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THE OUTLOOK FOR LOW-GRADE FUELS IN TOMSK REGION: RESEARCH EXPERIENCE AT TOMSK POLYTECHNIC UNIVERSITY

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Abstract. The urgency of the discussed issue is caused by the need to substitute in the regional fuel-energy balances imported energy resources with local low-grade fuels. The main aim of the study is to estimate thermal properties of local fuels in Tomsk region and evaluate its energy use viability. The methods used in the study were based standard GOST 52911-2008, 11022-95 and 6382-2001, by means of a bomb calorimeter ABK-1 and Vario micro cube analyzer. The mineral ash of researched fuels was studied agreeing with GOST 10538-87. The results state the fact that discussed low-grade fuels of Tomsk region in the unprepared form are not able to replace imported coal in regional energy balance, because of the high moisture and ash content values. A promosing direction of a low-temperature fue processing is a catalytic converter, which allows receiving hydrogen-enriched syngas from the initial solid raw.

1 Introduction

The share of imported energy in the regional fuel and energy balance is about 45% [1]. At the same time the cost of transporting those resources is put to their working cost, increasing the final price for energy facilities in several times that is reflected in the size of the heat and electricity tariffs [2 – 4].

In this connection, according to the Energy Strategy of Russia until 2030, power industry will focus on the use of local resources, low-grade fuels (peat, biomass, urban centers wastes). For this purpose the modernization of existing energy units will be aimed to local fuel incineration, as well as commissioning of new thermal power plants will be performed using low-grade fuels [1]. Implementation of these measures should lead to a reduction of the imported fuel share at 1.3-1.5 times [2].

An efficient energy use of local low-grade fuel requires a detailed study of its thermal characteristics and mineral content [3]. This data is necessary for selecting the combustion method and designing of equipment for the selected method implementing.

The aim of the work is to determine thermal properties of Tomsk region local fuels and assess its rational energy use methods.

2 Object of Study

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Tomsk region is rich in peat (29.34 billion tons), lignite (75.7 billion tons) and wood (2.7 billion m^3). The authors investigated the following deposits of low-grade fuel: peat - Sukhovskaya, Arkadievskoe and Kandinsky, lignite - Talovskoye. A various wood species wastes of timber plant “Partner-Tomsk” were also considered.

Sukhovskoe and Arkadievskoe deposits are located near the major population centers of Tomsk region: Sukhovskoe - 12 km north-east from the village Bakchar, Arkadevskoe - 4 km to the north-west of the village Kozhevnikovo. These deposits are formed by lowland peat deposits in the sedge-hypnum marsh area. During the 1986-1995 period the industrial development was conducted on the deposits. Thus, highly mechanized peat enterprises were built close to them, and then ceased to exist in the late 90s [5]. Kandinskoe deposit, located 19 km from the city of Tomsk, is also formed by lowland peat deposits. Currently, clay, sand and gravel are mined at this deposit from under a layer of peat. Peat is stockpiled without any practical application.

The Talovskoye lignite deposit is located at 24-50 km to the southeast from the city of Tomsk. The deposit is estimated to be relatively large with probable lignite reserves about 3.6 billion tons (annual production could reach 10-15 million tons) [5].

3. Research Methods

Thermotechnical characteristics of low-grade fuels were determined by standard methods GOST R 52911-2008, 11022-95 and 6382-2001. The calorific value and element composition were studied using a bomb calorimeter ABK-1 and Vario micro cube analyzer. The composition of the mineral ash was investigated in accordance with GOST 10538-87.

Considering particular qualities of the mechanism of low-grade fuel replenishment, the geographical location of its deposits (disconnected with the rail link and major highways) and production rate, development of considered deposits is rational only for the needs of an autonomous heating facility located in the vicinity. Therefore, the feasibility of their energy use should be estimated applied to small power heating units, characterized, mostly, by using of stocker or gas fire-tube boilers [6, 7].

4. Results

Low-grade fuels are characterized by a high moisture value – from 38 to 73%. Such a high humidity enables suggestion that the burning of researched fuels will be accompanied by high costs associated with the evaporation necessity. Worth noting that the presence of such moisture amounts significantly facilitates the fuel sticking and restricts its production and transportation in winter season.

According to the value of ash-content (one of the most important indicators of the fuel quality), the test samples can be divided into 2 groups: high-ash fuel (Sukhovskoe and Arkadevsky peat, Talovsky coal) and low-ash fuel (Kandinsky peat and wood chips).

The content of calcium oxides (CaO) is more than 13% in combination with a high proportion of silica (SiO_2) in Sukhovskoe and Arkadevsky peat that indicates its propensity to form dense ash deposits during the combustion on the heating surfaces. The composition of the mineral part of coal Talovsky also indicates an increased predisposition to slagging. Wood chips, despite the high content of CaO and SiO_2, due to the low value of ash content are not regarded as a slagging fuel.

The high content of aluminum and titanium oxides in Talovskoe coal demonstrates a potentially high abrasion effect produced by the ash combustion. Considering this, one may conclude that designing of combustion systems for the flue gases velocity estimation in the convective heating zones is supposed to be a complicated task.

Pretty impressive volatile content (63,2-91,9%) shows a high fuel reactivity, low ignition temperature, the absence of the organic part thermal stability. These are important prerequisites for the thermal processing of raw materials in the gaseous fuel.

