Part 1

AIR PROTECTION FROM POWER INDUSTRY EMISSIONS

1.3. Sulfur oxide emission reduction
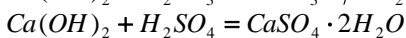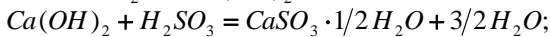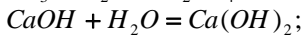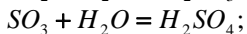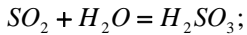
1.3.2. Technologies of sulfur oxide emission reduction
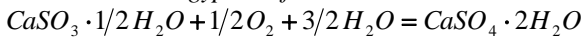
1.3.2.12. Wet lime technology

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Wet lime technology is based on binding of sulfur oxides SO_2 and SO_3 with water suspension of lime with formation of calcium sulfite and its subsequent oxidation to the double water sulfate (gypsum). The main chemical reactions of this technology are the following:

at absorption of SO_2 and SO_3

$SO_2 + H_2O = H_2SO_3;$

$SO_3 + H_2O = H_2SO_4;$

$CaOH + H_2O = Ca(OH)_2;$

$Ca(OH)_2 + H_2SO_3 = CaSO_3 \cdot 1/2\,H_2O + 3/2\,H_2O;$

$Ca(OH)_2 + H_2SO_4 = CaSO_4 \cdot 2H_2O$

at double water gypsum formation :

$CaSO_3 \cdot 1/2\,H_2O + 1/2\,O_2 + 3/2\,H_2O = CaSO_4 \cdot 2H_2O$

A diagram of the wet lime desulphurization installation is shown in Fig. 1.47.

Fig. 1.47. A principle diagram of the wet lime desulfurization installation

It consists of an absorber *1* with several stages of irrigation *2* and a mist extractor *3*; pumps of limestone slurry circulation *4*; collecting oxidizing reservoir *5*; a unit of the forced oxidation of calcium sulphite *6*; purified gas heater *7*; a system of hydrocyclones *8*; a unit of gypsum dewatering *9*; a unit of neutralization and treatment of wastewater *10*; a silo for lime storage *11*; an installation of lime slaking *12* and a unit of the lime slurry preparation *13*.

The installation (Fig. 1.47) operates just as the wet limestone one. Calcium hydroxide has a higher solubility in water than limestone, and it is more active, so the absorber volume is approximately twice as little as a volume of the installation for the wet limestone technology and an irrigation density is typically less than 10 l/m^3.

A unit for removing from the cycle of a part of well-soluble magnesium sulfate $MgSO_4$ and its processing into a dry or a medium dry waste is added in the technological scheme with the use of dolomite lime $CaO \cdot MgO$.

For preparation of the lime slurry, quicklime CaO or drowned lime $Ca(OH)_2$ is used. Drowned lime is always ground, so that at its presence a reagent from the silo is blended in to the reservoir, and upon reaching the required concentration, the slurry is fed into the absorber. Lump quicklime or crushed lime is fed into the lime-slaking apparatus. From this apparatus the concentrated slurry is poured into the reservoir of the reagent preparation, which is mixed with water and brought up to necessary indicators.

Technical and economic indicators of the wet limestone technology are presented in Tab. 1.26.

Specific indicators and SO_2 collecting costs are determined for a different number of hours of power unit operation, to 6000 h/year. Greater values of indicators are referred to lesser number of operation hours and vice versa.

Wet limestone desulphurization takes the second place in the world practice at expansion at TPPs due to smaller sizes and equipment costs and lower operating costs compared to wet limestone technology. But working with lime requires meeting of the certain accident-prevention rules to avoid its impact on environment and human health.
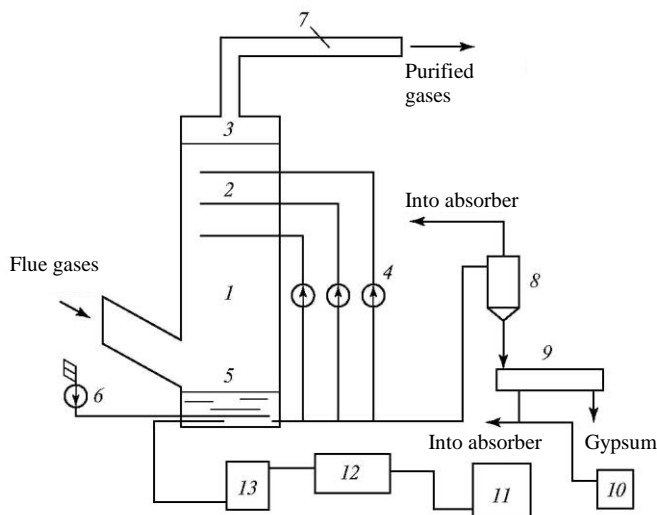
Table 1.26. **Indicators of the wet lime technology of desulfurization**

Achievable desulfurization efficiency, %	96

Reduced sulfur content of fuel depending on the heat capacity of the boiler, % kg/MJ	According to GOST R 50831—95:
	  up to 199 MW — 0,63…0,75; 200…249 MW — 0,5;
	  250…299 MW — 0,38; ≥ 300 MW — 0,38
	According to requirements of the II Protocol to SO_2 ICTM (for solid fuel):
	  50…100 MW — 1,1; 100…500 MW — 1,1…0,22; ≥ 500 MW — 0,22

Used reagents	Lump lime, drowned or slaked lime with containing of calcite hydroxide $Ca(OH)_2$ 70…98 %
Reagent excess factor	1,02... 1,04
Resulting waste	Double water calcium sulphate (gypsum) $CaSO_4$
Demands to efficiency of ash collection	Cocentration of fly ash in flue gases not more than 250 mg/m^3
Desulfurization effect on ash collector operation	Desulfurization reduces dust content of gases in 30…35 %
Specific area for equipment installation, m^2/kW	0,03... 0,04
Specific energy consumption, % of equivalent unit (boiler) capacity	1,4…1,8 for $n' = 0,6…1,0$ g/MJ and $N_e = 300…500$ MW 1,8…2,1 for $n' = 3,0$ g/MJ and $N_e = 300…500$ MW 1,6…1,9 for $n' = 3,0$ g/MJ and $N_e = 80…200$ MW
Specific capital costs, U.S. $/kW of the installed capacity	65…110 for $n' = 0,6…1,0$ g/MJ and $N_e = 300…500$ MW 150…170 for $n' = 3,0$ g/MJ and $N_e = 300…500$ MW 87…178 for $n' = 3,0$ g/MJ and $N_e = 80…200$ MW
Specific operating costs, U.S. cents/(kW·h)	1,6…6,8 for $n' = 0,6…1,0$ g/MJ and $N_e = 300…500$ MW 4,2…13 for $n' = 3,0$ g/MJ and $N_e = 300…500$ MW 4,3…13,3 for $n' = 3,0$ g/MJ and $N_e = 80…200$ MW
SO_2 collecting costs, U.S. $/t	520…2050 for $n' = 0,6…1,0$ g/MJ and $N_e = 300…500$ MW 235…605 for $n' = 3,0$ g/MJ and $N_e = 300…500$ MW 265…750 for $n' = 3,0$ g/MJ and $N_e = 80…200$ MW