Part 1

AIR PROTECTION FROM POWER INDUSTRY EMISSIONS

1.5. Technologies of organic fuel combustion at TPPs with the lowered level of harmful emissions into atmosphere

1.5.3. Combustion of solid fuel in the melt

1.5.3.1. Gasification of coal in the melted slag

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Another example of a new technology of using solid fuel, which allows to solve the problem on environmental protection, is the method of coal gasification in the melted slag. The essence of this method, which is under development for several years in Scientific and Research Institute of Ecological Problems in Power Engineering [1, 2], is as follows. Solid fuel is fed into a special chamber-gasifier, which is a part of the power boiler. When starting-up, a bath of the chamber-gasifier is filled with a liquid slag, the required volume of which is subsequently maintained automatically. With a lance-burner the slag layer is blown by the enriched blast, due to that it is maintained in a state of a gas-slag emulsion. Coal is fed into the melt without any pretreatment. In order to bind the sulfur and provide specific viscosity of the melt, limestone is added to coal. The released generator gas is after-burnt in the furnace, located above the chamber-gasifier of the boiler (Fig. 1.64).

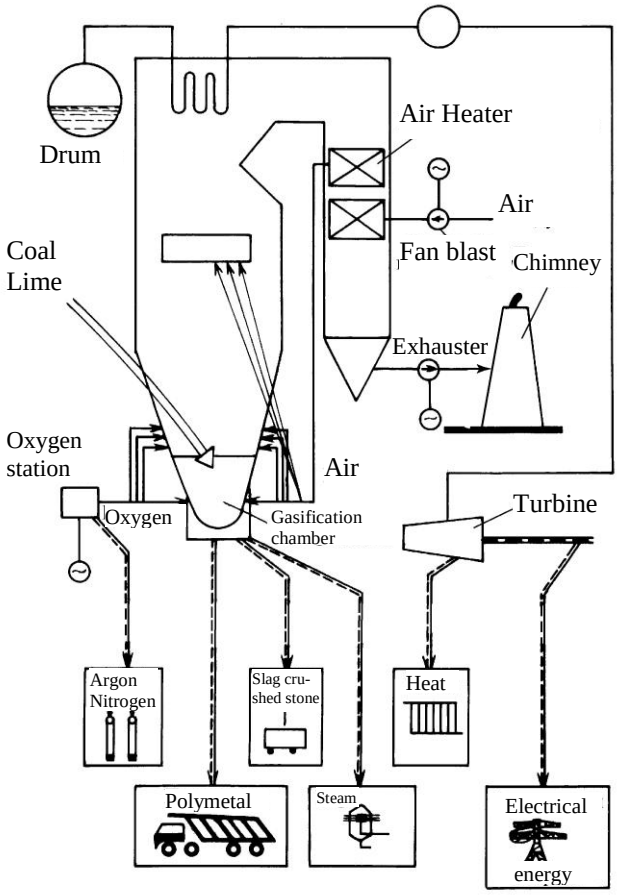

Fig. 1.64. A flow diagram of the boiler plant with gasification of coal in the melted slag

When bubbling of the melt by steam and oxygen-containing blast in the chamber-gasifier, the slag undergoes complex physical and chemical transformations with restoration of metals and their accumulation in the bottom of the chamber. This so-called heavy slag is a cast iron or ferrosilicon, in which, as in the extracting phase, relatively high concentrations of non-ferrous and rare metals are achieved (polymetal concentrate). This makes further processing of this valuable raw material for ferrous and nonferrous metallurgy efficient. Heavy slag is periodically discharged from the chamber-gasifier in the mold of the filling machine, where it is cooled, then sent in the form of individual billets to the warehouse of finished products. Light slag, consisting of oxides of silicon, calcium, aluminum, magnesium, sodium and potassium is drained from the bath top of the chamber-gasifier and enters the plant for its processing into commercial products.

Based on results of the tests studies, conducted at laboratory and pilot plants, the authors of the method believe that coal gasification technology in the melted slag bubbled by steam and oxygen-containing blast has several important advantages:

- possible use of any low-grade and non-standard coal, regardless of its grade and quality;
- implementation of a maximum concentration of the process in terms of ideal mixing of liquid, solid and gaseous components;
- no ash and slag wastes, provided by transfer of almost all the mineral part of fuel into the melt and a possibility of adjusting its composition for recycling purposes;
- reduction and removal of ferrous and nonferrous metals from the melt;
- high environmental soundness, especially relating to particulate matter emissions (50 mcg/m^3) and nitrogen oxide emissions (100 mg/m^3), a decrease in SO_2 emissions by 30% and CO_2 emissions by 10%;
- possible regulation by changing the amount of limestone fed to the melt, of conversion of sulfur compounds into gaseous (flue gases) or liquid (slag) phase and binding to 90% of fuel sulfur by slag;
- no cumbersome fuel preparation, dust supply and ash purification systems, no ash disposal sites;
- wide application of the deficit associated gas from the oxygen plant (nitrogen, argon) for the needs of a region;
- high economic efficiency, including by further expanding a range of the sold products made from the mineral part of fuel.

