The Development of Environmentally Friendly Technologies of Using Coals and Products of Their Enrichment in the Form of Coal Water Slurries

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Abstract. The article presents the current state of the technology for production and combustion of fuel coal water slurries in Russia and foreign countries. Experimental and industrial facilities show the technological and economic efficiency of using this technology for disposal of wastes resulting after coal processing and enrichment. The feasibility studies of use of the technology at large Kuzbass thermal power stations are presented. The possibility of solving a serious environmental problem of reducing storage of the most toxic waste of coal enrichment in the location areas of coal washing plants and coal mining enterprises is demonstrated.

1 Introduction

The technology of CWF production is one of the most effective technologies for obtaining environmentally friendly and technological fuel. This technology is successfully used in energy industries of a number of foreign countries, although the main developments were carried out in Russia in the middle of the last century. Today, China's energy industry is using this experience successfully [1-8].

There also is a long and successful experience of operating the Emil Gyushe power plant in France, where a project of direct combustion of coal slimes in the form of a suspension in boilers with a circulating fluidized bed has been realized. A complete disposal of coal slimes using this technology at several thermal power stations in the USA has been carried out. The technology for preparation and combustion of CWF obtained both from coal and slimes became a frequent practice in China.

In recent years, the Scientific and Production Enterprise «Sibecotechnika» (Novokuznetsk) has developed this technology in Russia very successfully. Thus, at the turn of the 20th and 21st centuries, technological complexes were developed and implemented both in Russia and abroad.

The purpose of the work is to show the possibilities of wide introduction of the ecologically friendly technology for preparation and combustion of coal and coal slimes in the form of coal water slurries, while solving the problems of resource saving and improving the environmental situation in coal-mining regions.

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2 Results and discussion

At present, the formulations of effective plasticizer reagents are worked out, which makes it possible to obtain a statically and dynamically stable CWF with the required thermophysical characteristics for direct combustion. To stabilize technological characteristics of the CWF prepared on the basis of fine-dispersed waste of coal enrichment, a technological scheme (figure) has been developed in which the industrial product of the enrichment factory (EF) plays the role of «stabilizer» of the finished fuel ash contents.

The results of industrial testing of the developed technology on the technological complex of OJSC «Mezhdurechye» are given in the work. This technology can be successfully implemented at the EF, enriching coals of coking grades, and which have some difficulties with sale of industrial products. The fact is that its burning by traditional methods (on a grate, in a fluidized bed, etc.) is ineffective. The organization of construction of a mini TPP with production of own cheap electric and heat energy based on combustion of industrial products and filter cake using CWF technology is economically viable.

A vortex combustion system with organization of adiabatic or similar conditions in the boiler has been developed and is successfully used for reliable combustion of coal water slurry fuel, ballasted with moisture and mineral constituents, prepared on the basis of finely-dispersed waste and other products of coal enrichment. This technology is currently implemented by «ProEnergoMash» (Barnaul) to burn many local ballasted fuels.

The use of the vortex combustion technology made it possible to successfully carry out several projects with the reconstruction of boilers of small and medium capacity (Table 2).

Table 1. Characteristics of the heat generators operation.

Indicator name	**Technological complexes**					
	Boiler house «Zarechnaya» mine, Leninsk-Kuznetsk	**SibUME of the Russian Agricultural Academy SD, Novosibirsk**	**Temirtau, Kazakhstan**	**Mezhdurechensk**	**Hanoi, Vietnam**	**Cherepanovo, Novosibirsk region**
Heating effciency, Gcal /h	0.50÷0.58	0.25	0.3÷0.6	4.05	1.08	0.3÷0.6
Fuel consumption, l/h	120÷130	55	110÷220	Up to 1300	220÷210	110÷220
Temperature in a furnace, 0C	950	950	950÷1050	1050÷1150	1000÷1100	950÷1050

However, taking into account, that the amount of finely-dispersed coal enrichment (filter cake) wastes at modern EF ranges from 0.5% to 10% of the processing of ordinary coal, and their annual output is from 150 to 1 000 tons per year, the use of these wastes in their own boiler houses with a fuel requirement of ~ 5 ÷ 15 thousand tons / year does not solve the problem of their full disposal. Therefore, to use the entire volume of formed coal slimes, it is advisable to burn them in the form of CWF, either at a nearby coal-fired thermal power plant or at the own mini-TPP, to generate electricity and heat. In this case, the industrial product of EF can be effectively used (as shown above). Tables 2-5 provide technical and economic calculations of the use of fine coal enrichment waste at Kuznetsk and Central TPPs of Novokuznetsk, Belovskaya SDPP and mini TPPs with capacities of 1.5 and 10 MW.

Table 2. Technical and economic indicators of the complex for preparation, transportation and combustion of coal water fuel, prepared on the basis of coal enrichment waste of Novokuznetsk EF at Kuznetskaya TPP.

Indicators	Units	CWF
Annual production of CWF	thousand t.	500
Lower calorific value of fuel	kcal / kg	3000
Capital costs, including:	million rubles	225
- CWF preparation workshop (capacity 75 t / h)	million rubles	130
- Transfer of TPP boilers to co-burning of pulverized and coal water fuel	million rub.	95
CWF cost at TPP	rub./ t	600
The cost of fuel for production of 1 Gcal of thermal energy	rub.	184
Cumulative economic effect	million rubles / year	207,5
Payback period of investments	year	< 1,5

Table 3. Technical and economic indicators using coal slurry fuel, prepared on the basis of coal and coal slimes, by LLC «Central TPP».

The name of indicators	Units	Coal	Coal slimes	Coal and coal slimes
Annual capacity of the CWF producing installation	thousand t.	708	383	740
Lower calorific value of fuel	kcal / kg	3600	3300	3444
Capital costs, including:	million rubles	430	285	490
The cost price of slurry fuel	million rubles	1134	738,5	858
The cost of fuel for production of 1 Gcal of energy (70% -CWF + 30% -gas)	million rub.	371	214	440

Table 4. Technical and economic indicators using coal slurry fuel, prepared on the basis of filter cake and coal slimes, by EF «SUEK-Kuzbass» at Belovskaya SDPP (1 block of the PK-40 boiler).

Indicators	Units	CWF
The annual CWF demand	thousand t.	92,4
Share of CWF in the fuel balance of the boiler block	%	20
Lower calorific value of fuel	kcal / kg	3200

Capital costs, including:	million rubles	40,5
CWF cost at SDPP	rub./t	500
The cost of fuel for production of 1 Gcal of thermal energy	rub.	184
Cumulative economic effect	million rubles / year	30,2
Payback period of investments	year	< 1,5

Table 5. Economic indicators of technological complexes (mini TPP).

Indicators	**Electric power, MWh**		
	1,0	5,0	10,0
The cost price of fuel, rubles / t	300	270	250
The cost price of the produced electric energy, rubles / kWh	0,95	0,80	0,70
Cost of electrical energy, rub. / kWh	2,50	2,50	2,50
The economic effect of generating 1 kWh, rubles / kWh	1,55	1,70	1,80
Capital costs, mln. rub.	96	400	640
Payback period, year	5	4	3,5

3 Conclusion

The technology of production and combustion of coal water slurry fuel in boilers of different capacity is being developed in many countries. Experimental and industrial tests showed that the biggest economic efficiency and the essential environmental effect are reached using WCF, produced from coal slimes. In this case the serious problem of disposal of the most toxic finely-dispersed wastes of coal enrichment is solved, as their storage requires large place in the areas of coal mining and conversion.

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