemental composition of a coal briquette without adding vinyl chloride (b).

The fine dispersion of substandard coals also determines a large specific interface between the phases, which leads to a significant excess of surface energy on the surface of coal and vinyl chloride vapors. The process of the formation of the polymer matrix was checked by Raman spectra (Figures-2, 3) by comparing the vibrational spectra of the initial coal and coal after polymerization.

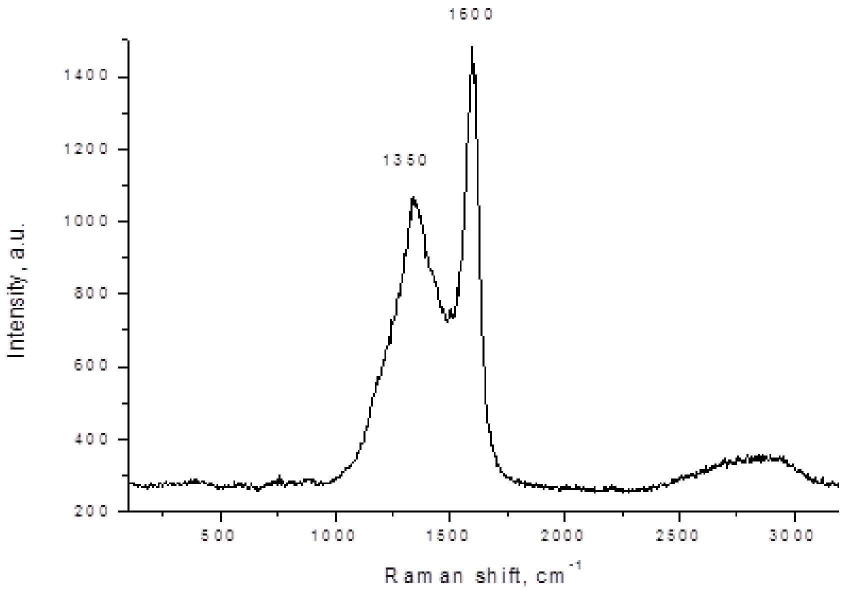


Figure-2. Raman spectrum of the initial coal.

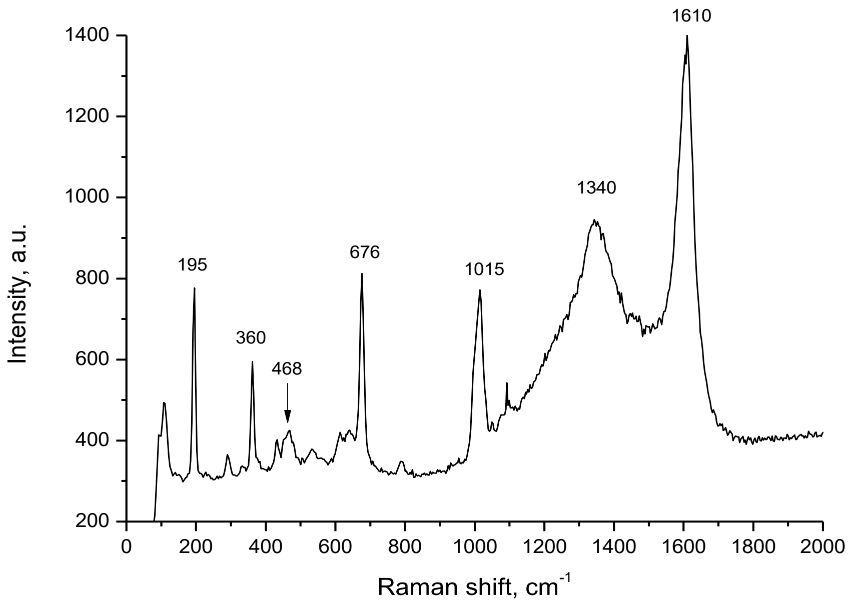


Figure-3. Raman spectrum of coal after polymerization.

Particles of a binder component, gaseous chlorvinyl, are characterized by coarsening of particles into a solid polymer phase with a slight increase in temperature. This is due to adhesion and the formation of larger aggregates - polymer coagulants. This process is accompanied by physicochemical and thermal processes such as adsorption, adhesion, coagulation and the formation of new phases. When coal fines and binder (chlorvinyl) are mixed, the phenomenon of adsorption occurs, i.e. spontaneous concentration of chlorvinyl on the surface of coal (Figure-4).

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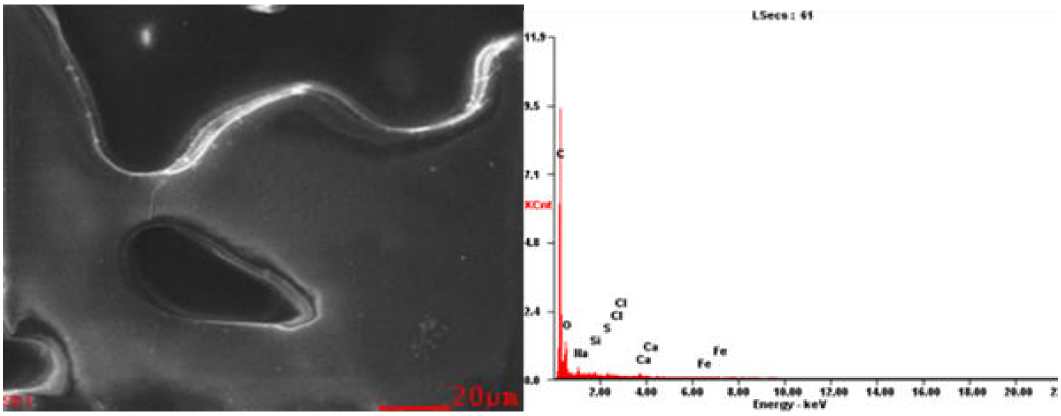

(a) (b)

Figure-4. SEM image of the coal briquette (a) and elemental composition of the coal briquette (b).

