1.3. Sulfur oxide emission reduction

1.3.2. Technologies of sulfur oxide emission reduction

1.3.2.1. Dry limestone technology

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Dry limestone technology is based on burning of the finely crushed limestone in furnace at the temperature of 1000 ... 1100°C until lime is formed with its following reaction with sulfur dioxide. The main chemical reactions of this technology are as follows:

$$CaCO_3 + Q \longrightarrow CaO + CO_2\uparrow;$$
$$CaO + SO_2 + 1/_2O_2 = CaSO_4.$$

A layout of the desulfurization plant for dry limestone technology (Fig. 1.40) consists of the following main units: silo bin for the crushed limestone *1*, feed bin *2*, limestone pneumatic conveying system and its distribution *3* in the boiler furnace *4*, and ash collector *5*.

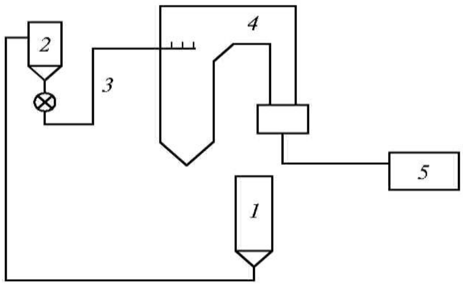

Fig. 1.40. A layout of the dry limestone desulfurization plant

The plant operates as follows. The crushed limestone from the power plant silo is fed to the feed bin, from which it's supplied to the top of the furnace, where a zone with a gas temperature of 1000 ... 1100°C exists. Limestone particles due to flue gas heat are decomposed resulting in formation of active lime. While burning, the lime particles due to CO_2 emissions, become porous and bulky, which determines a large surface of their contact with flue gases. Lime reacts with SO_2, starting from the gas temperature of about 850°C. At the gas temperature of about 500°C, there's no further binding of sulfur dioxides, and fly mixture of ash with desulfurization wastes is supplied to the ash collector *5* together with flue gases. As a result of this reaction, anhydrous plaster (anhydride) is formed.

Application of the dry limestone technology has a number of features:

- in this technology it's possible to use limestone of any crystallization degree, including wastes from crystallized limestone and marble production;
- limestone injection into flue gases can change the ash chemical composition and, consequently, reduce an initial deformation temperature of ash, which can result in increase in slagging of the heating surfaces;
- limestone reacts, primarily, with sulfur trioxide SO_3, which leads to reduction of sulfuric acid dew point temperature (for large quantities of the injected limestone, dew point temperature can be lowered almost to the value of water).

Decrease in the dew point temperature affects the boiler operation in two ways: on the one hand, it allows to reduce the flue gas temperature and, thereby, partially compensate desulfurization costs; on the other hand, electrical properties of flue gases go down that is especially important at coal combustion, because inverse crown effect increases in electrostatic precipitator, which entails a need to meet the appropriate actions;

- presence of the anhydrous plaster in combustion products can result in formation of hard-to-remove deposits in scrubbers – dust collectors that requires a precise chemical balance in ash collectors.

Key indicators of the dry limestone technology are presented in Tab. 1.18.

Table 1.18. **Indicators of the dry limestone technology of flue gas desulfurization at TPPs**

Achievable efficiency of desulphurization, %	30...35
The reduced sulfur content of fuel depending on heat capacity of the boiler, %·kg/MJ	According to GOST P 50831—95: to 199 MW — 0,04; 200…249 MW — 0,035; 250…299 MW — 0,02; ≥ 300 MW — 0,02 According to demands of the II Protocol to the ICTE SO_2 (for solid fuel): 50…100 MW — 0,07; 100…500 MW — 0,015…0,07; more than 500 MW — 0,015
Reagent used	Limestone of any crystallization degree
Reagent toxicity	Not toxic
Reagent excess factor	2...3
Resulting wastes	Mixture of fly ash with anhydrous plaster and calcium oxide
Waste toxicity	Not toxic
Technologies and industries of waste usage	Wastes can only be used in a mixture with ash for road construction and territory planning
Working environment	Air pressure of 0,2…0,3 MPa
Requirements for ash collection efficiency	At electrical gas purification the air conditioning of flue gases is needed

An effect of desulphurization on ash collector operation	Worsens the operation of electrostatic precipitator by increase in the inverse corona effect; in wet ash collectors deposits can be formed
Specific area for equipment installation, m^2/kW of the installed capacity	Less then 0,0005
Specific energy consumption, % of equivalent capacity of the boiler (power generation unit)	Less then 0,2
Specific capital costs, U.S. $/kW of the installed capacity	2,4…2,8 for n' = 0,6…1,0 g/MJ and N_e = 300…500 MW 3,1…3,9 for n' = 0,6…1,0 g/MJ and N_e = 80…200 MW
Specific operational costs, U.S. cent/(kW·h)	0,45…0,76 for n' = 0,6…1,0 g/MJ and N_e = 300…500 MW 0,45…0,76 for n' = 0,6…1,0 g/MJ and N_e = 80…200 MW
SO_2 collecting cost, U.S. $/t	257…395 for n' = 0,6…1,0 g/MJ and N_e = 300…500 MW 265…430 for n' = 0,6…1,0 g/MJ and N_e = 80…200 MW