ZH. ROMAZANOV, O. SILAYEVA,
M. TATIEVA, M. LATYPOVA, A. PETROVSKAYA

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FEASIBILITY STUDY OF THE CREATION OF A SPECIAL COKE PRODUCTION IN KAZAKHSTAN

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The article examines the issues of creating a special coke production in the country. The objectives of the study were to assess the technical and economic feasibility of organizing such production. In the course of the study, the production program, investment estimates and a model of financial and economic payback of the project were calculated. The study confirms the effectiveness of creating a special coke production in Kazakhstan, and the project itself can be recommended for implementation.

Keywords: coke production, properties, investments, financial modeling, Kazakhstan

INTRODUCTION

The production of ferroalloys and technical silicon are the basic components of the metallurgical industry. Kazakhstan has significant reserves of low-caking and non-metallurgical coals unsuitable for the production of metallurgical coke. At the same time, such coals can be used in the production of metallurgical special coke [1].

Of all carbonaceous materials (petroleum coke, charcoal and wood chips, some grades of coal) used in the smelting of ferroalloys and technical silicon, only special coke meets all the requirements for a solid reducing agent. Since it has a low ash content, a developed porous structure, high mechanical strength, reactivity and electrical resistance [2].

Hence, the article discusses the prospects of organizing the production of special coke.

Potential consumers of the products planned for production (special coke) are two ferroalloy enterprises – Temirtau Electrometallurgical Combine JSC and Taraz Metallurgical Plant LLP, as well as the silicon production of Tau-Ken Temir LLP. The total demand of these enterprises for special coke is more than 6 000 tons per month.

ANALYSIS OF THE RAW MATERIAL BASE

The main raw materials for the production of special coke are Shubarkol coal and K-12 grade coal.

The coal industry of Kazakhstan is one of the largest sectors of the country's economy. In terms of coal reserves, Kazakhstan is among the top ten leading countries, second only to China, the USA, Russia, Australia, India, South Africa, and Ukraine.

The state balance sheet takes into account reserves for 49 deposits, they amount to 33,6 billion tons, including stone – 21,5 billion tons, brown coal – 12,1 billion tons. Most of the coal deposits are concentrated in the Central (Karaganda and Ekibastuz coal basins, Shubarkol deposit) and Northern Kazakhstan (Turgai coal basin) [3].

The main indicators of coal quality are: humidity (W), ash content (A), yield of volatile substances (V), heat of combustion (Q), elemental composition (C, H, O, N), sulfur (S) and phosphorus (P) content, petrographic composition of coals and reflectivity of vitrinite (R).

In the work of the authors [4-5], the raw material base of non–baking coal grades 3BC and LFC of Kazakhstan was studied, including the deposits as follows: in the south - Alakol, in the northeast – Sarykol, in the north – Priozerniy, in the west – Mamyt (Table 1).

Table 1 **Technical characteristics of coal deposits in Kazakhstan / %**

Indicators	Deposits				
	Alakol	Sarykol	Priozerniy	Mamyt	Shubarkol
	3BC	3BC	3BC	3BC	LFC
W^r	8,9	12,85	36,9	23,3	9,61
A^d	11,10	8,15	16,55	6,2	3,33
V^{daf}	46,49	35,42	48,34	43,2	45,57
S^d	0,55	1,29	0,63	1,08	0,48
P^d	0,009	0,032	0,045	0,018	0,009
C_{fix}	47,6	59,3	43,1	53,3	52,6

The results of the analysis allow us to identify long-flame coals of the Shubarkol deposit, which are characterized by a very low ash content (A^d – 3,33 %) and a low phosphorus content (0,009 %) with an average sulfur content (0,48 %). The yield of volatile substances V^{daf} is 45,6 %. At the same time, the carbon content is 52,6 %.

