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ECONOMIC EFFICIENCY OF USE OF COAL PRODUCTION GASEOUS AND SOLID WASTE

ЭКОНОМИЧЕСКАЯ ЭФФЕКТИВНОСТЬ ИСПОЛЬЗОВАНИЯ ГАЗООБРАЗНЫХ И ТВЕРДЫХ ОТХОДОВ ПРИ ДОБЫЧЕ УГЛЯ

©Kuzmina T.
Dr. habil.
Moscow State University of Mechanical Engineering
Moscow, Russia
Tutor007@list.ru
©Кузьмина Т. И.
д–р экон. наук
Московский государственный машиностроительный университет
Москва, Россия
Tutor007@list.ru

Abstract. The article overviews the problem of utilization of the gaseous and solid waste that emerges in the issue of extraction, preparation and burning of coal from the ecological and economic points of view. Moreover, an assessment of efficiency of utilization of coalmine methane as energy raw material is suggested. What is more, the efficiency of use of solid coal waste as a technological raw material is calculated.

Аннотация. В статье рассматривается проблема использования газообразных и твердых отходов, которые появляются в процессе извлечения, подготовки и горения угля с экологической и экономической точек зрения. Кроме того, предложена оценка эффективности использования метана угольных пластов как энергетического сырья. Более того, произведен расчет эффективности использования твердых угольных отходов при использовании в качестве технологического сырья.

Keywords: Coal production waste, coalmine methane, agloporit, efficiency of utilization of coal waste.

Ключевые слова: отходы при добыче угля, метан угольных пластов, аглопорит, эффективность использования угольных отходов.

The enterprises of coal industry, along with the production of primary products (coal, concentrate, pellets) generate a large amount of gaseous, solid and liquid waste (CMM, rock, refinement tailings, and waste water). The combustion of coal in power plants produces the following waste: ash, slag, and flue gases containing carbon dust, sulfur compounds and nitrogen oxides. Essential scope of coal utilization determines the scale of the output of waste and emissions that deteriorates the environmental situation in the areas of placement of mines, open-cuts and processing plants and adversely affects the economic performance of the enterprises that depends on the cost of collection and storage of waste.

The basic document that serves to solve the problems that occur due to inefficient use of energy resources, reduce waste output and encourage its utilization, is the “Program for development of Russian coal industry up to 2030”. This document outlines the conceptual statements of the development strategy for all branches of the fuel and energy industry. For the coal industry it is stated that the delivery of coal fuel to the consumer market should be carried out not in the form of natural "combustible stone", but in the form of coal products, refined to the necessary of conditions in respect of ash, moisture, sulfur and particle–size distribution [1].

The relevance and usefulness of coal upgrading and waste management on the basis of different technologies is quite clear from ecological and economic point of view. Therefore, let us consider the technical capabilities and determine the economic feasibility of the use of such bulk waste like coalmine methane and washery refuse as power fuel and process feedstock.

The effectiveness of use of coalmine methane (CMM) as power fuel. CMM extracted simultaneously from coal seams, is a major potential source of power fuel and chemical feedstock. Stocks of methane within the technical development of coal mining depth (1800 m) are estimated between 40 and 60 trln.m^3. In such kind of declining coalfields of Kuznetsk, Donetsk and Pechora basins 1 ton of coal accounts for about 20 to 100 m^3 of methane. In general for coal industry the figure is — 20 m^3.

Problems of CMM utilization are caused by a number of factors. First, coal bed methane is an explosive mixture and, historically, it is seen as a hindrance during mining operations. Secondly, coal mine methane is the by-product, and its extraction is inextricably linked to coal mining. Therefore, methane utilization process is not considered as a separate technological operation.

However, the material composition of CMM allows us to consider it as an eco–friendly energy fuel. Taking into account the specific yield and heat of combustion, as well as the volume of coal mining, it is easy to calculate that methane contains about 3 million tons of fuel in coal equivalent. Therefore, utilization of CMM is economically viable, since given the needs of the economy in fuel, production volumes and costs of seizure of coal decrease, as a consequence — reduction of production costs. Cost saving is due to the fact that part of the general production costs will be charged to the CMM. Utilization of methane is also acute from the environmental point of view, as it will allow reducing the anthropogenic load in the air basin of coal mining region [2].

Potential consumers of methane–air mixture as power fuel are the boiler stations.

