Coal Technology

New Technology Solution for Coal-fired Boilers

Cost per unit of heat energy is determined mainly by three factors: specific capital costs, thermal efficiency, cost of fuel. The determining factor is the unit price of fuel. Disadvantages of present schemes of coal utilization consist in the need for preliminary thermal processing of solid fuels. Specialists of Sibtermo have been developed and successfully tested at semi-commercial level, a new solution of this problem, which largely eliminates the mentioned drawbacks.

In thermal power stations, traditional technology of production of thermal energy by direct combustion of coal largely exhausted its economic potential. Cost per unit of heat energy is determined mainly by 3 factors: the specific capital costs, thermal efficiency, the cost of fuel. In certain specific applications, the first 2 indicators are fixed within a fairly narrow range of values. The determining factor, as a rule, is the price of energy of natural fuel. Thus, the cost of steam (hot water) always has a rigid constraint from below. And, moreover, the rising price trend in primary energy resources provides a continuous increase of this magnitude. To date, the maximum efficiency of solid fuel utilization can be achieved only through the combined heat and power production. At the same time as the basis of this scheme is a classic boiler, it does not provide a qualitative improvement in environmental performance of the station. This usually requires additional investment in equipment for cleaning the flue emissions, and disposal of ash and slag waste. As a result, the higher level of ecological safety of the plant, the higher the cost of production.

Dr. S*ergey Islamov*,
Energy-technological Company Sibtermo, Krasnoyarsk/Russia

Disadvantages of Energy-technological Schemes of Coal Processing

In the 1970-1980ies many efforts have been conducted to improve the economic efficiency of coal utilization through the development of various schemes of energy and technology combining production. As is known, for these purposes are the most promising young coals with a high yield of volatiles. These primarily include brown coals of Kansk-Achinsk Basin. Unfortunately, so far none of the technologies of coal processing have been brought to the level of commercial utilization. The main reasons are common to most technologies of this class. First, it is the need to introduce in the energy plant of special facilities for preliminary thermal processing of solid fuels (pyrolyzers, gasifiers, etc.). Typically, they are quite bulky and therefore require large production volumes, and have a lower reliability compared to conventional energy equipment. The second problem stems from the fact that the thermal processing of coal is accompanied by the formation of a number of harmful substances that are simply not available in the direct combustion of coal or produced in small quantities.

First, it is condensed pyrolysis products (resinous substance). Processing or direct burning of gas, ballasted by such products will have significant difficulties. In the case of separation of resin from the gas is a problem of its effective utilization in large quantities. Combustion of the resins in the boilers is unlikely to be useful economically, and from technical and environmental point of view it is – a separate challenge, which so far has no acceptable solutions for the practice. Each of the above reasons has made a definite contribution to the decision to close the energy-technology plant ETH-175, built in the 1980ies in the HPP-2 in Krasnoyarsk. Thus, a number of technical deficiencies, which are inherent to the classic ways of combining processes of coal conversion and energy generation, significantly increasing capital and operating costs per unit of final product that really nullified the a priory high effectiveness of energy and technology combining.

New Solution of the Problem

To date, the specialists of Sibtermo Company have developed and successfully tested at semi-commercial level a fundamentally new solution of the energy and technology coal utilization, which basically eliminates all of the above disadvantageous [1]. This project was implemented in 2007 in partnership with R&D Center Biyskenergomash by the order of company Suek. The technology is patented under the trademark Termokoks-KS and represents a partial coal gasification with obtaining lignite coke and fuel gas, which is produced in a reactor with a free fluidized bed [2].

The novelty of the proposed solution is to abandon construction of an independent apparatus for the processing of coal – it is embedded in the lower part of the combustion chamber of power boiler. By reducing the residence time in the zone of high temperature coal particle to undergo only pyrolysis and partial gasification, and then unloaded from the reactor in the form of fine brown coal coke. Gaseous products of gasification and a small portion of coal fines are burning in the upper part of fluidized bed. Completeness afterburning is provided by the secondary blast (40 to 50 % of the total air flow). The emitting heat is partly directed to the surface of the fluidized bed, but most of it is given to the boiler heating surfaces. Using mainly gaseous fuel and a radical reduction in the concentra-

tion of particulate matter in the boiler furnace provides the beneficial impact on the ecological characteristics of flue gases.