Zh. Romazanov, O. Silayeva, M. Tatieva, M. Latypova, A. Petrovskaya, Department of Economics and Business, Karaganda Industrial University, Temirtau, 101400, Republic of Kazakhstan.
Corresponding author: rzhanat@mail.ru

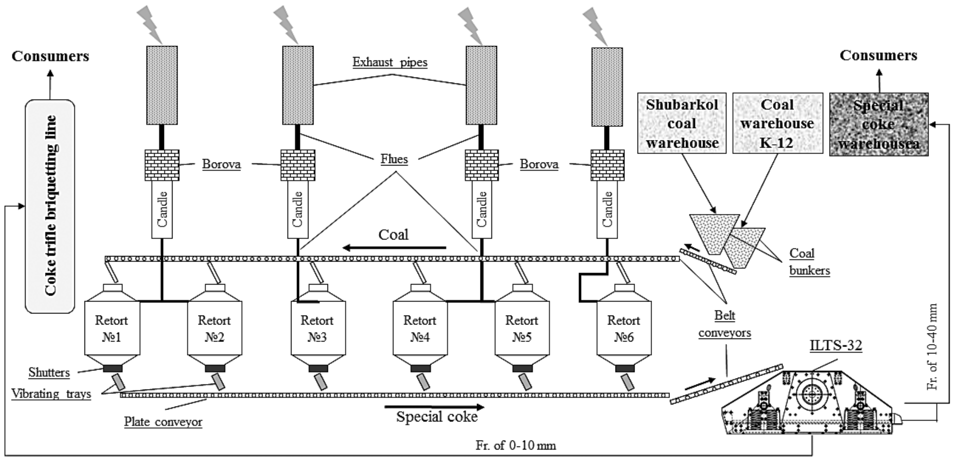

Figure 1 Technological scheme of special coke production according to the project

The qualitative characteristics of the coal of the Shubarkol section and the products of its thermal processing can be attributed to the category of low-phosphorous reducing agents of high quality.

COMPARISON OF VARIOUS TECHNOLOGICAL SOLUTIONS

In Kazakhstan, the production of similar products (coke nut, semi-coke, rexil and special coke) is carried out by several enterprises.

JSC "Arcelor Mittal Temirtau" produces coke according to the classical scheme with a number of improvements in atmospheric emissions: smokeless loading of furnaces using steam injection of loading gases; a system of dust-free coke delivery. The production capacity is about 3,2 million tons of coke per year [6].

The production of special coke at the Sary-Arka Special Coke LLP has been established using the Chinese low-temperature dry distillation technology consisting of 6 square furnaces of the SJ type (low-temperature) with drying, pyrolysis and cooling zones and a total project capacity of 300 thousand tons per year [6].

The production of special coke on a grate made of the Shubarkol coals is carried out at the Aksu ferroalloy plant of TNK Kazchrome JSC. The method is characterized by the complexity and continuity of production in the conditions of the main thermal power equipment [6].

Production of the carbonaceous reducing agent for crystalline silicon - rexyl on a retort from Shubarkol coals at Armak LLP. The process of obtaining rexyl is carried out by an autothermal method by high-speed thermal oxidative carbonation of coal in periodic retorts combined into one module by three units. Carbonation of coal occurs from top to bottom, and in the fuel layer it is possible to distinguish zones of raw coal and prepared rexil, between which there is an interface [6].

The technology proposed by the project - thermal oxidative coking in retorts is carried out by partial gasification of volatile coal components through air blowing by the method of autothermy, i.e. all the heat required for pyrolysis of coal mass is released directly in the coal loading layer, due to selective combustion of volatile substances (Figure 1).

The essence of the autothermy method is that in the coal filling, i.e. in the layer of coal loaded into the retort at certain modes of blowing, the combustion front will shift against the air flow. At the same time, all products of coal pyrolysis passing through the zone of the coke packing and undergoing thermal decomposition are split into simple compounds in the form of CO, CO_2, H_2, H_2O.

Among the advantages of this method of coking are:

1. simplicity of hardware design;
2. one-step process;
3. environmental safety of the technology.

The proposed retort furnace for coking, equipped with a grate with a diameter of 0,8 m, has a work area of approximately 7,1 square m. It is designed for loading up to 20 tons of coal. The height of the coal layer in the retort is about 3 m. For the purpose of thermal insulation, the walls of the retort, including the conical part, are walled with fireclay brick.

Thermal decomposition of coal takes place in the retort. The volatile products released in this case partially burn in the presence of air supplied through the grate. The air supply to the retorts is carried out by high-pressure fans. Complete afterburning of the combustible components of the exhaust coke gases is carried out in a candle and a flue, after which the combustion products are discharged through the chimneys into the atmosphere.

The process of complete thermo-oxidative coking in the retort occurs at a temperature of about 700-1 000 °C for 18-20 hours. Subsequently, the coke in the retort is cooled for 4-5 hours to a temperature of 300-400 °C by periodically supplying water to the retort.

