IDENTIFYING THE QUANTITY OF COMBUSTION HEAT WHEN BRIQUETTING OIL WASTE PROCESS

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Abstract. During the works by calculation, there were grounded the makeup of fuel briquettes, which are produced from oil wastes, coal and biomass - rice husk. Within changing considered makeups and concentration, combustion heat values calculated, which in future will allow to compare the experimental values of the fuel characteristics of the briquettes with an assigned structural composition

Keywords: oil, oil waste, ecology, briquettes, fuel, rice husk, coal, energy.

Briquetted fuel is mechanical and thermal robust sorted product and it has specific geometric shape, size and mass. It is obtained in the result of physical and chemical process using additives (binding) or without them. Briquettes should meet the following requirements: to have atmospheric constancy, mechanical strength, sufficient porosity, temperature stability, to contain minimal quality of moisture [1].

Using technology of briquetting off-spec coal will fully avoid ecological costs and profit by additionally produced commercial product-briquettes.

During the work process it was proposed to use mixture of fibred structure-forming agent which is not binding. It is expected that these structure-forming agents will act the part of peculiar kind of “armature” reinforcing briquettes.

On the basis of performed researches, the operating practises of briquetting process have been fixed. The content of mixture, which consists of off-spec coal, rice husk and asphalt, resin and wax deposits, has been determined.

Varieties of all complicated physical-chemical and structural-rheological processes, which are performed in the period of forming structural carcass of briquette, based on great number of independent factors. Therefore it is necessary to determine more essential factors with significant influence on intensity of adhesive and autohesive and cohesive interactions, as during preparation of briquette mixture like pressing. Analysis results makes the best use of positive factors during development of optimal composition of briquetted fuel using asphalt, resin and wax deposition, coal and rice husks.

Among the main factors, effecting significant structure-forming action in the system of “asphalt, resin and wax deposition – coal – rice husks” first off, it is necessary to indicate chemical nature and physical characteristic of asphalt, resin and wax deposition, coal and rice husks, their relation in the system and to condition of interaction.
Dominant role in the forming solid frame structure of coal briquettes is fulfilled by binding agent. Influence of binder is determined by physical-chemical and structural rheological properties complex, whereas the main among them is adhesiveness and cohesiveness depend on chemical nature of binder. Moreover, the temperature, humidity, thickness of gluing skim of binder affects the processes of structure formation.

Asphalt, resin and wax deposition, coal and rice husks are suggested to apply for briquetting culm as binding agents which are capable to connect discrete solid and keep them strong in the condition of significant external influence, i.e. to provide briquettes obtaining strong structure [1, 2, 3].

Structure of coal briquette can be considered as a system consisting of binding elements by location (in dispersion medium – binding resin, asphalt and wax deposition, and dispersion phase – coal and rice husk).

Bounding process is carried out under the influence of temperature between solid particles during mechanical impact process of coal-asphalt, resin and wax deposition – husk. Finally solid binding mixture is formed. Then the mixture is poured into different form and pressed in a certain temperature.

Heating value of briquettes will be higher than initial coal by means of increasing their density in comparison with initial coal, if their ash level is not increased by nonorganic binding.

During fuel combustion it produces heat, and obtained heat is applied in the technologic process or turns to different energy. One of the heat producers is carbonic substance.

For instance, under the test in this case, makeup and structure of asphalt, resin, and wax deposition is a complex carbon-hydrogen binding. These oil wastes content: 80.0÷86.0 % carbon, 7.0÷9.0 % hydrogen, before 9.0 % - sulphur, 1.0÷9.0 % oxygen and 1.5 % - nitrogen. And there are small amount of resin, oil, water and mechanical impurities as well.

General equation of combustion reaction of any hydrocarbon as follows.

$$C_mH_n + (m + n / 4)O_2 = mCO_2 + (n /2)H_2O + Q$$

(1)

here $m, n$ – are numbers of carbon and hydrogen atoms in molecule, $Q$ – heat effect reaction or heat of combustion. Heat of combustion is called the energy to be released during combustion of 1 kg fuel.