Based on the technology information of project developments, let us carry out an economic evaluation of use of recycled gas at the boiler stations. We will consider the boiler stations of the same (typical) capacity that burn alternatively: raw coal using conventional blast (air); methane-air mixture with 40% methane content; raw coal using methane-air mixture with 2.5% methane as a blowing. Comparative economic evaluation of three types of fuel for boiler stations is presented in Table. 1.

On the basis of the data presented in Table 1, you can make an unambiguous conclusion about the economic feasibility of the use of methane–air mixture in comparison with other fuels.

Table 1.

THE COST OF PRODUCTION OF THERMAL ENERGY BY BOILER STATIONS BURNING VARIOUS FUELS, rub. / Gcal

Type of combusted fuel	*The amount of costs when placing the boiler in the coalfield*		
	Donetsk	*Kuznetsk*	*Pechora*
Rough coal	98,0	74,0	110,0
Methane–air mixture (40%)	79,0	66,0	96,0
Rough coal with methane–air mixture (2,5%)	106,0	78,0	119,0

Involvement of CMM in the sphere of use will ensure the safe performance of mining operations and reduce the cost of production to the extent in which it enters into the production cycle as one of its elements. This general economic situation is confirmed by calculations performed in respect to the conditions of the three coal basins (Table 2).

Utilization of CMM will have a positive impact on other indicators of economic activity of the mines. Firstly, the mass of profit per unit of output will increase due to the increase of the difference between the price and the production cost of 1 ton of coal.

Table 2.

CALCULATION OF COAL PRODUCTION COSTS

Coalfield and indices	*The amount of costs of coal production using CMM,%*				
	0	*25*	*50*	*75*	*100*
Donetsk:					
costs of production 1 ton, RUR.	193	190	188	183	180
ratio, %	100	98	97	95	93
Kuznetsk:					
costs of production 1 ton, RUR.	155	153	152	151	150
ratio, %	100	97	98	97	96
Pechora:					
costs of production 1 ton, RUR.	176	174	172	170	169
ratio, %	100	99	98	97	96

Secondly, consumption of the primary fuel (coal) for internal needs will decrease, resulting in a carbon product increase and sales cost. Thirdly, fines for environmental pollution will also reduce.

The effectiveness of use of solid carbon waste as process feedstock. The main types of solid wastes at coal mines are mine rock formed during the extraction of coal by underground methods (overburden) and mine refuse — on coal–processing enterprises. In case of underground mining with each ton of coal is given to the surface comes in average 0.25 tons of mine rock, at open pit mining — 7.1 tons and 0.25 tons of mine refuse is obtained while upgrading.

Current volumes of waste generation in the coal industry are presented in Table 3.

As to the content of the main components of the solid part (SiO_2, AL_2O_3, F_2O_3, CaO) solid waste in most cases are similar to the clay raw material, traditionally used for the production of building materials.

Table 3.

WASTE GENERATION IN THE COAL INDUSTRY, kt.

The objects of wastes generation	*Coal production*		*Coal conversion*	*Total*
	coalmine	*open–pit mine*	*washing–houses*	
Coal industry enterprises	61 580	1 121 388	18 426	1 201 394

As to the material composition of the waste, which predetermines the direction of use, one of their particular features should be emphasized — the presence in of organic components — the residual coal. The presence of residual coal will enable the reduction of primary fuels consumption in industrial processes based on thermal reactions. Such processes should include production of bricks and agloporite — lightweight concrete aggregate. It is evaluated that when using washery refuse for the production of agloporite, consumption rate of primary fuel is reduced by 60% (from 73 kg to 30 kg of reference fuel) compared to its production using traditional raw materials — clay. The situation is similar when processing the waste into bricks. In this case, the primary fuel savings are of 34% (consumption rate is reduced from 190 to 125 kg of fuel equivalent per 1000 pcs.) [3]. Another positive aspect is that the waste–based production technology does not differ from conventional processing technologies using traditional raw materials — clay. This helps to reduce the timescales of elaboration of design and estimate documentation and construction of industrial facilities.

Using coal waste is tested on an industrial scale abroad. Polish-Hungarian Joint Stock Company "Haldeks" was the first enterprise established to process coal mining waste. Currently, it includes several factories that extract coal from the refuse heaps and produce agloporit and brick from mineral residues. Enterprises processing coal waste operates in Poland, Germany, England, France, Belgium and other countries. On their basis porous aggregates, bricks, cellular concrete, slabs, blocks and other building materials are produced.

Let us define the economic viability of using the waste as raw material for the production of bricks and agloporite (Table 4).

