

## AIR PROTECTION FROM POWER INDUSTRY EMISSIONS

### 1.3. Sulfur oxide emission reduction

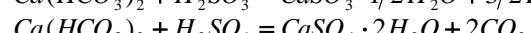
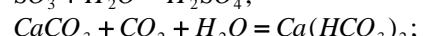
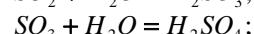
#### 1.3.2. Technologies of sulfur oxide emission reduction

##### 1.3.2.11. Wet limestone technology

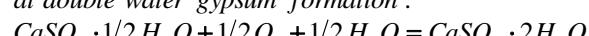
*Shmigol I.N., JSC "VTI"*

Wet limestone technology (WLT) is based on binding of sulfur dioxide and trioxide with the limestone slurry, during which calcium sulfite is formed, which is oxidized to the double water sulfate (gypsum). The main chemical reactions of WLT are the following:

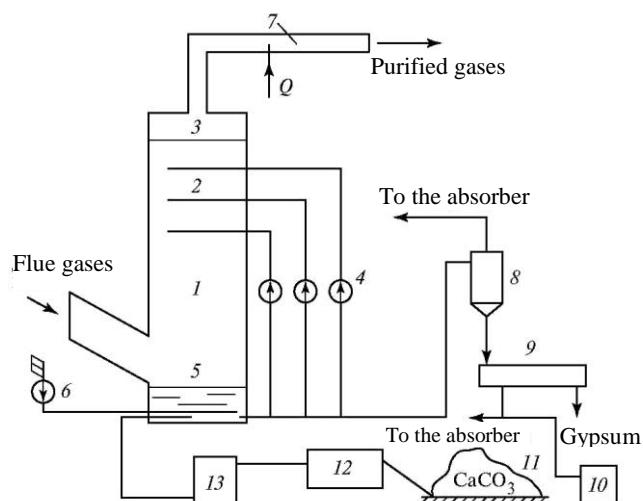
*at absorption of SO<sub>2</sub> and SO<sub>3</sub>*



*at double water gypsum formation :*



A diagram of the wet limestone desulphurization installation is shown in Fig. 1.46. It consists of an absorber 1 with several stages of irrigation 2 and an 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; limestone storage 11; a system of crushing and grinding of limestone 12; a unit of preparation of limestone slurry 13.



**Fig. 1.46. A principle diagram of the wet limestone desulfurization installation**

The installation operates in the following way. Flue gases dedusted to 50 ... 100 mg/m<sup>3</sup>, enter the absorber. If it's a single-stage absorber with countercurrent flow of liquids and gases (Fig. 1.46), the gases are injected into its bottom part above the liquid surface, into the collecting oxidizing reservoir. In the two-stage absorber the gases are fed into the top part of the first stage with the downtake cocurrent flow of liquids and gases. Then the gases are directed into the second stage with the countercurrent flow of liquids and gases. Since limestone calcite CaCO<sub>3</sub> is poorly soluble in water, then an intensive irrigation of the absorber, density of which reaches 20 ... 22 l/m<sup>3</sup>, is arranged.

Purified gases pass through the mist extractor to separate the drop moisture from them. After that flue gases are heated by 20 ... 25°C and discharged into atmosphere. Slurry from the absorber enters the collecting oxidizing reservoir, where air for the forced oxidation of calcium sulfite in sulfate (double water gypsum) is injected. Limestone slurry, which binds SO<sub>x</sub>, is also injected there. PH of the circulating liquid is regulated by suspension injection. This prevents from formation of difficult-to-remove sulfite-sulfate deposits in the absorption zone.

Suspension from the collecting oxidizing reservoir is fed into the absorber by circulation pumps and sprayed along the installation volume by mechanical nozzles of various constructions. Desulfurization start-up also covers a reception of gypsum crystals of the required size, typically of 100 microns. That provides an efficient operation of a gypsum dewatering unit. Standard gypsum slurry passes through one or two stages of hydrocyclones, where fine particles of gypsum and unreacted limestone particles, returning to the absorber together with the liquid, are separated. These particles have a larger surface that makes them the preferred crystallization centers of the dissolved calcium sulfate. Thanks to that, a probability of deposit formation at the internal equipment of the absorber additionally reduces. Enriched slurry with large crystals of gypsum is dewatered in vacuum precipitators of a belt or a drum type. The filtrate is also returned into the installation. If the burnt coal contains chlorine, then the liquid part is removed from the absorber to maintain the set concentration of chlorides in liquid, since their excess inhibits a process of flue gas desulfurization. Wastewater (usually the filtrate) is neutralized and released from heavy metals, and then discharged into natural water reservoirs.