To test the justification of the method advantages in the nearest few years, a full-scale experiment is proposed to be conducted. At Nesvetay State District Power Plant (SDPP) of the JSC "Rostovenergo" a pilot plant with application of the technology of coal gasification in the melted slag, will be set up. Thermal capacity of the pilot plant is 200 MW, steam consumption of the boiler plant with a temperature of 510°C and a pressure of 10 MPa, will make 220 t/h. The main fuel is Donetsky ASh coal with its calorific value of 19,82 MJ/kg.

A developer of the research project is SRI of Environmental Problems in Power Engineering (JSC "SRIEPPE"). A designer and manufacturer of the boiler for the pilot plant is TKZ "Krasny Kotelshchik"; of the chamber-gasifier - NPO "ALGON" and the Institutes "Stalproekt" (Moscow).

Pilot plant flowsheet includes the following structural elements: a fuel and flux supply system, a boiler with the

chamber-gasifier, an oxygen station, a system preparation and supply of the blast; plants for slag processing into commercial products, a device of receiving and briquetting of polymetallic wastes; a unit of natural gas supply; a system industrial water supply.

Fuel and flux from the warehouse pass through the existing fuel supply path of Nesvetay SDPP and are fed to the raw coal hopper of the pilot plant, and then without any additional preparation (metal catching, crushing, grinding, etc.) are supplied to the chamber-gasifier. Oxygen with a pressure of 0,3 MPa is supplied to the tuyeres. For oxygen production, a serial air separation unit of KAAr-15 type is applied. Coal in the chamber due to a high temperature is subjected to thermal destruction and by bath bubbling is evenly distributed over the cross section. As a result, in the chamber-gasifier ideal conditions for heat and mass transfer are created, providing a high efficiency of the coal gasification process. Combustion heat of the formed generator gas is 6,0 ... 11,0 MJ/m^3 (1400 ... 2700 kcal/m^3) that allows to after-burn it in the boiler furnace at a moderate temperature level of the torch. Gases are after-burnt in the hot air medium. After passing the convection heating surfaces of the boiler and air heater, flue gases are sent to a chimney of the SDPP.

In general, the gasification process in the melted slag can be conducted at atmospheric or increased pressure in the chamber-gasifier. Pilot plant of Nesvetay SDPP, intended for research and testing of new modes of domestic technology, is designed for the most simple scheme, in which the generator gas from the chamber-gasifier, operating at atmospheric pressure, is sent for combustion in the boiler furnace, immediately adjacent to the exit of the chamber-gasifier. Energy efficiency of this option of generator gas use is determined by parameters of steam and thermal flow diagram of the steam power cycle. Steam parameters, adopted in the pilot plant project, are not optimal, since in order to ensure industrial application of the pilot plant for generation of electricity at SDPP with minimal additional investments, the pilot plant boiler fits into the existing steam power cycle of the Nesvetay SDPP with relatively low vapor pressure of 10 MPa and a temperature of 510°C without reheat.

Thermal efficiency of coal use at application of this gasification technology sharply increases in case of its application in more efficient heating schemes and thermodynamic cycles (under supercritical steam parameters in boilers, combined-cycle plants with the integrated gasification at atmospheric and high pressure, steam injection into the gas turbine plants, thermoemission superstructure, etc.) .

For practical implementation of this technology, creation of a gasifier with air and slag melt under pressure is planned. Together with TKZ "Krasny Kotelshchik" technical proposals for the poster version of the gasifier has been developed. Operating pressure in the reaction chamber is 2 MPa, thermal power makes 6 MW. The gas-generator is planned to be installed at Nesvetay SDPP.

Development and application of this technology in power sector allows to implement a complex waste-free use of all organic and mineral coal mass as valuable natural resources for production of not only energy, but also other types of commodity products, greatly demanded and thus, it results in significant increase in the efficient use of coal, as a whole.

References to item 1.5.3.1

1. **Опытно-промышленная** установка мощностью 200 МВт (тепл.) для газификации и сжигания твердого топлива в шлаковом расплаве / А.А. Мадоян и др.: сборник «Новые технологии сжигания твердого топлива: их текущее состояние и использование в будущем». М.: ОНТИ ВТИ, 2001. С. 175—180.
2. **Принципиально** новая безотходная экологически чистая энерготехнология термической переработки твердого топлива в шлаковом расплаве / А.А. Мадоян и др. // Ведомости МТЭА (специальный выпуск). 1998. № 22. С. 260—268.