After cooling, the finished product is poured through a tray vibrating feeder onto an apron conveyor and fed to a screen for separation into fractions.

Carbon reducing agents produced in Kazakhstan are characterized by various properties, which are shown in Table 2 [6-7].

Comparison of different technologies for obtaining such products provides an opportunity to note their main disadvantages and advantages:

1 Coking of coals in floor mine furnaces using the technology of Sary-Arka Specialcox LLP requires large capital investments and has environmental problems.

2 Semi-coking on a moving grate of continuous action by the technology of the Aksu ferroalloy plant of Kazchrome JSC TNK requires medium capital investments, but has difficulty with maintaining the technological mode.
3 Coal gasification in modules consisting of periodic retorts proposed by the project, require minimal capital investments, and also have ease in process control, stable production of a special coke of necessary composition.

Table 2 **Qualitative characteristics of carbon reducing agents in Kazakhstan**

Indicators	Coke nut AMT	Special coke Sary-Arka	Semi-coke AZF	Rexil Armak
Humidity W / %	9,4	15-20	15-20	4,3
Ash A^d / %	12-14	6-10	12-15	2,4
Volatile V^{daf} / %	1,04	4 -7	20-25	1,0-1,5
S / %	0,65	<1,0	0,31	0,34
P / %	0,07	0,03	0,03	0,025
Reactivity at 1000 ^{0}C / cm^3 / g*s	0,62	1,0-1,5	2,8	9,1
Electrical resistivity при 1600 ^{0}C / Ohm * cm	0,32	1,83	-	3,67
Structural strength / %	84,62	67,4	48,3	67,0

THE ASSESSMENT OF ECONOMIC EFFICIENCY OF THE PROJECT

For the successful implementation of the project, it is necessary to attract investments in the amount of 771 470 US dollars (Table 3), including capital expenditures – 96,2 % as well as working capital – 3,8 %.

Table 3 **Investment plan of the project / $**

Name	Cost
Design and pre-design work	120 588
Dismantling and installation works	77 500
Equipment installation and supply	544 088
Working capital	29 294
TOTAL investments	771 470

It is offered to locate the new enterprise in the D-101 shop, located on the territory of Temirtau Electrometallurgical Combine JSC (Karaganda region).

The annual production volume of special coke will be 24 000 tons, including fractions of 10-40 mm – 21 600 tons (90 %) and fractions of 0-10 mm – 2 400 tons (10 %).

The company’s staffing requirements - 47 people.

The cumulative net present value (NPV) for a 5-year period will account for about 1,2 million US dollars and is sufficient to fully cover discounted investments. The discounted internal rate of return (IRR) is 119,5 %. The simple payback period (PBP) of the project is 1,8 years, and the discounted payback period (DPBP) is 2,0 years.

The net income for the project is formed from the first year (the time of production launch) in the amount of 0,09 million US dollars and will amount to 7,5 million US dollars at the end of the 5-year period (Table 4). The profitability of production is expected to average 20 %.

Table 4 **Profit and loss statement for the project / mln USD**

Indicators \ Year	1	2	3	4	5
Sales revenue	0,93	4,51	4,69	4,88	5,07
Cost of production	0,68	3,27	3,33	3,46	3,60
Gross income	0,25	1,24	136	1,42	1,48
Expenses of the period	0,07	0,13	0,13	0,13	0,14
Commercial expenses	0,00	0,01	0,01	0,01	0,01
General and administrative expenses	0,06	0,12	0,12	0,12	0,13
Amortization	0,07	0,10	0,08	0,07	0,06
Profit before % and taxes	0,11	1,01	1,15	1,22	1,28
Payments of % on the loan	-	-	-	-	-
Profit before taxes	0,11	1,01	1,15	1,22	1,28
Corporate income tax	0,02	0,20	0,23	0,24	0,26
Transfer of losses of previous years	-	-	-	-	-
Net profit / EBIT	0,09	0,81	0,92	0,97	1,03

CONCLUSION

To conclude, it can be noted that the proposed production of special coke by the method of autothermy in retorts has a number of advantages in comparison with similar productions:

- in the product quality;
- in the simplicity of technological solutions;
- in the production process;
- in the environmental friendliness of production;
- in saving on investments.

In general, the project is cost-effective and can be recommended for implementation based on the results of the proposed financial model.

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Note: The responsible for English language is Dana Rahimbekova, Kazakhstan.