Due to this mathematical model of combustion process of solid fuel is made up. Submitted differential equations are considered all passable physical-chemical processes during fuel of briquette combustion. The methods of phenomenological thermodynamics were applied taking into account of combustion dynamics [4].

Low combustion of heat is the most important of characteristic of fuel and it is determined experimentally for each substance. When the composition of element is identified, then the heat of combustion is determined by D.I. Mendeleyev’s formula.

$$Q_{h}^{p} = 339C^{p} + 1256H^{p} - 109(O^{p} + S_{L}^{p}) - 25.14(9H^{p} + W^{p})$$

(2)

here $C^{p}, H^{p}, O^{p}, S_{L}^{p}, W^{p}$ – fuel elements: carbon, hydrogen, oxygen, sulfur and the common value of humidity.

On the basis of carried out researches, the number of heats of combustion of considered fuel briquette is identified. For this purpose we performed calculation, changing concentration of briquette components in possible diapason. Software program is prepared for calculation and received results are given in tables 1-4 and picture 1.

### Table 1. Heat of briquettes combustion, when the concentrate of all components are variable

| Natural heat of combustion | Composition of briquette | Proportion of mixture | Heat of combustion $Q$, kilocalorie |
|---------------------------|--------------------------|----------------------|-------------------------------------|
| Resin, asphalt and wax deposition | coal | Rice husk | Resin, asphalt and wax deposition | coal | Rice husk |
| kcal/kg | kcal/kg | kcal/kg | Weight part | Weight part | Weight part |
| 10400 | 6500 | 3180 | 0 | 0.9 | 0.1 | 1 | 6168 |
| 10400 | 6500 | 3180 | 0.05 | 0.8 | 0.15 | 1 | 6197 |
|-------|------|------|------|-----|------|---|------|
| 10400 | 6500 | 3180 | 0.1  | 0.7 | 0.2  | 1 | 6226 |
| 10400 | 6500 | 3180 | 0.15 | 0.6 | 0.25 | 1 | 6255 |
| 10400 | 6500 | 3180 | 0.2  | 0.5 | 0.3  | 1 | 6284 |
| 10400 | 6500 | 3180 | 0.25 | 0.4 | 0.35 | 1 | 6313 |
| 10400 | 6500 | 3180 | 0.3  | 0.3 | 0.4  | 1 | 6342 |
| 10400 | 6500 | 3180 | 0.35 | 0.2 | 0.45 | 1 | 6371 |
| 10400 | 6500 | 3180 | 0.4  | 0.1 | 0.5  | 1 | 6400 |
| 10400 | 6500 | 3180 | 0.45 | 0  | 0.55 | 1 | 6429 |

**Table 2.** The results of the calculation, where the value of rice husk is used constantly (10%) and other compositions make different values

| Natural heat of combustion | Composition of briquette | Proportion of mixture | Heat of combustion Q, kilocalorie |
|---------------------------|--------------------------|----------------------|----------------------------------|
| Resin, asphalt and wax deposition kcal/kg | heat of combustion kcal/kg |  
| 10400 | 6500 | 3180 | 0 | 0.9 | 0.1 | 1 | 6168 |
| 10400 | 6500 | 3180 | 0.05 | 0.85 | 0.1 | 1 | 6363 |
| 10400 | 6500 | 3180 | 0.1 | 0.8 | 0.1 | 1 | 6558 |
| 10400 | 6500 | 3180 | 0.15 | 0.75 | 0.1 | 1 | 6753 |
| 10400 | 6500 | 3180 | 0.2 | 0.7 | 0.1 | 1 | 6948 |
| 10400 | 6500 | 3180 | 0.25 | 0.65 | 0.1 | 1 | 7143 |
| 10400 | 6500 | 3180 | 0.3 | 0.6 | 0.1 | 1 | 7338 |
| 10400 | 6500 | 3180 | 0.35 | 0.55 | 0.1 | 1 | 7533 |
| 10400 | 6500 | 3180 | 0.4 | 0.5 | 0.1 | 1 | 7728 |
| 10400 | 6500 | 3180 | 0.45 | 0.45 | 0.1 | 1 | 7923 |