The new technology demands another fractional composition of fuel. Given the known effect of thermal crushing of brown coal for processing in a fluidized bed can be used fraction 0 to 25 mm. Due to changes in expenditure items of the heat balance of approximately two times increased fuel supply to the boiler. About half of the energy of incoming flow of coal is consumed to provide the basic function of the boiler unit, i.e. for thermal energy production. The second half is accumulated in lignite coke. His pre-cooling is carried out in the shell and tube heat exchanger situated under boiler with reverse flow of feed water. In fact, we can say that the boiler is transferred to the operating mode with the maximum mechanical loss of the combustible matter. However, such loss using Kansk-Achinsk brown coal, has 8 to 9 % of the ash, 8 to 10 % of volatiles, zero humidity and net calorific value of about 29,3 MJ/kg. Naturally, during such process the boiler does not produce slag waste. After some reconstruction the line for ash removal and appropriate silos for ash accumulation are used for output and the accumulation of coke.

Using a model of standard boiler as the basic machinery for energy and technology coal processing significantly facilitates the solution of a complex set of design tasks, and industrial test the technical solutions, material selection, additional equipment, as well as the development of manufacturing technology for elements of new equipment in machinery plants.

Virtually all of these problems have been solved in the application to the standard energy boilers. Therefore it remains to perform a minor upgrade of this boiler, which has a long history of reliable operation in the form of many thousands of working boilers. And timing of such upgrades, and cost an order of magnitude close to the big repair of the boiler.

It should be noted that fluidized bed in the lower part of boiler radically changes the temperature field in the main part of combustor chamber and increases the heat flux to its walls. As a consequence, it requires an increase of the tail surfaces square with a corresponding increase in the nominal capacity of the boiler.

In fact, in the lower part of the boiler, coal is divided into two streams - gas fuel with a low concentration of coal dust and highly reactive coke residue. Such scheme provides the maximum economic benefit from the use of brown coal.

Brown Coal Coke Utilization

Brown coal coke is an effective substitute for some sorts of classic coke produced from the scarce and therefore expensive coking coals. It has a high reactivity, which is extremely important when using it as a reductant in various metallurgical processes. For 1 t of brown coal coke requires approximately 2.25 t of coal. However, it is in the form of a fine-grained fraction of 0 to 5 mm (coke fines) and has low structural strength, due to a low degree of metamorphism of initial coal. Therefore, to bring this product to the condition of commercial metallurgical coke it is necessary to briquette it. However, such stage is not a great technical challenge and is not associated with a significant increase in cost. At the same time, the market price of formed coke increased several times compared with the price of coke fines. In the last pre-crisis years, world prices for coke products began ticking on the level of approximately US$400 per t. Now in terms of falling steel market price of coke nut in Russia is about US$ 200 per t.

The simplified material and heat balance of energy and technology boiler is as follows: every 4.5 t of coal supplied to the boiler produces 1 t of coke and 7 MW of thermal energy. If we consider that the price of brown coal delivered to the station in the Siberian region does not exceed 400 rub per t, a simple calculation shows that after selling of one product, such as thermal energy (the existing prices are higher than 500 rub/MW) can compensate all operating costs of combined production. So the second product can be considered to have conditionally zero production cost and its selling price will be the real profit.

From the standpoint of the overall environmental balance of the country we do not even need a detailed comparison of ecological efficiency of the classic coke enterprise and technology Termokoks-KS in the production of comparable quality products.

Based on data collected during more than a year life of the energy and technology boiler, in 2008 was carried out a preliminary feasibility study for reconstruction of the Power Plant #3 in Krasnoyarsk city, which consists of 4 boilers with unit capacity 117 MW. Discounted payback period of investment in creating a parallel production of about 480,000 t/a of brown coal coke is not more than three years.

Conclusions

- The proposed method of energy and technology coal processing does not require construction of special devices that going beyond the dimensions of boiler cell. From the technological scheme is excluded dust preparation stage, the smoke emissions are much cleaner, the ash and slag wastes are absent. Modernization does not require any increase in staff.
- Due to the effect of co-production of two products on the base of one boiler reached a qualitatively new integral result, which consists of increased the technological, environmental and economic indicators.
- This technology has a local scope of application, limited by use of low-ash coal, due to the requirements of the technical characteristics of metallurgical coke. First of all, for these purposes can be used brown coals of Kansk-Achinsk Basin, as well as several sorts of subbituminous coals mined in the Kuznetsk Basin.

References

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termo@24kr.ru

www.sibtermo.ru