The solution to this problem is performed for the following conditions:

–Washery refuse of Donetsk, Kuznetsk and Pechora coalfields is considered as raw material for the processing;

–Processing plants are located in the area of waste generation and are the structural unit's concentrators;

–Production capacity of the waste treatment facility corresponds to typical capacity of factories using clay as raw material. These enterprises produce 60 or 80 million. pcs. of brick and manufacture 300 000 or 600 000 m³ of agloporite;

–Indicators of production efficiency are profit, the payback period of capital investment and the level of profitability; products are sold at current prices prevailing in the areas of facility location.

On the basis of the data in Table 4, we can draw conclusion about high efficiency of the production of bricks and agloporite using the tailings of coalfields considered.

Table 4.

EFFICIENCY OF PRODUCTION OF CONSTRUCTION MATERIALS FROM TAILINGS

Enterprise area — coalfield	*Indices and their values*		
	Profit, RUR for 1000 pcs. and (1m³)	*Payback period of capital investment, years*	*Level of profitability, %*
	Brick production		
Donetsk	139 (145)	5,6 (4,9)	17,7 (20)
Kuznetsk	519 (529)	2,0 (1,5)	62,0 (67)
Pechora	384 (399)	3,6 (3,3)	27,0 (30)
	Agloporite production		
Donetsk	50 (53)	2,3 (2,0)	43 (30)
Kuznetsk	85 (92)	1,5 (1,2)	69 (88)
Pechora	75 (80)	1,7 (1,3)	59 (76)

Note: The figures in brackets refer to enterprises of higher capacity: brick — 80 million units and agloporite — 600 thousand m³.

Involvement of waste in processing will be accompanied by amelioration of the economic performance of concentrators, whereby additional (non-core) facilities will be organized. This statement is based on calculations made in relation to the following concentrating mills: Sholokhov (Donetsk coalfield), attached to the mine n.a. Kirov (Kuznetsk coalfield) and Pechora (Pechora coalfield). Let us assume that workshops (departments) for the production of bricks and agloporite are conventionally incorporated in these plants; let us define indicators of sales costs and profit with and without using the wastes. Results are presented in Table 5.

According to the data presented in the table it follows that the organization of additional facilities will have a positive impact on the economic performance of the concentrating factories.

Table 5.

IMPACT OF WASTE MANAGEMENT ON THE RESULTS OF OPERATIONS OF CONCENTRATING FACTORIES

Enterprise area - coalfield	Indices and their values, thous. rub.					
	without using the waste		using the waste		an increase of the index when using the waste	
	sales cost	profit	sales cost	profit	sales cost	profit
Brick production – 60 million units						
Donetsk	182495	16385	205535	24732	32040	8347
Kuznetsk	214684	19100	261664	50289	46980	31189
Pechora	332582	29728	378722	52779	46140	23051
Agloporite production – 300 thous.m³						
Donetsk	182495	16385	218795	31604	36300	15219
Kuznetsk	214684	19100	259984	44654	45300	25554
Pechora	332582	29728	377882	52108	45300	22380

Considering the results of the research performed we can draw the following conclusions.

1. Qualitative characteristics of methane and composition of mine and waste rock and tailings allow us to consider this category of waste as power fuel and prospective raw material for the manufacturing of various types of products, which is confirmed by domestic and foreign experience.

2. A promising area of using of CMM is combustion in a boiler plants for the purpose of production of thermal energy and solid waste - processing in building materials.

3. The combustion of CMM and solid waste management allows getting thermal energy and building materials at reasonable rates, and will have a positive impact on the economy of enterprises: the cost of key products (coal, coal concentrate) will be reduced; the cost of implementation and the mass of profit will increase.

References:

1. Programma razvitiya ugolnoy promishlennosty Rossii do 2030 goda. Available at: http://www.rg.ru/2014/06/27/ugol-site-dok.html.
2. Kuzmina T. I. Ekonomika kompleksnogo ispolzovaniya ugley. Moscow, MGOU, 2010.
3. Kuzmina T. I. Ekonomicheckaya otzenka I effektivnost napravleniy ispolzovaniya tverdih ugolnih othodov. Moscow, MGOU, 2011.

Список литературы:

1. Программа развития угольной промышленности России до 2030 года. Режим доступа: http://www.rg.ru/2014/06/27/ugol-site-dok.html.
2. Кузьмина Т. И. Экономика комплексного использования углей. М.: МГОУ, 2010.
3. Кузьмина Т. И. Экономическая оценка и эффективность направлений использования твердых угольных отходов. М.: МГОУ, 2011.

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