For preparation of the limestone slurry, limestone of a moderate degree of crystallization, being sufficiently soluble in water, is used. Chalk – the uncristallized calcite is the most suitable. Lump or milled limestone is applied. Stored lump limestone is crushed, then ground in a wet or a dry mill and is mixed with water in the required proportion. When using the crushed limestone, it is stored in silos, from which it is fed by pneumatic conveying into the reservoir of suspension preparation. Chalk does not require pre-milling, and for its preparation a loam mill is used. The prepared suspension is fed in to the collecting oxidizing reservoir.

Indicators of the wet limestone technology are presented in Tab. 1.25.

It should be noted that the wet limestone technology is the most popular in the world practice of desulfurization, because it allows providing a high degree of the sulfur dioxide collection at a continuous tightening of sanitary norms. It is also the only environmentally friendly technology, as the reagent and waste are neutral and poorly soluble, so that no disturbances of the process or accidents will lead to environmental pollution or make harm to the human health.

An important feature of the wet limestone technology is availability of the natural agent almost in any place of the country.

The economic indicators of desulfurization are the most favorable for the long-term (not less than 3000 h/year) plant

operation in a scheme of the boiler.

Table 1.25. Indicators of the wet limestone desulfurization

Achievable desulfurization efficiency, %	95
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 — 0,5...0,6; 200...249 MW — 0,4...0,45; 250...299 MW — 0,3; $\geq$ 300 MW — 0,3 According to requirements of the II Protocol to SO <sub>2</sub> ICTM (for solid fuel): 50...100 MW — 0,875; 100...500 MW — 0,875...0,175; $\geq$ 500 MW — 0,175
Used reagents	Poorly crystallized limestone, chalk with calcite content CaCO <sub>3</sub> of 95 ... 98%
Reagent excess factor	1,03 ... 1,05
Resulting waste	Double water calcium sulphate (gypsum) CaSO <sub>4</sub>
Waste toxicity	Not toxic
Technologies and industries of waste application	Cement production, manufacture of gypsum products, concrete fillers, land levelling
Necessity of the purified gases heating	Gas heating by 20...25°C is required
Requirements for the ash collection efficiency	Concentration of fly ash in flue gases not more than 250 mg/m <sup>3</sup>
Desulfurization effect on the ash collector operation	Desulfurization reduces dust content of gases in 30...35 %
Specific area for equipment installation, m <sup>2</sup> /kW	0,04...0,05
Specific energy consumption, % of equivalent unit (boiler) capacity	2,3...2,8 for $n' = 0,6...1,0$ g/MJ and $N_e = 300...500$ MW
	2,8...3,8 for $n' = 3,0$ g/MJ and $N_e = 300...500$ MW
	2,6...3,7 for $n' = 3,0$ g/MJ and $N_e = 80...200$ MW
Specific capital costs, U.S. \$/kW of the installed capacity	90...160 for $n' = 0,6...1,0$ g/MJ and $N_e = 300...500$ MW
	215...245 for $n' = 3,0$ g/MJ and $N_e = 300...500$ MW
	125...290 for $n' = 3,0$ g/MJ and $N_e = 80...200$ MW
Specific operating costs, U.S. cents/(kW·h)	1,6...5,6 for $n' = 0,6...1,0$ g/MJ and $N_e = 300...500$ MW
	1,8...7,3 for $n' = 3,0$ g/MJ and $N_e = 300...500$ MW
	2,4...5,7 for $n' = 3,0$ g/MJ and $N_e = 80...200$ MW
SO <sub>2</sub> collecting costs, U.S. \$/t	650...2870 for $n' = 0,6...1,0$ g/MJ and $N_e = 300...500$ MW
	265...785 for $n' = 3,0$ g/MJ and $N_e = 300...500$ MW
	270...990 for $n' = 3,0$ g/MJ and $N_e = 80...200$ MW