The obtained values of the carbon (C^{daf} = 50,87-68,38%) and hydrogen content (Hdaf = 5,25-6,28%) cause a sufficiently high calorific value of its combustible matter (Q^{daf} = 18,6-27,1 MJ/kg).

However, high ash-content and moisture of raw fuel reduce its calorific value down to 9.3 MJ/kg in terms of an operating state.

Slight sulfur content (S^{daf} = 0,02-0,44%) shows that the adverse environmental impact of SO_x emissions during combustion is minimal and does not require additional costs for its reduction.

The high content of oxygen (O^{daf} = 24,28-42,70%) characterizes the fuel, as being in the early stages of metamorphism, and points to the possibility of an exothermic reaction during the thermal processing. This statement is confirmed by the experimental data obtained at low the temperature fuel pyrolysis: heat decomposition of organic mass ranged from 1.24 to 3.69 MJ per 1 kg of the dried initial fuel [5].

5. Discussion

Summarizing the results, it is possible to sum up that all the studied raw fuels due to the high operating costs are unsuitable for an effective burning. These costs are caused by high values of the moisture and an ash content in a raw material, leading to the low calorific value in terms of an operating state and the necessity of pre-drying. Moreover, high humidity leads to problems of coal stickiness at transportations in winter, requiring additional time and financial costs for that. The fragility and friability of raw materials cause a high magnitude of a dip during the bed firing.

Mentioned disadvantages can be eliminated by a heat processing of raw materials into energy products of acceptable quality, such as solid composite [8-12], liquid [13-15] or gaseous fuels [16-18]. Given the advantages of the gaseous fuels energy use (possibility of combustion process automating, ecological compatibility, low abrasive deterioration of heating surfaces and intensive heat transfer due to higher flow velocities available), the authors examined processing of low-grade raw material to a gaseous fuel.

A method of producing the hydrogen enriched by a combustible gas [5, 11] was tested, wherein the initial organic material was subjected to low-temperature catalytic conversion (Fig. 1.) to obtain hydrogen-containing gaseous fuel called syngas. Due to the absence of the air blowing with the inlet of superheated steam and iron oxides into the reaction zone high concentration of hydrogen with a minimum of ballasting components is achieved (Table 1.). Low temperatures of the main processes (300-500 ° C) allow less demanding in selecting of the materials for manufacturing plants.

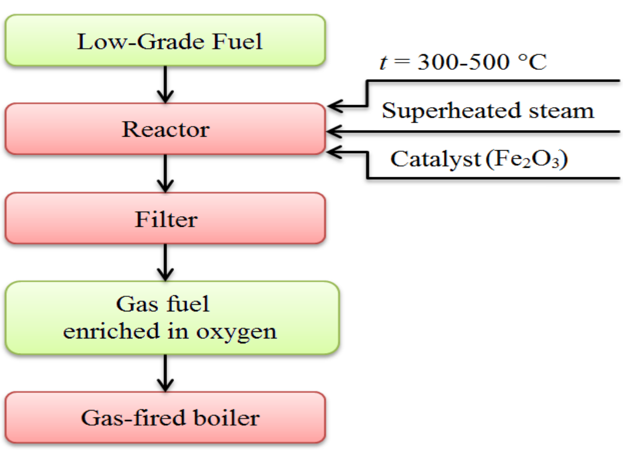

Figure 1. Heat processing of low-grade fuel.

Depending on the type of raw materials and the processing parameters the concentration of hydrogen in syngas can achieve 47,5 % (Table 1.) that, considering thermal properties of hydrogen, shows a high efficiency of low-grade fuels processing for power engineering. Despite the fact, that nowadays syngas has a high use potenial in Power Engineering and Industrial spheres, there is still no commercially available equipment for its employment [19]. Therefore, while power plants designing to burn syngas the issues concerning the existing units applicability of the gas equipment, developed and extensively tested for natural gas combustion are often raised up.

Less in comparison with natural gas, syngas calorific value at the same burner power leads to a higher fuel massflow rate through the nozzle, whereas the amount of air required for stoichiometric combustion is significantly lower because of a high ballast content, thereby the massflow rate through the air channels reduces.

Table 1. The composition of the syngas obtained by Sukhovskoe peat conversion at different temperatures.

Conversion temperature, °C	The components of the hydrogen-containing gas, %			
	H_2	CH_4	CO	Incombustible Residue
300	47,5	13,0	9,0	30,5
350	46,0	20,0	5,0	29,0
400	46,5	25,0	6,5	22,0
450	47,5	27,0	7,5	18,0
500	47,5	27,0	9,0	16,5

6. Conclusion

Discussed low-grade fuels of Tomsk region in unprepared form are not able to replace an imported coal in regional energy balance, because of the high moisture and ash content values. A promising direction of a low-temperature fuel processing is a catalytic conversion, which allows receiving the hydrogen-enriched syngas from the initial solid raw.

The low-temperature catalytic conversion, allowing to receive syngas, high in hydrogen content, from the solid initial raw is a promising way of fuel recycling. The resulting syngas can be effectively used in Power Engineering to produce heat and electricity without expensive upgrades of gas equipment.

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