The SEM image of the briquette (a) and the elemental composition of the briquette (b) (Figure-4) indicated the formation of polyvinyl chloride in the briquette structure. In this case, in the synthesis of briquettes on the surface of the coal, adsorption of binder molecules occurs, i.e. coal particles are adsorbents. The part of the binder located in the space between the solid particles of coal is an adsorbent. Part of the binder adhering to the surface of the solid particles is an adsorbate. That is, in the process of preparing a coal briquette, both physical sorption and chemical sorption occur [33, 34].

Thus, the interfacial interaction between the surface of coal and gaseous vinyl chloride brings into contact condensed bodies of different nature. In this case, adhesion of chlorovinyl to polyvinyl chloride in the presence of coal particles provides a connection of a certain strength between the particles of briquettes, which can occur due to physical or chemical molecular forces.

In this work also the change in the strength characteristics of briquettes using polyethylene terephthalate (PET) has been investigated. For this purpose, in the process of preparing briquettes to improve the strength, calorific value and energy properties of briquettes, additives of PET were also used.

Experiments with different concentrations of PET mixed with coal showed that with an increase in the concentration of this binder, the calorific value of the briquettes increases linearly. This is due to the increase in the composition of the briquettes in the quantity of organic (combustible) components: original calorific value of the organic (combustible) substances is in the range of 39-45 kJ/kg, whereas the original calorific value of coal is 20-35 kJ/kg. it is Obvious that the calorific value of the binder of polyethylene terephthalate significantly increases the calorific value of the briquettes, however, and increases the speed of combustion. With an increase in the concentration of non-combustible component-bentonite clay-essentially ballast-the calorific value of briquettes, as expected, decreases (Figure-5).

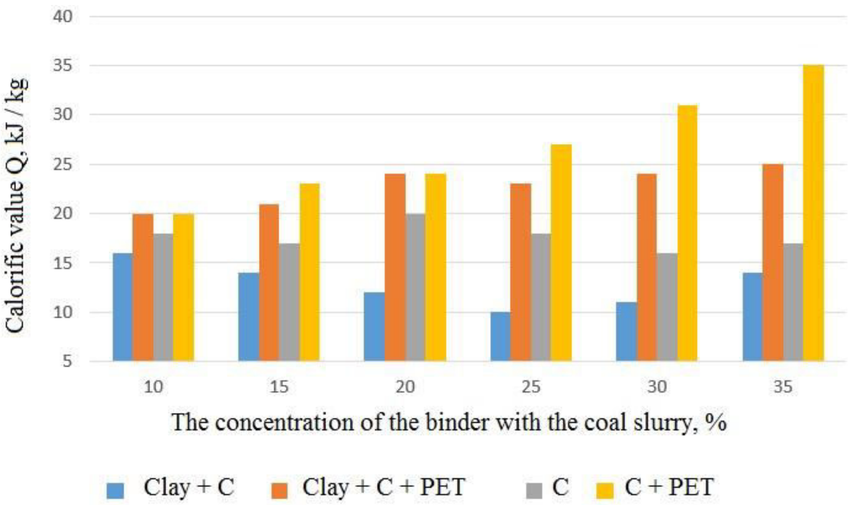

Figure-5. Change in the calorific value of coal briquettes at various concentrations of binder.

As can be seen from the Figure-5, coal slurry itself does not have a constant calorific value, but the limit of change of this parameter is about 7-10%. This circumstance can be explained by the fact that often coals from the same deposit can differ in their physicochemical parameters. Moisture content is one of the factors affecting the properties of coal briquettes. Moisture content directly reduces the calorific value. Brown coals that are of “a young age” have a higher moisture content. It was revealed that the addition of PET to the coal leads to an increase in the calorific value of briquettes to Q = 35 kJ/kg. A direct increase in this parameter is associated with an increase in the amount of polymer-containing product. In a polymer-containing product, the net calorific value can typically be in the range of 40-50 kJ/kg. At the same time, the presence of clay and mineral components in the composition of coal briquettes, on the contrary, leads to a decrease in the calorific value of the briquette to Q = 12 kJ/kg. Optimization of the composition of the briquette implies the addition of both clay and PET to the briquettes. The presence of both of these components will make it possible to obtain the optimal composition of briquettes having a constant calorific value in the range of Q = 20-25 kJ/kg.

CONCLUSIONS

Thus, a study on the synthesis of coal briquettes based on substandard coals of Kazakhstan deposits with the addition of vinyl chloride and polyethylene terephthalate was performed. It has been established that the hardening of coal briquettes occurs through polymerization reactions with the appearance of intermolecular bonds between the solid phase of the coal charge and the binder medium with vinyl chloride. This causes the formation of a structured polymer matrix. To optimize the composition of the briquette, it is necessary to introduce an addition of clay and PET. The addition of both components makes it possible to obtain an optimal composition of long-lasting briquettes with a constant calorific value in the range Q = 20-25 kJ / kg.

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