**Table 3.** Results of calculation for determining heat of briquette combustion, coal constant value (40%), and when the other components are changed

| Natural heat of combustion | Composition of briquette | Proportion of mixture | Heat of combustion Q, kilocalorie |
|---------------------------|--------------------------|----------------------|----------------------------------|
| Resin, asphalt and wax deposition kcal/kg | heat of combustion kcal/kg |  
| 10400 | 6500 | 3180 | 0 | 0.4 | 0.6 | 1 | 4508 |
| 10400 | 6500 | 3180 | 0.05 | 0.4 | 0.55 | 1 | 4869 |
| 10400 | 6500 | 3180 | 0.1 | 0.4 | 0.5 | 1 | 5230 |
| 10400 | 6500 | 3180 | 0.15 | 0.4 | 0.45 | 1 | 5591 |
| 10400 | 6500 | 3180 | 0.2 | 0.4 | 0.4 | 1 | 5952 |
| 10400 | 6500 | 3180 | 0.25 | 0.4 | 0.35 | 1 | 6313 |
| 10400 | 6500 | 3180 | 0.3 | 0.4 | 0.3 | 1 | 6674 |
| 10400 | 6500 | 3180 | 0.35 | 0.4 | 0.25 | 1 | 7035 |
| 10400 | 6500 | 3180 | 0.4 | 0.4 | 0.2 | 1 | 7396 |
| 10400 | 6500 | 3180 | 0.45 | 0.4 | 0.15 | 1 | 7757 |
**Table 4.** Average value of heat of combustion when the concentration of all components are changed

| Natural heat of combustion | Composition of briquette | Средняя Heat of combustion Q, kilocalorie |
|---------------------------|--------------------------|------------------------------------------|
| Resin, asphalt and wax deposition | coal kcal/kg | Rice husk kcal/kg | All components are changed Heat of combustion Q, kilocalorie | Rice husk is constant Heat of combustion Q, kilocalorie | coal is constant Heat of combustion Q, kilocalorie |
| kcal/kg | kcal/kg | kcal/kg | Heat of combustion Q, kilocalorie | Heat of combustion Q, kilocalorie | Heat of combustion Q, kilocalorie |
| 10400 | 6500 | 3180 | 6168 | 6168 | 4508 | **5614** |
| 10400 | 6500 | 3180 | 6197 | 6363 | 4869 | **5809** |
| 10400 | 6500 | 3180 | 6226 | 6558 | 5230 | **6004** |
| 10400 | 6500 | 3180 | 6255 | 6753 | 5591 | **6199** |
| 10400 | 6500 | 3180 | 6284 | 6948 | 5952 | **6394** |
| 10400 | 6500 | 3180 | 6313 | 7143 | 6313 | **6589** |
| 10400 | 6500 | 3180 | 6342 | 7338 | 7035 | **6784** |
| 10400 | 6500 | 3180 | 6371 | 7533 | 7396 | **7174** |
| 10400 | 6500 | 3180 | 6400 | 7728 | 7757 | **7369** |

**Figure 1.** Value of heat of briquette combustion obtained for different concentration
On the basis of the above, mathematical model of determining heat of combustion is fixed. Taking into account of all condition and accepted amendment, the system of equation was obtained, determining the process of heat of combustion. Integrating these quotation and applying approximate methods, considering only hydrogen and carbon, on the basis of fixd imitiating mathematical model is targeted the average value of heat of combustion of substatnces, chemical composition which coincides with oil wastes [5].

The most minimal value of heat combustion for fuel briquette is fixed and it is equal to $Q_{\text{min}}=4500$ kcal, and the most maximum value is $Q_{\text{max}}=7923$ kcal.

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